Climate Action Partnership

UC Berkeley Climate Action Partnership

Feasibility Study 2006- 2007 Final Report

CalCAP is a collaborative of faculty, administration, staff and students working to reduce greenhouse gas emissions at UC Berkeley

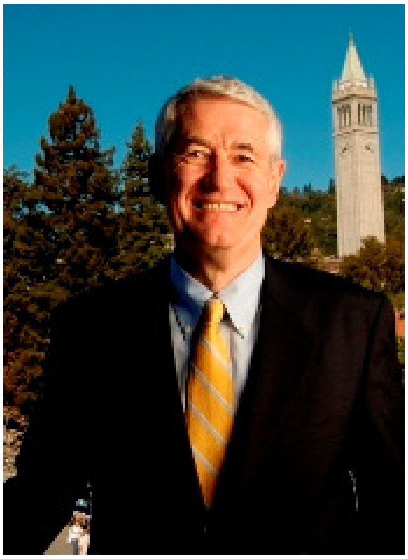
by

Fahmida Ahmed
Sustainability Specialist, UC Berkeley

Website: http://calcap.berkeley.edu

July 2007

SPOTLIGHT



On April 27, 2007, UC Berkeley Chancellor Robert Birgeneau committed the UC Berkeley campus to reducing its greenhouse gas emissions to 1990 levels by the year 2014. The announcement was made at the 4th Annual Sustainability Summit of the Chancellor's Advisory Committee on Sustainability, and it was based on the final Cal Climate Action Partnership recommendations made to the Chancellor and his cabinet in early April.

"This new emissions target is the next step in the campus's drive to play a pivotal role in California's climate strategy and action. UC Berkeley's new emissions target not only meets [the] ACUPCC criteria, but emphasizes Berkeley's leadership in sound analysis and actionable policy".

- Chancellor Robert Birgeneau, April 27 2007 Keynote address, UC Berkeley Sustainability Summit

In March 2007, UC President Robert Dynes signed the American College and University Presidents Climate Commitment (ACUPCC), which calls for the University of California to reduce its greenhouse gas emissions, with the ultimate goal of making all ten UC campuses carbon-neutral (Appendix Z). The CalCAP feasibility study was already underway at the time, so the campus not only supports ACUPCC but also serves as a pioneering program for all.

TABLE OF CONTENTS

LIST OF FIGURES 5

ACKNOWLEDGEMENTS 6

EXECUTIVE SUMMARY 7

CHAPTER 1: CLIMATE CHANGE AND THE NEED FOR ACTION 15

1.1 The Reality of Climate Change 15
1.2 Climate Change Policy 16
1.3 UC Berkeley Action 18
1.4 Feasibility Study Approach 18

CHAPTER 2: GHG EMISSIONS INVENTORY 20

2.1 Inventory Planning 20
2.2 Emissions Sources 21
2.3 Emissions Data and Calculation Methodology 21
2.4 Emissions Inventory Results 24
2.5 Carbon Footprint and Emissions Inventory 26
2.6 Lifecycle Calculations 27
2.7 Emissions Trends and Growth Projections 28
2.8 Application of Emissions Reduction Targets 29

CHAPTER 3: EMISSIONS REDUCTION PROJECTS 31

3.1 Types of Emissions Reduction Projects 31
3.2 Project Evaluation Criteria and Selection Process 33
3.3 Financial Analysis & Results 34
3.4 Proposed Funding Scenario for Projects 35

CHAPTER 4: DETERMINATION OF CAL EMISSIONS TARGET 36

4.1 Scenario Evaluation 36
4.2 Scenario Evaluation – Financial Picture 37
4.3 Reaching the Cal Target – 1990 levels by 2014 38

CHAPTER 5: RECOMMENDATIONS & CONCLUSIONS 41

APPENDICES 45

A GUIDE FOR UNIVERSITY STUDENT GROUPS 107

GLOSSARY OF TERMS 131

BIBLIOGRAPHY 133

APPENDICES

APPENDIX A: AB-32 GLOBAL WARMING SOLUTIONS ACT 46

APPENDIX B: UC OFFICE OF THE PRESIDENT POLICY ON SUSTAINABLE PRACTICES 47

APPENDIX C: CITY OF BERKELEY MEASURE G 48

APPENDIX D: CALIFORNIA CLIMATE ACTION REGISTRY 50

APPENDIX E: ENERGY POWER MIX FOR UC BERKELEY ELECTRICITY 51

APPENDIX F: LETTER TO THE CHANCELLOR FROM STUDENTS AND FACULTY 2005 52

APPENDIX G: CALCAP COMMITTEE LETTER TO THE CHANCELLOR 2006 56

APPENDIX H: CALCAP STEERING COMMITTEE MEMBERSHIP 2006-2007 57

APPENDIX I: INVENTORY CALCULATION - ELECTRICITY & NATURAL GAS SOURCES 58

APPENDIX J: INVENTORY CALCULATION - PURCHASED STEAM 60

APPENDIX K: INVENTORY CALCULATION - CAMPUS FLEET 67

APPENDIX L: INVENTORY CALCULATION - REFRIGERANTS 69

APPENDIX M: INVENTORY CALCULATION - COMMUTE 70

APPENDIX N: INVENTORY CALCULATION - AIR TRAVEL 72

APPENDIX O: INVENTORY CALCULATION - WATER CONSUMPTION 76

APPENDIX P: INVENTORY CALCULATION - LANDFILLED SOLID WASTE 79

APPENDIX Q: ENERGY INTENSITY 2006 80

APPENDIX R: LIFECYCLE ANALYSIS – UC BERKELEY CLIMATE FOOTPRINT 81

APPENDIX S: CALCAP PROJECTS 89

APPENDIX T: CALCAP PROJECT RANKING 90

APPENDIX U: RENEWABLE ENERGY CREDITS 92

APPENDIX V: CARBON OFFSETS ANALYSIS 93

APPENDIX W: WATER CONSERVATION PROJECT ANALYSIS 97

APPENDIX X: CALCAP SCENARIOS 102

APPENDIX Y: UNIVERSITY LEADERSHIP 103

APPENDIX Z: AMERICAN COLLEGE & UNIVERSITY PRESIDENTS' CLIMATE COMMITMENT (ACUPCC) 106

List of Figures

Executive Summary:

Figure A: UC Berkeley GHG Emissions by Source in Calendar Year 2006
Figure B: UC Berkeley Emissions Trend from 1990 to 2050
Figure C: Projected Emissions and Potential Targets

Chapter 1:

Figure 1: CalCAP Project Plan

Chapter 2:

Figure 2.1: Emissions Scope
Figure 2.2: Emissions Sources and Scope
Figure 2.3.1: Global Warming Potential
Figure 2.3.2: Required Reporting Methodology
Figure 2.3.3: Optional Reporting Methodology
Figure 2.4.1: CARROT: UC Berkeley 2006
Figure 2.4.2: UC Berkeley Emissions Inventory 2006
Figure 2.5.1: UC Berkeley 2006 – Carbon Footprint Vs Emissions Inventory
Figure 2.5.2: UC Berkeley 2006 – Lifecycle Calculations
Figure 2.7: UC Berkeley Emissions Trends (1990-2050)
Figure 2.8.1: Emissions Reduction Targets
Figure 2.8.2: Emissions Reduction Targets and Reduction Amounts

Chapter 3

Figure 3.3: Emissions Reduction Targets and Reduction Amounts

Chapter 4

Figure 4.1: Emissions Reduction Scenarios (Subset)
Figure 4.2: Emissions Reduction Scenarios (Subset)
Figure 4.3.1: Meeting the Cal Target
Figure 4.3.2: Emissions Reduction Target for UC Berkeley – 1990 levels by 2014

ACKNOWLEDGEMENTS

CalCAP is indebted to the Climate Action Partnership Steering Committee Chair Catherine Koshland and to core members of the committee for their guidance and their contributions to the feasibility study. CalCAP also received valuable support from members of the Chancellor's Advisory Committee on Sustainability (CACS).

The CalCAP team would like to thank the following individuals for their ongoing involvement with the project:

- Administration: Nathan Brostrom, Emily Sexton, Mark Freiberg, Greg Haet, Tim Pine, Kira Stoll, Eric Robinson
- Berkeley Institute of the Environment: Inez Fung, Dan Kammen, Chris Jones
- Department of Civil and Environmental Engineering: Arpad Horvath, Bill Nazaroff
- Energy Resources Group: Scott Zimmermann, Sam Arons
- Facilities Services: Ed Denton, Paul Black, Judy Chess, Lisa Bauer
- Haas School of Business: Chris Rosen
- Kyoto USA: Tom Kelly
- Office of the President: Matt St. Clair
- Office of the Vice Provost-Academic Planning & Facilities: Catherine Koshland, Sarah Nathe

Special thanks to the following student and post-doctorate volunteers who provided research support to CalCAP: Vi Do, Kristen Durham, Ryan Firestone, Jessica Huang, Timothy Huang, Sally Maki, Anna Motschenbacher, Aaron Parsons, and Jennifer Stokes. Their reports are included in the appendices to this study. I am grateful to graduate student researcher Scott Zimmermann and undergraduate intern Dana Riley at UC Berkeley for their outstanding contributions to this study and to campus communication.

The CalCAP team looks forward to working together in 2007-2008.

Fahmida Ahmed
Sustainability Specialist
Project Manager, Cal Climate Action Partnership
May, 2007

Visit us at: http://calcap.berkeley.edu

EXECUTIVE SUMMARY

About the Cal Climate Action Partnership

A group of student leaders conceived of the Cal Climate Action Partnership (CalCAP) in March, 2005 (see Appendix F). In response to their passion and support from members of faculty and staff, a CalCAP Steering Committee was convened by Vice Provost Catherine Koshland in early 2006 (see Appendix G). At the Campus Sustainability Summit in April, 2006, Chancellor Birgeneau announced that, at a minimum, UC Berkeley would adopt the State of California's greenhouse gas emissions reduction targets. The Chancellor then approved the request for this feasibility study and inventory certification. The Chancellor's Advisory Committee on Sustainability (CACS) hired Project Manager Fahmida Ahmed in September, 2006 with administrative support from Facilities Services and Environment, Health & Safety.

Feasibility Study Results

Since October 2006, CalCAP has engaged with campus decision makers and stakeholders to complete the following activities:

- ☒ California Climate Action Registry – Joined in October, 2006.
- ☒ Greenhouse Gas (GHG) Inventory – Emissions from the campus have been inventoried, reported to the Registry, and the certification was completed in August, 2007.
- ☒ Project Identification and Evaluation – Over 30 GHG reduction projects were identified in initial scoping, and quantitative analysis was completed for 14 of those projects.
- ☒ Emissions Reduction Target Analysis – Evaluated options to meet state, Kyoto, and more aggressive GHG reduction targets using identified projects.
- ☒ Financial Feasibility Analysis – Estimated the costs and savings associated with implementation of the identified projects, showing that the project portfolio of identified on-campus projects has a 4-year simple payback.

Final Recommendations to the Office of the Chancellor

CalCAP recommends that the university take the following actions:

- **Commit** to reducing greenhouse gas emissions to **1990 levels by 2014**. This is equivalent to meeting California Assembly Bill 32 (passed in September, 2006) six years early. The feasibility study demonstrated that this target can be met or exceeded through execution of identified projects and a greening of the electricity supply.
- **Commit** to long-term climate neutrality, without specifying a target date. In parallel, the university should continue to develop a better understanding of its overall climate footprint.
- **Provide a directive** to the campus to incorporate greenhouse gas reduction criteria and sustainability into the institutional decision-making process. This directive should be targeted at every member of the campus community: administrators, faculty, staff, and students.
- **Support the continuation of CalCAP and sustainability initiatives**. Allocate resources for permanent sustainability staff roles (requests through Facilities Services and Administration), and incorporate GHG reduction criteria and reporting into their mandates.

Why UC Berkeley Should Take Action

Anthropogenic climate change is the most significant problem of our time. Recognizing this, almost all developed countries are taking action to reduce greenhouse gas (GHG) emissions, with both the Kyoto Protocol increasing its influence and the European Union implementing its recent Emissions Trading Scheme. California is already demonstrating national and international leadership in committing to reduce its GHG emissions. AB 32--*Global Warming Solutions Act of 2006*-- requires that the state's global warming emissions be reduced to 1990 levels by 2020 (Appendix A). On March 22, 2007, UC President Robert Dynes signed the systemwide *Policy on Sustainability Practices* that endorses meeting the goals outlined in AB-32. In addition, this policy urged each UC campus to "pursue the goal of reducing GHG emissions to 2000 levels by 2014 and provide an action plan for becoming climate neutral as specified in the Implementation Procedures" (see Appendix B for full language).

As the nation's leading public educational institution, the University of California, Berkeley is poised to play a pivotal role in California's climate strategy. It is important to demonstrate strategic and financial commitment to reducing climate change and to encourage students to be conscious of their carbon footprints. Furthermore, by taking action, the campus can reap the following benefits:

- Reduce campus energy costs
- Implement GHG reduction technologies developed by campus researchers
- Prepare for future climate regulations and energy price volatility
- Create demand for low-cost renewable energy technologies through its purchasing power
- Appeal to a campus community that has a strong culture of environmental ethics
- Collaborate with local communities and the City of Berkeley in implementing Measure G (Appendix C).

CalCAP Feasibility Study

CalCAP was formed to develop a strategy for significantly reducing UC Berkeley's GHG footprint without compromising its operations. There were three goals for the CalCAP feasibility study:

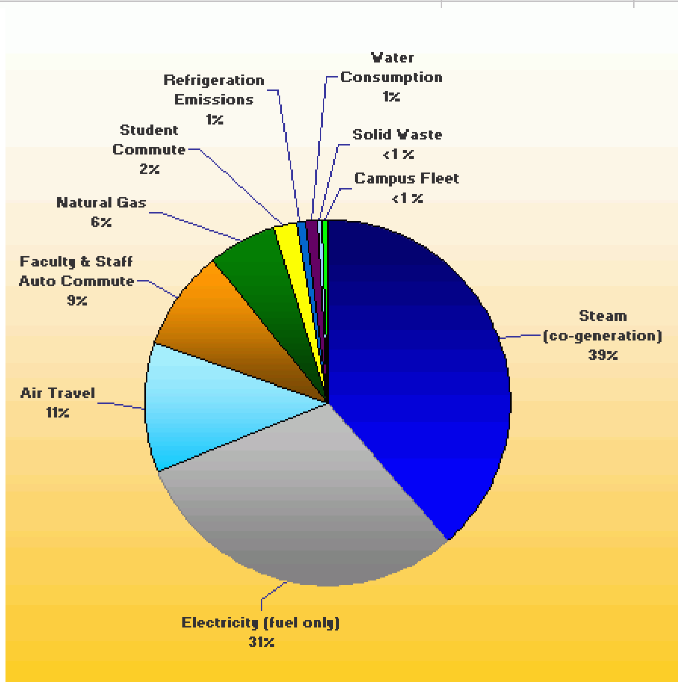
- Create a carbon emissions inventory
- Assess the financial feasibility of emissions reduction through various campus initiatives
- Create an institutional model for emissions reduction.

UC Berkeley GHG Emissions Inventory

The UC Berkeley GHG emissions inventory includes ten emissions sources: electricity consumption; steam use; natural gas consumption; the university fleet; student commuting; faculty and staff commuting; faculty and staff air travel; fugitive emissions from coolants; solid waste; and water use. The geographic boundary for the inventory was defined as campus buildings on the central campus, all student housing on- and off-campus, and the Richmond Field Station.

Figure A: UC Berkeley GHG Emissions by Source in Calendar Year 2006

Emissions Sources (required & optional reporting)	CO_2 equivalent (metric tons)	Percentage Contribution
Steam (co-generation)	82,000	38.8%
Purchased Electricity	65,000	30.6%
Air Travel	24,000	11.3%
Faculty and Staff Auto Commute	19,000	8.6%
Natural Gas	13,000	6.1%
Student Commute	4,000	1.8%
Fugitive Emissions- Refrigeration	2,000	1.0%
Water Consumption	2,000	0.9%
Solid Waste	1,000	0.4%
Campus Fleet	1,000	0.4%
Total Emissions	209,000	100.0%
Required reporting emissions sources	160,000	76.5%
Optional Reporting emissions sources	50,000	23.5%



The university joined the California Climate Action Registry (the Registry) in October, 2006 to voluntarily report its emissions. The Registry requires reporting emissions from electricity consumption, steam use, natural gas consumption, university fleet, and fugitive emissions of coolants. The study included the additional emissions because the CalCAP Steering Committee wanted the inventory to reflect the campus's actual greenhouse gas footprint as closely as possible. This has the additional benefit of addressing emissions from additional sources that may eventually be regulated under AB-32 (see Appendix D for more information on the Registry).

In 2006, total GHG emissions from the ten sources were approximately 209,000 metric tons of CO_2 equivalent (Figure A). For a campus population of 48,000, this corresponds to 12g CO_2/person/day, which is about a third of the total average per capita emissions for Californians (Nazaroff, 2006).

During the course of the inventory process, the CalCAP team recognized that the emissions inventory does not fully reflect the complete carbon footprint of the campus. The UC Berkeley emissions inventory is only a subset of our campus's total carbon footprint, as it excludes the full lifecycle carbon emissions associated with some of the campus activities. The Steering Committee decided that UC Berkeley should take a leadership role in documenting and reporting additional optional sources of emissions such as procurement (university purchases including office supplies, furniture, food) and construction. A lifecycle analysis includes greenhouse gas emissions from all stages of a product or service's lifecycle, including mining, manufacturing, transportation, retail, use, and disposal. See Appendix R for more information on lifecycle calculations.

The result of adding the lifecycle calculation to the emissions inventory estimates is striking. In 2006, the campus carbon footprint according to lifecycle analysis is at least 482,000 metric tons of CO_2 equivalent. The lifecycle calculation of additional emissions sources for procurement, construction and electricity (not otherwise calculated) adds an additional 273,000 metric tons of CO_2e to our total carbon footprint, which can be expressed as a 130% emissions increase (from 210,000 to 480,000 metric tons). Recognizing and understanding carbon emissions in terms of lifecycle analysis is important to UC Berkeley, and is considered a critical component to achieving the emissions reduction goals.

UC Berkeley GHG Emissions Trend

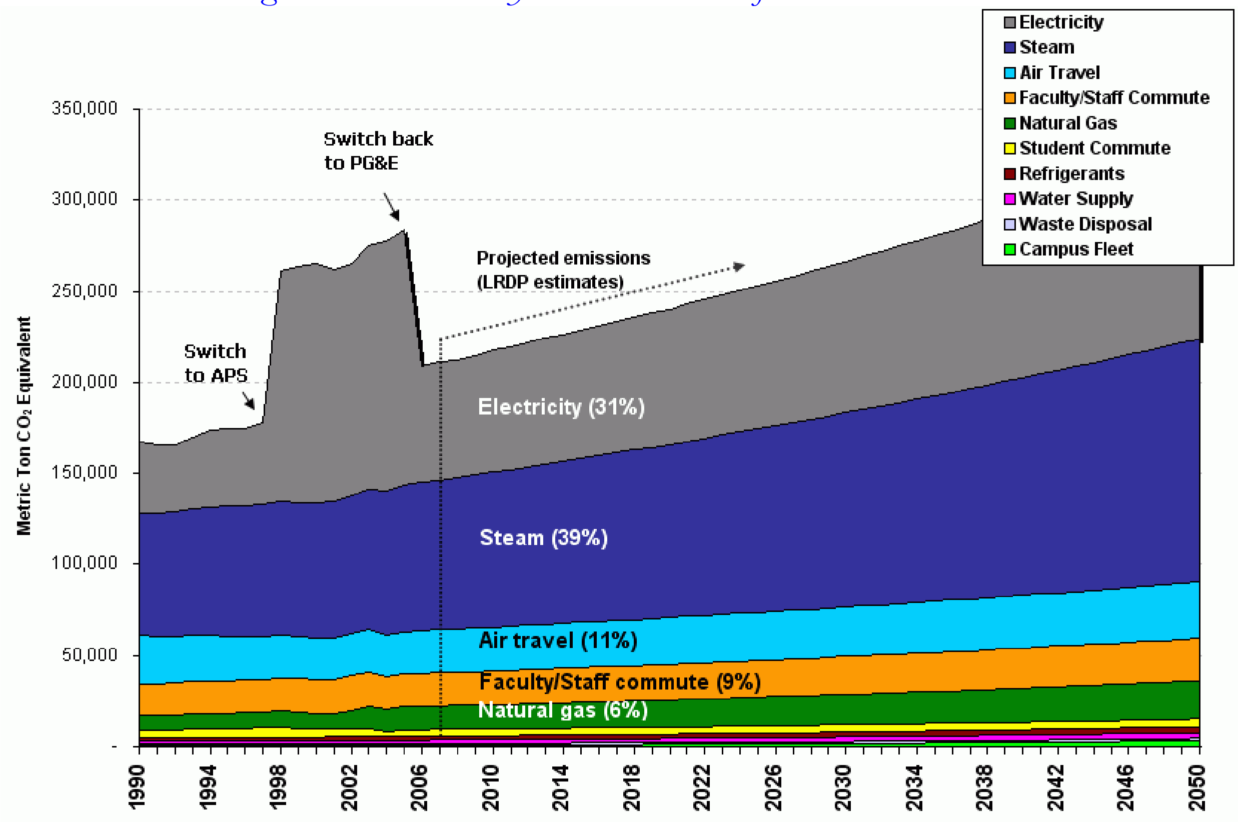
UC Berkeley has data for 1990 through 2006. From 2007 onwards, growth was projected from the *UC Berkeley Long Range Development Plan* , which estmates a 1.14% annual increase in gross square footage and a 0.609% annual increase in population). The annual gross square footage increase estimate was applied to electricity, steam, gas, waste, water supply, and refrigerant, while the annual population increase estimate was applied to commute and air travel calculations. A 2.8% annual growth rate was applied to campus fleet based on calculation performed by campus fleet manager (Robinson, 2006). Figure B displays UC Berkeley's GHG emissions by source over the past 16 years and projected through year 2050.

Two notable items are the largest emissions sources and the importance of choosing a utility provider that uses clean and renewable fuel sources.

- Steam usage is the single largest source of GHG emissions, representing roughly 40% of total emissions, followed by electricity, air travel and faculty and staff auto commute.

- The increase in electricity emissions between 1998 and 2006 is due primarily to the higher coal content in the power mix for the electricity generated by Arizona Public Services (38% coal for APS vs. 1% coal and a larger percentage of energy from hydroelectricity for PG&E). In 2006, the main campus account (88% of the campus electricity) switched back to PG&E, which uses only 1% coal, 42% natural gas, 12% nuclear, 20% hydro, and 12% renewable--a fuel mix that improves our emissions inventory for calendar year 2006 (see Appendix E).

Figure B: UC Berkeley Emissions Trend from 1990 to 2050



Emissions Reduction Projects

The CalCAP study identified a range of mitigation strategies available to UC Berkeley that fall into four main categories. At present, CalCAP implementation is focused on projects in the first two categories; we expect these to produce monetary savings that can be recycled to fund more projects. The CalCAP team is also developing strategies for the third and fourth categories, but implementation of these strategies will come later. These project lists are by no means exhaustive and the energy savings calculations are fairly conservative by design. It is essential for this program to identify more intensive and additional reduction opportunities as it evolves.

1. **Infrastructure projects** – These projects are meant to enhance the energy efficiency of campus energy systems. They have a significant upfront cost, but they have a quick payback and generate savings that can be further invested. Projects about which we have gathered information include:

    - Monitoring-based commissioning
    - Co-generation plant steam capture and repair
    - Automated lighting controls
    - Fluorescent lighting retrofits

- On-site photovoltaic system
- Retrofitting bathrooms for better water conservation
- Energy Star (EPA) computer settings

2. **Behavior Projects** – These are campus initiatives that will encourage individuals to conserve more energy. These projects require some capital investment and a significant dedication to coordination and planning. They have a quick payback and also contribute to establishing a culture of environmentally sustainable practices. These projects vary in scope and focus:

    - Introduce fleet biking
    - Expand electric vehicle fleet
    - Implement high priority bicycle plan projects & programs
    - Reward department level energy reduction
    - Increase utilization of videoconference room(s)
    - Increasing occupant awareness and electricity curtailment
    - Introduce Campus Composting program

3. **Renewable Energy Credits** (RECs) – In many jurisdictions, the markets for energy and the environmental attributes of energy production are separate. The campus can green its electricity supply by making an investment in green power credits, also known as Renewable Energy Credits. One REC covers the technological and environmental attributes of one megawatt hour of electricity generated from renewable sources (see Appendix U). RECs are third party certified, increase the demand for renewable energy in the utilities market, and are recognized as a sound method for compensating for carbon emissions from essential energy consumption. UC Berkeley will invest in RECs once possible infrastructures improvements have been implemented.

4. **Carbon Offsets** – The purchase of carbon offsets reduces net carbon emissions through arrangements with a carbon-offset provider specializing in projects off-campus that retire or capture carbon from the atmosphere (see Appendix V). Examples include investments in renewable energy projects, and carbon capture and sequestration projects. Carbon offsets can be purchased from many organizations, but the lack of formal regulation of this market raises questions about whether the offset credits are only awarded for emissions reductions that would not have otherwise happened, and whether the offsets are permanent. In the coming years, UC Berkeley will investigate local and regional offset opportunities that offer tangible environmental, social and economic benefits to the local community.

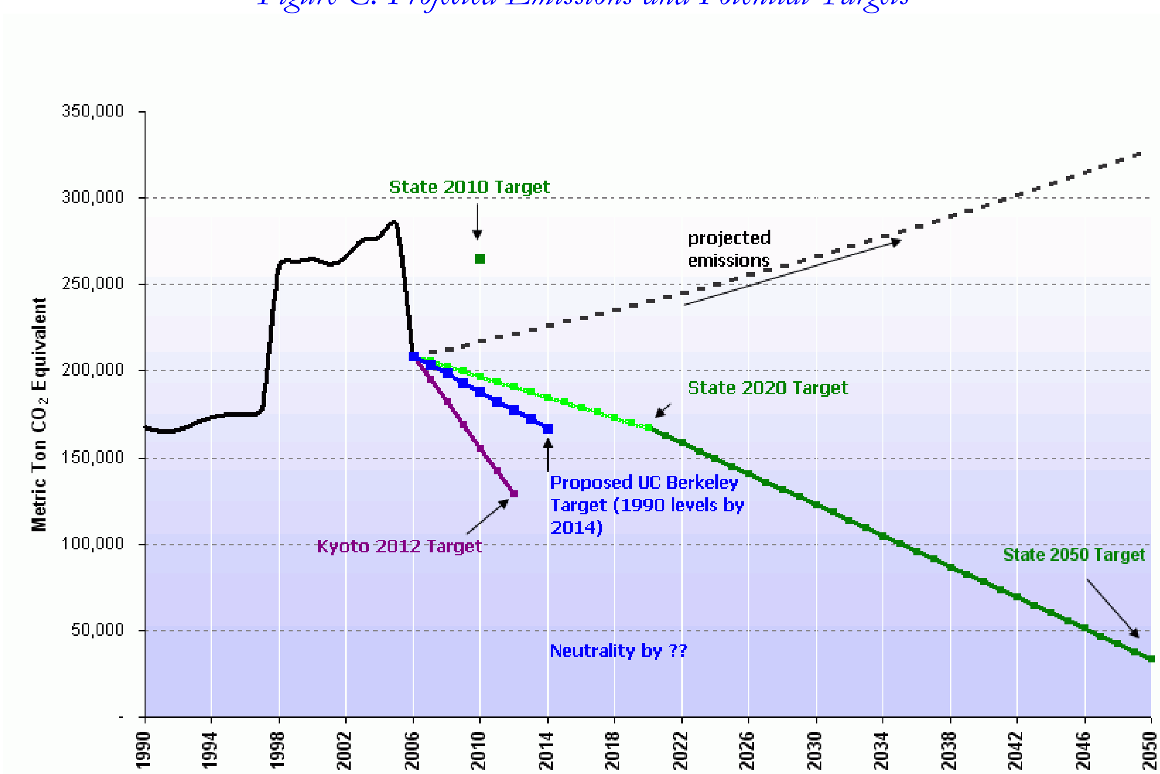
Financial Feasibility Analysis

For each project, we calculated capital cost, associated savings (e.g., energy), annual GHG reduction potential, net cost per unit of GHG reduced,[1] and payback period. We found that with an initial investment in the infrastructure projects in the first years in the amount of $14 million (one-time capital) and an additional $1 million (annual operating), the university can break even approximately around the 4th year, and start generating a **net** savings of approximately $3 million dollars annually (see Appendix S for project calculations--spreadsheet available upon request). The upfront capital investment need not be done in the first year--but the sooner the investment happens, the sooner the savings accrue for additional investments.

Emissions Targets for UC Berkeley

We analyzed three separate emissions targets as applied to UC Berkeley through 2050: the U.S. targets from the first commitment period of the Kyoto Protocol (7% below 1990 levels by 2010), the California state targets (2000 levels by 2010, 1990 levels by 2020 or AB-32, and 80% below 1990 levels by 2050), and a target appropriate for UC Berkeley based on the identified projects and their financial feasibility (Figure C).

Figure C: Projected Emissions and Potential Targets



[1] This includes the upfront capital cost and the discounted savings over the lifetime of the project.

With consideration of the GHG inventory and evaluation of various emissions reduction efforts, the CalCAP findings show that UC Berkeley can make a firm commitment to reach **1990 emissions levels by the year 2014.** To accomplish this, UC Berkeley would:

- Use aggregate emissions targets as a metric in campus communication and planning
- First implement infrastructure-related emissions reduction projects, starting with the most cost-effective (i.e., highest $/MTCO$_2$e) projects, and then use the savings from those projects to invest in additional projects or to purchase Renewable Energy Credits (RECs)
- Focus on identifying additional cost-effective GHG mitigation opportunities on campus, such as energy efficiency.

The UC Berkeley target (in blue) is more aggressive than AB-32 and the UCOP Climate Protection mandates. The UC Berkeley target is more aggressive than is required by California state law and the University of California Office of the President for reaching 2000 levels by 2014. This puts the university on a faster trajectory towards neutrality. The next emissions reduction feasibility study and assessment in 2008 will focus on setting a target for neutrality. We know that reaching it will be a challenge, but we believe we have created a process and a team that can get us there.

CHAPTER 1: CLIMATE CHANGE AND THE NEED FOR ACTION

1.1 The Reality of Climate Change

The debate is over about the legitimacy of climate change as one of society's biggest challenges. Global climate change will affect natural systems, and the services we derive from them, in new and profound ways. The question now concerns how soon and at what intensity the impacts of climate change will be felt.

The scientific consensus, reflected by recent reports of the Intergovernmental Panel on Climate Change (IPCC) and confirmed by the U.S. National Academy of Sciences, is that the Earth's climate is warming and that human activities are largely responsible (IPCC, 2007; Joint Science Academies Statement, 2005). Specifically, the IPCC notes in its most recent comprehensive report that:

- The present atmospheric CO_2 concentration of 379 parts per million (ppm) is about 35% higher than pre-industrial levels (280 ppm) and greatly exceeds the natural range over the last 650,000 years[2] (IPCC, 2007)
- This increase in atmospheric CO_2 concentration since pre-industrial times is primarily due to human fossil fuel use and land use change (IPCC, 2007)
- Global average surface temperature has increased by 0.74 ºC over the last 100 years, and the rate of temperature increase in the Arctic is almost twice the global average (IPCC, 2007)
- All but one of the last 12 years has fallen among the 12 warmest years in recorded history, in terms of measured global surface temperature (IPCC, 2007)

The impacts of this increase in global surface temperature can be observed in decreases in snow cover, shrinking of sea ice, sea level rise of 0.17 meters over the 20th Century, changes in precipitation patterns, and increasing frequency and intensity of extreme weather events (IPCC, 2007). The impacts of climate change are likely to be more obvious in the future. The IPCC's climate scenarios project a global average surface temperature increase of 1.1 to 6.4ºC from1980 to 2099, with a resulting sea level rise of 0.18 to 0.59 meters (IPCC, 2007). This unprecedented warming is also projected to further reduce snow cover and sea ice, and to increase extreme weather events, such as tropical storms and droughts (IPCC, 2007).

Such unprecedented climate change has wide ramifications for human and natural systems world-wide, likely including increased flooding, reduced farm output in dry regions, fresh water shortage, loss of coastland ecosystems, animal and plant extinctions, and droughts. Additionally, as GHGs have atmospheric lives ranging from decades to centuries, GHG emissions will affect atmospheric composition and climate for many generations (IPCC, 2007).

[2] A new ice core taken from the EPICA Dome C site in Antarctica extends the CO_2 concentration record back to 650,000 before the present (BP). The new data show CO_2 concentrations between 430,000 and 650,000 BP ranging from 260-180 parts per million, suggesting that the current CO_2 concentration is the highest concentration in the last 650,000 years (Siegenthaler, 2005).

Although climate change is a global issue, its impacts are decidedly local. Due to regional variations in projected climate change and vulnerability, it is difficult to predict all the impacts on California, but suffice it to say that sea level rise could damage agricultural stocks, increase the risk of extreme weather events, and speed coastal erosion. Shrinking snow pack in the mountains could threaten water supply. Climate change also has potentially significant and negative implications for the health of Californians, associated as it is with increased air pollution and extreme heat waves (California EPA, 2006a; Union of Concerned Scientists & Ecological Society of America, 1999).

1.2 Climate Change Policy

Scientists estimate that global carbon emissions need to decline from the global average from about 3 KgC/person/day to to 1-2 kgC/person/day just to stabilize the atmospheric CO_2 level at 450-550 ppm by year 2100 (Nazaroff, 2006). This translates to a 80-90% reduction in California's per capita carbon emissions, a rationale used to determine the emissions reduction target proposed by California Governor Arnold Schwarzenegger (see section below on California Leadership). Such a significant reduction in the US and worldwide will require strong carbon regulations and effective implementation worldwide – a challenge that marks emissions reduction as one of the most critical sociopolitical challenge of this century.

International Efforts

International efforts to address climate change began in 1992 with the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC established the aim to stabilize atmospheric GHG concentrations "…at a level that would prevent dangerous anthropogenic interference with the climate system" and affirmed several important principles of environmental law, including common but differentiated responsibility, sustainable development, and the precautionary principle (UNFCCC, 1992). The Kyoto Protocol quantified this objective by establishing specific targets and timetables for GHG reduction. Adopted in 1997, the Kyoto Protocol set binding targets for developed countries to reduce GHG emissions (7% below 1990 levels for the U.S., 8% for Europe) by the 2008-12 commitment period and, consistent with the principle of common but differentiated responsibility, left the issue of developing country commitments to the post-2012 commitment period (UNFCCC, 1997). In order to meet its Kyoto targets, the European Union (EU) established the European Union Greenhouse Gas Emission Trading Scheme (EU ETS). It is the largest multi-country, multi-sector greenhouse gas emission trading scheme in the world (European Commission, 2007).

U.S. Federal Government Efforts

The United States has no national GHG emissions reduction regulation. The U.S. is party to the UNFCCC, but not to its implementing treaty, the Kyoto Protocol. Following the Senate's issuance of the Byrd-Hagel Resolution, expressing concern over the potential negative economic impacts of emissions restrictions, and its refusal to participate in a treaty that did not also cover developing countries, the Clinton administration did not send the Kyoto Protocol to the Senate for ratification. The Bush II administration renounced the Kyoto Protocol, and has been a vocal opponent of any mandatory GHG emissions reductions commitment despite efforts by international leaders to urge the U.S. to adopt a more responsible GHG policy. The Bush II administration has instead established GHG emissions intensity targets (which are less aggressive than business-as-usual emissions scenarios), voluntary programs (e.g., EPA's Climate Leaders and Energy Star), and international partnerships without mandatory enforcement mechanisms (i.e., Asia-Pacific Partnership on Clean Development and Climate).

Nevertheless, federal GHG regulation—probably via a cap-and-trade system—is on the horizon and is progressing on three fronts. First, with increasing media attention to climate change and broader demand for a federal response, the current administration's policies are becoming increasingly unpopular. An April 2007 poll by the New York Times/CBS revealed that 80% of all Americans believe that immediate action is required to curb the warming of the atmosphere and deal with its effects on the global climate. Political consensus, scientific consensus, and public opinion all support the notion that observed increases in global temperature are a result of human activities. Second, the Supreme Court recently ruled that carbon dioxide is a pollutant under the federal Clean Air Act, and it said EPA "abdicated its responsibility" under the Clean Air Act in deciding not to regulate carbon dioxide. Although EPA reopened California's petition to regulate GHGs from auto emissions the following day, it remains to be seen whether EPA will drag its feet while President Bush remains in office. Third, numerous bills addressing climate change have been introduced in both the House and the Senate over the past year, at least nine of which call for cap-and-trade of carbon dioxide emissions.

Until some version of GHG regulation becomes federal law, however, GHG regulation in the United States will be pioneered by states like California.

California Leadership

California is proving to be a leader in climate change mitigation, with a number of policies in effect or in the development stages that directly or indirectly address global warming. In 2002, the California legislature enacted the California Assembly Bill (A.B) 1493-Pavley, which directs the Air Resources Board to adopt standards that will achieve "the maximum feasible and cost-effective reduction of greenhouse gas emissions from motor vehicles," taking into account environmental, social, technological, and economic factors. California also currently has a Renewable Portfolio Standard that requires its regulated utilities (i.e., PG&E, SCE) to source 20% of retail electricity from renewable energy sources by 2010. In 2005, California Governor Arnold Schwarzenegger signed Executive Order S-3-05, committing California to specific emissions reduction targets and creating a Climate Action Team to help implement the directives. Under this order, three specific targets have been established: 2000 levels by 2010, 1990 levels by 2020, and 80% below 1990 levels by 2050.

Governor Arnold Schwarzenegger made history again in 2006 by signing the Assembly Bill 32 (AB-32) that codified the 2nd state target--1990 levels by 2020 (see Appendix A). Due to California's large size (it is the 12th largest emitter of GHGs in the world) and reputation for innovation in addressing environmental issues, actions taken by California can motivate changes in larger sectors (California EPA, 2006b).

University of California

On March 22, 2007, UC President Robert Dynes signed the systemwide *Policy on Sustainability Practices* that emphasizes meeting the goals outlined in AB-32. In addition, this policy urged each UC campus to "pursue the goal of reducing GHG emissions to 2000 levels by 2014 and provide an action plan for becoming climate neutral as specified in the Implementation Procedures" (see Appendix B for full language). Given the opportunity for GHG emissions reduction and leadership, efforts in research and implementation from the University of California are socially significant. It is important on many levels for UC to demonstrate strategic and financial commitment to emissions reduction and to educate our students by example about being conscious of our carbon footprints.

1.3 UC Berkeley Action

Given the lack of federal leadership on climate change in the United States and the urgency of the problem, bottom-up efforts to address climate change have emerged across the nation in private and public sectors. Universities have found that they can provide both practical and moral leadership for society's efforts to address climate change by reducing their own emissions (see Appendix Y for action other universities have taken). In a similar spirit, a grassroots initiative was kicked off in early 2005 at UC Berkeley when students circulated a petition calling on the campus to take responsibility for its GHG emissions (see Appendix F). After it garnered wide support, Vice Provost Catherine Koshland then convened the CalCAP Steering Committee in early 2006, bringing together a broad constituency from across the campus to provide recommendations to the Chancellor (see appendix G). The Steering Committee consists of 25 students, staff, faculty, and administrators (see Appendix H). In April, 2006, the Chancellor announced that the campus would strive to achieve Governor Schwarzenegger's state targets at a minimum, and he called for a feasibility study to identify mitigation opportunities and to determine how best to meet aggressive targets. The campus hired a Project Manager in October, 2006 to conduct the feasibility study.

1.4 Feasibility Study Approach

The feasibility study was conducted according to a number of principles. Though they are listed below in a sequential fashion, in many cases the activities occurred in parallel:

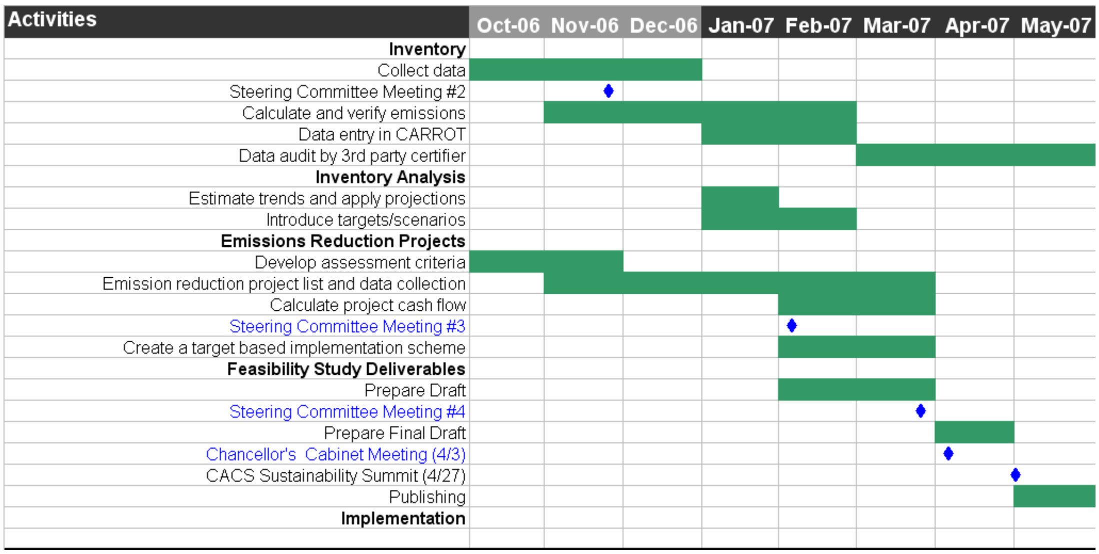
- Engaged with campus decision makers and stakeholders
- Inventoried GHG emissions
- Evaluated projects to meet targets
- Analyzed GHG emission targets
- Evaluated financial feasibility

This study drew heavily from the experiences and lessons learned at UC Santa Barbara regarding engaging with the campus. (Please refer to the Special Presentation attached at the end of this report --a "How To" guide that outlines many of the steps in detail.)

This report is focused on inventory and analysis for emissions target determination. Chapter 2 explains the emissions inventory planning and methodology for data collection. Chapter 3 explains how the emissions reduction projects were evaluated. Chapter 4 outlines how an emissions target was determined for UC Berkeley. Finally, Chapter 5 outlines the key recommendations for the campus.

While no project is ever as smooth as it appears on a flow chart, Figure 1 is a fairly accurate depiction of the project timeline. Many of the feasibility study components were managed in parallel.

Figure 1: CalCAP Project Plan



Milestones: ♦

Nov 27, 2006:	Steering Committee meeting #2, project approach
February 21, 2007:	Steering Committee meeting #3, target analysis
March 15, 2007:	Steering Committee meeting #4, recommendations
April 3, 2007:	Recommendations to Chancellor (cabinet meeting)
April 27, 2007:	Announcement at Sustainability Summit

CHAPTER 2: GHG EMISSIONS INVENTORY

The CalCAP study began by formulating the university's emissions inventory to identify, quantify, and categorize major sources of GHG emissions. Performing a GHG inventory is integral to a legitimate GHG reduction strategy and is a sign of long-term commitment to address climate change.

2.1 Inventory Planning

To start the inventory process, UC Berkeley became a member of the California Climate Action Registry (The Registry)[3] in October, 2006 and voluntarily committed to performing an inventory of its annual GHG emissions, starting in 2005 (see Appendix D). This inventory is audited annually by a third-party verifier and made available to the public. The Registry inventory is primarily designed to allow companies and institutions "to establish GHG emissions baselines against which any future GHG emissions reductions requirements may be applied" (California Climate Action Registry, 2006). The CCAR inventory focuses only on Scope I & II emissions (see Figure 2.1), as defined by the World Resources Institute (2004). It measures only carbon dioxide for the first three reporting years, and demands increasingly rigorous data each year.

Figure 2.1: Emissions Scope

Three scopes (Scope I, Scope II, and Scope III) are defined for GHG accounting and reporting (WRI, 2004). Scopes I and II are defined by WRI and WBCSD's Greenhouse Gas Protocol to ensure that two or more organizations will not account for emissions in the same scope (Ahmed et al., 2006). The Greenhouse Gas Protocol requires organizations to separately account for, and report on Scopes I and II, at a minimum.

Scope I: Direct GHG emissions	Direct GHG emissions from sources that are owned or controlled by the organization. For example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.
Scope II: Electricity indirect GHG emissions	This encompasses GHG emissions from the generation of purchased electricity consumed by the organization. Scope II emissions physically occur at the facility where electricity is generated, not at the end user site.
Scope III: Other indirect GHG emissions	This is an optional reporting category under the Greenhouse Gas Protocol that allows for the inclusion of all other indirect emissions. Scope III emissions are a consequence of the activities of the organization, but from sources not owned or controlled by the organization. Some examples include extraction and production of purchased materials, and use of sold products and services.

[3] The California Climate Action Registry was established by the California legislature as a voluntary registry for GHG emissions.

2.2 Emissions Sources

For the purposes of our inventory, the *geographic boundary* for the inventory has been defined to include all central campus buildings, all student housing on and off campus, and the Richmond Field Station. The *operational boundaries*--the GHG emitting activities for which UC Berkeley will take responsibility--include all activities represented in the Registry inventory. The Registry only requires emission from purchased electricity, steam generation, natural gas use, fugitive refrigerants and campus fleet. The CalCAP study included additional sources such as automobile commute by students, staff and faculty, air travel emissions, solid waste disposal, and embodied energy consumption in water use for UC Berkeley's emissions inventory. Figure 2.2 below outlines all the emissions sources accounted for in CalCAP study, matched with the emissions scope (Figure 2.1).

Figure 2.2: Emissions Sources and Scope

Registry Required or optional?	Emissions Source	Scope
Required	Purchased Electricity & natural gas	Scope II
Required	Imported Steam, District Heating, Cooling, Co-gen (also boilers and backup diesel engine)	Scope II
Required	Direct Fugitive - fugitive emissions of HCFCs from cooling units	Scope I
Required	University Vehicle Fleet (Mobile Combustion)	Scope I
Optional	Staff, faculty, student commuting--auto commuting in individually owned vehicles	Scope III
Optional	Air Travel	Scope III
Optional	Municipal Solid Waste: landfill emissions caused by university-generated waste	Scope III
Optional	Water Consumption	Scope II

2.3 Emissions Data and Calculation Methodology

The CalCAP study used the California Climate Action Registry's Online Tool (CARROT), as well as the Greenhouse Gas Inventory Calculator (Volume 5.0), developed by Clean Air – Cool Planet[4] (CA-CP) specifically for universities, to create a GHG inventory for UC Berkeley. Using these tools, activity data (e.g., therms of natural gas, kilowatt hours of electricity, number of commuters, miles of air travel) are multiplied by an emissions factor (e.g., kg CO_2/kWh, kg CH_4/kWh) to yield emissions for each activity by specific type of greenhouse gas. However, each GHG has a different heat-trapping potential and a different atmospheric lifetime, which results in a different global warming potential (GWP) for each GHG (see Figure 2.3 below).

[4] A non-profit based in Portsmouth, NH dedicated to finding and promoting solutions to global warming. http://www.cleanair-coolplanet.org/

Figure 2.3.1: Global Warming Potential 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)	9-15	21
Nitrous Oxide (N_2O)	120	310
HFC – 134A	15	1,300
HFC – 404A[1]	>48	3,260
Sulfur Hexafluoride (SF_6)	3,200	23,900

(Source: CA-CP, 2005)

CARROT and the CA-CP Calculator convert all types of GHG emissions to a common unit of measurement, *metric tons of carbon dioxide equivalent ($MTCO_2e$)*, that can be used to compare all emission sources. What follows is a brief description of the major sources of GHG emissions from UC Berkeley operations.

The CalCAP study accepted the California Climate Action Registry Protocol as a standard to be applied to all required and optional reporting emissions sources. However, whenever applicable, the study utilized UC Berkeley-specific calculations for energy mix (see Appendix E) as well as detailed calculations on transmission losses to get a more accurate picture of the carbon emissions related to energy use on campus. Figure 2.3.2 summarizes the emissions data sources and methodology used for calculating emissions for required sources.

Figure 2.3.2: Required Reporting Methodology

Emissions Source	Campus Data Source	CalCAP Methodology
Purchased Electricity & Natural Gas	PG&E account representative for UC Berkeley	**California Climate Action Registry Protocol**: Electricity (kWh) and gas (therm) values are from PG&E account data (see Appendix I).
Steam (co-generation and auxiliary boilers)	Paul Black, Utility Engineering David McEligot, Delta Power (cogeneration plant)	**California Climate Action Registry Protocol and more specific emissions factor analysis:** About 95% of steam (by weight) consumed by UC Berkeley is produced by the Delta Cogeneration Plant, with the remaining 5% from the Plant's auxiliary boilers. UC Berkeley's fractional share of the total cogeneration plant's greenhouse gas emission was computed from the fractional steam energy consumed compared to the total energy output (both steam and electrical) of the plant, as described in the California Climate Action Registry General Reporting Protocol. The total emissions of the Delta Cogeneration Plant were computed using the measured

		natural gas consumption and an estimated emission factor for natural gas burned. Emissions from the auxiliary boilers were similarly computed using the measured natural gas consumption and the same emission factor (see Appendix J).
Fugitive (refrigerants)	Tim Pine, EH&S	**Specific Emissions Factor Analysis:** The categories most relevant for our emissions inventory are the emissions of HFCs from air conditioning systems. The CalCAP study determined whether HFC emissions are significant, performed a mass balance equation, and convert each HFC emission to CO2e (see Appendix L).
Campus Vehicle Fleet	Eric Robinson, Fleet Services	**California Climate Action Registry Protocol and more specific emissions factor analysis:** The CalCAP study used the actual odometer reading data for approximately 600 vehicles owned by the University to extract total mileage. Then we used EPA's Miles Per Gallon values taken from <www.fueleconomy.gov> to estimate fuel consumption in gallons. Then we applied emissions factors for diesel and gasoline fleet to calculate CO2 emissions (see Appendix K).

Figure 2.3.3 summarizes the emissions data sources and methodology used for calculating emissions for optional sources.

Figure 2.3.3: Optional Reporting Methodology

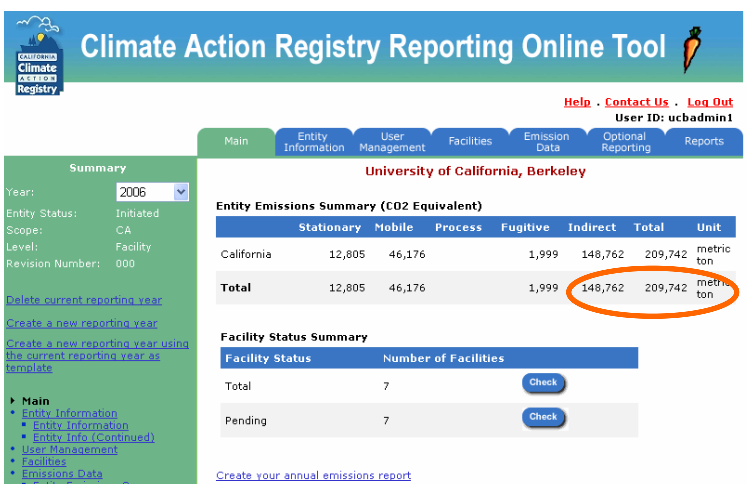
Emissions Source	Campus Data Source	CalCAP Methodology
Municipal Solid Waste Disposal (Landfill)	Lisa Bauer, Campus Recycling and Refuse Services	**California Climate Action Registry Optional Reporting Protocol and more specific emissions factor analysis:** We applied an emissions factor from the EPA for landfilled waste with methane recovery and electric generation (verified by Geoff Harrison of West Contra Costa Sanitary Landfill) (see Appendix P).
Staff, faculty, and Student Commute	Kira Stoll, Parking and Transportation	**California Climate Action Registry Optional Reporting Protocol and more specific emissions factor analysis:** We applied an emissions factor for auto commuting from the EPA. Emissions associated with public transportation are not included in the current analysis due to limitations in the way that commuting information is reported. The initial calculations were based on transportation surveys with data on travel mode split and trip distance from 1990, 1992, 1996, 1997, 1998, 2000, 2001, 2004, and 2005. Population numbers and number of work/school days were obtained from UC Berkeley IST and Budget Office (see Appendix M).

Air Travel	UC Berkeley Department of Travel and entertainment	**UC Berkeley specific, based on World Resources Institute:** The method used for estimating GHG emissions - 1) collect estimates of commonly assumed emissions rates per kilometer of air travel; 2) collect ticketing data on air travel at UCB; and 3) calculate UCB air travel emissions, based on emissions rates and total UCB air travel (see Appendix N).
Water Consumption	Paul Black, Utility Engineering	Based on the water consumption data on campus, we applied the emissions factor associated with EBMUD's water supply, conveyance, treatment, and distribution, and sewage collection, treatment, and disposal to calculate emissions (see Appendix O).

2.4 Emissions Inventory Results

We entered the data into the California Action Registry Reporting Online Tool (CARROT) in early 2007. Figure 2.4 is a snapshot of how a CARROT entry is highlighted in the tool. The 3rd party certification of the data is expected to end in June, 2007. UC Berkeley's annual emissions in 2006 approximate 209,000 metric tonnes of CO_2. For a 48,000 campus population, this corresponds to 12 kgCO_2/person/day, or about 3.3 kgC/person/day, which is close to the global average emissions of about 3 KgC/person/day (Nazaroff, 2006). Scientists estimate that we need to reduce the global average to 1-2 kgC/person/day just to stabilize the atmospheric CO_2 level at 450-550 ppm (Nazaroff, 2006).

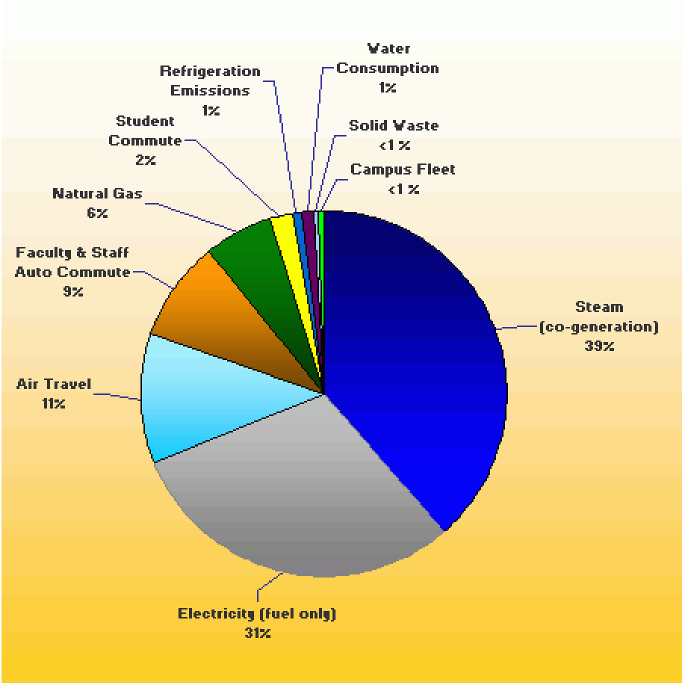
Figure 2.4.1: CARROT: UC Berkeley 2006



The two largest sources of GHG emissions, responsible for approximately 70% of the total emissions, are purchased electricity and steam (from the cogeneration plant owned by Delta Power). Air travel and faculty-staff-student automobile commute stands as the 2nd largest source of GHG emissions, at approximately 22% of the total emissions (Figure 2.4.2). This is consistent with the general expectation that most of the emissions are due to energy use and transportation, two common activities of the university population.

Figure 2.4.2: UC Berkeley Emissions Inventory 2006

Emissions Sources (required & optional reporting)	CO_2 equivalent (metric tons)	Percentage Contribution
Steam (co-generation)	82,000	38.8%
Purchased Electricity	65,000	30.6%
Air Travel	24,000	11.3%
Faculty and Staff Auto Commute	19,000	8.6%
Natural Gas	13,000	6.1%
Student Commute	4,000	1.8%
Fugitive Emissions- Refrigeration	2,000	1.0%
Water Consumption	2,000	0.9%
Solid Waste	1,000	0.4%
Campus Fleet	1,000	0.4%
Total Emissions	209,000	100.0%
Required reporting emissions sources	160,000	76.5%
Optional Reporting emissions sources	50,000	23.5%



The CalCAP study also calculated a ranking for energy intensity based on KWh/gross square footage to identify the most energy-intensive buildings on campus (see Appendix Q). The findings also indicated where potential conservation efforts could begin at a building level.

2.5 Carbon Footprint and Emissions Inventory

During the course of the inventory process, the CalCAP team recognized that the emissions inventory does not fully reflect the complete carbon footprint of the campus. The UC Berkeley emissions inventory is only a subset of our campus's total carbon footprint, as it excludes the full lifecycle carbon emissions associated with some of the campus activities. The Steering Committee decided that UC Berkeley should take a leadership role in documenting and reporting additional optional sources of emissions such as procurement (university purchases including office supplies, furniture, food) and construction. A lifecycle analysis includes greenhouse gas emissions from all stages of a product or service's lifecycle, including mining, manufacturing, transportation, retail, use, and disposal. See Appendix R for more information on lifecycle calculations.

The CalCAP study included emissions based on lifecycle analysis for emissions sources such as purchased electricity (applying faculty research on the lifecycle emissions of power plants in lower Colorado), university procurement (accounting for goods, services and food procured by the university), and construction activities (accounting for emissions from facilities, goods, and services required for construction). The study used the Economic Input-Output Life Cycle Assessment (EIOLCA) model, co-developed by Civil and Environmental Engineering Professor Arpad Horvath, for procurement and construction estimates. The model is published by Carnegie Mellon University and available online at http://www.eiolca.net/.

The result of adding the lifecycle calculation to the emissions inventory estimates is striking. In 2006, the campus carbon footprint, according to lifecycle analysis, is at least 482,000 metric tons of CO_2 equivalent (Figure 2.5.2), while the campus Emissions Inventory is only about 209,000 metric tons of CO_2 equivalent (Figure 2.5.1). The lifecycle calculation of additional emissions sources for procurement, construction and electricity (not otherwise calculated) adds an additional 273,000 metric tons of CO_2e to our total carbon footprint, which can be expressed as a 130% emissions increase (from 210,000 to 480,000 metric tons.)

Figure 2.5.1: UC Berkeley 2006 – Carbon Footprint Vs Emissions Inventory

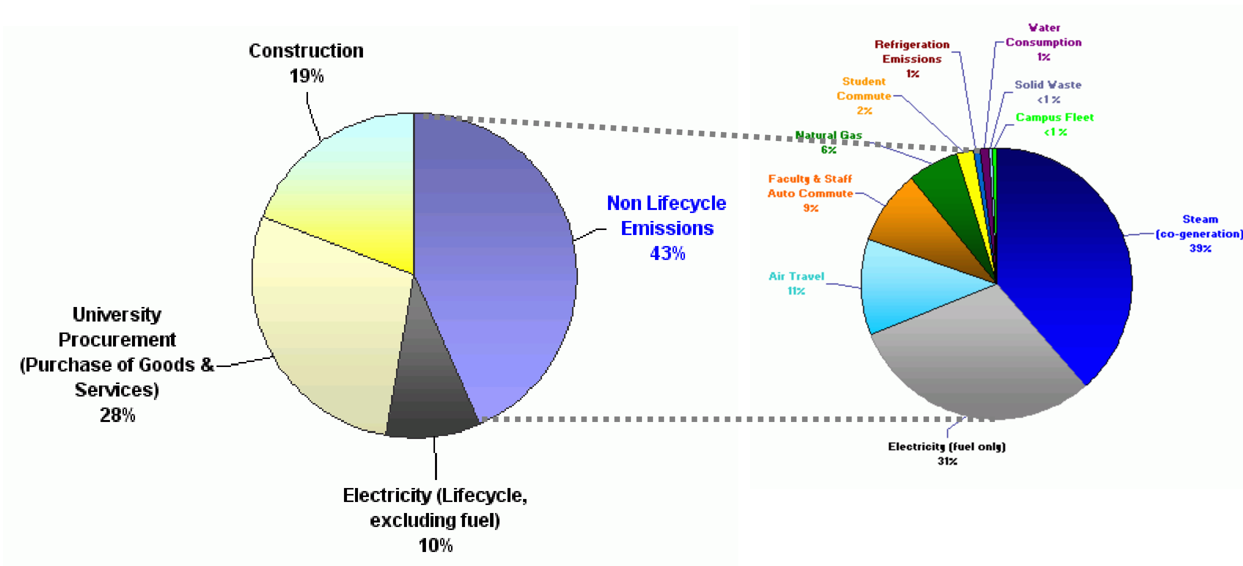


Figure 2.5.2: UC Berkeley 2006 – Lifecycle Calculations

Emissions Sources	CO_2 equivalent (metric tons)	Percentage Contribution
Procurement (all university purchase)	134,000	28%
Purchased Electricity (excluding fuel)	46,000	10%
Construction	93,000	19%
Non Lifecycle Emissions	209,000	43%
Total Emissions	482,000	100%

To be consistent with current industry practices, the study chose to base its analysis and target recommendations on the Emissions Inventory. However, in coming years, CalCAP's goal is to continue measuring the true carbon footprint and prepare actionable recommendations for the administration that will address university purchasing and consumption decisions.

2.6 Lifecycle Calculations

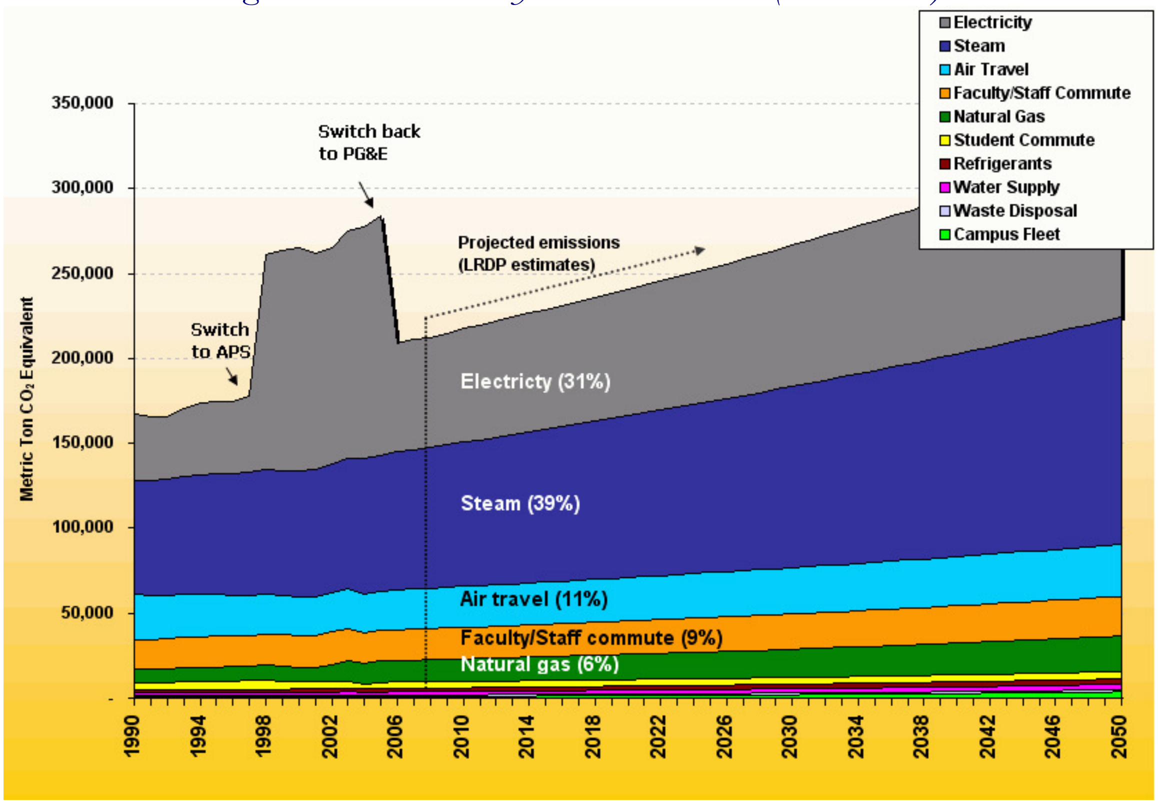
For procurement and construction, we used the Economic Input-Output Life Cycle Assessment (EIOLCA) (see http://www.eiolca.net/). The UC Berkeley Office of Procurement Services prepares an annual report of campus purchases in 130 categories of goods and services. We mapped these categories of purchases to appropriate sectors of the U.S. economy and input dollars spent into the EIOLCA calculator. Using GHG emission values provided by EIOLCA, the study produced a reasonable approximation of emissions from campus procurement. For calculating the lifecycle emissions for purchased electricity, a separate electricity emissions factor was calculated from 40 years of plant operations from different power plants in the lower Colorado basin (Pacca and Horvath, 2002). Please refer to Appendix R for more information on the lifecycle calculations and simplifying assumptions.

2.7 Emissions Trends and Growth Projections

For emissions trend calculations, we relied on the UC Berkeley Long Range Development Plan growth projections. The university population is expected to grow by 0.609% per year and the annual increase in gross square feet is estimated to be 1.14% per year (UC Berkeley LRDP, 2005). The university has actual data for electricity and natural gas from 1990 until 2006. For all other years, the study used annual growth estimates to create a trend analysis between the years 1990 and 2050. The annual gross square footage increase estimate was applied to electricity, steam, gas, waste, water supply and refrigerant, while the annual population increase estimate was applied to commute and air travel calculations. A 2.8% annual growth rate was applied to campus fleet based on a calculation performed by campus fleet manager (Robinson, 2006). Years 1990 and 2050 were chosen as milestones because they are reference years for the state targets outlined by Governor Arnold Schwarzenegger (see Appendix A).

Figure 2.7 displays UC Berkeley's GHG emissions by source over the past 16 years and projected through year 2050. The most striking finding of this analysis was the rise and fall of emissions related to purchased electricity between the years 1998 and 2006. The increase in electricity emissions between 1998 and 2006 is due to the higher coal content in the power mix for the electricity generated by Arizona Public Services (38% coal for APS vs. 1% coal for PG&E). In 2006, the main campus account (88% of the campus electricity) switched back to PG&E, which uses 1% coal, 42% natural gas, 12% nuclear, 20% hydro and 12% renewable--a fuel mix that shows significant improvements in our emissions inventory for calendar year 2006. Please also refer to Appendix E for the fuel content for electricity purchased by UC Berkeley.

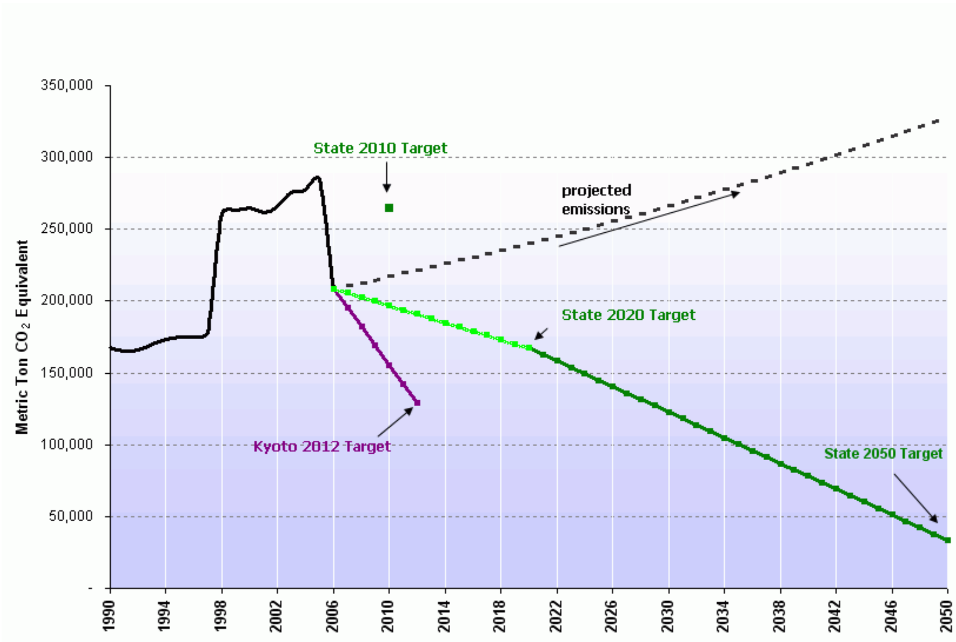
Figure 2.7: UC Berkeley Emissions Trends (1990-2050)



2.8 *Application of Emissions Reduction Targets*

There are several ways to set emissions targets. Perhaps the boldest approach would be to set a target based on the carbon emissions levels that climate change science suggests must be achieved to stop the effects of global warming. A conservative approach would lack a target or set a target that closely follows business as usual. Rather than setting an arbitrary emissions reduction target for UC Berkeley, the CalCAP study plotted the following targets proposed by policymakers and non-profit organizations to assess our options: the California Targets proposed by Governor Schwarzenegger; the Kyoto Target; and the targets outlined in the UC Policy on Sustainable Practices (Figure 2.8.1).

Figure 2.8.1: Emissions Reduction Targets



We determined the target lines by calculating the difference in emissions between base year 2006 and target year. The emissions amounts (tonnage) were determined by calculating the difference in emissions between target emissions and actual emissions in that target year. In reality, emissions reduction will unlikely be as even as Figure 2.8.2 suggests, but a linear calculation provides a general understanding of the necessary reduction amount.

Figure 2.8.2: Emissions Reduction Targets and Reduction Amounts

Emissions Targets	Description	Years to Target	Target Level (MT CO2e)	Baseline Level (MT CO2e)	Total Reduction from 2006 Level	Annual Reduction from 2006 Level to Reach Target	Total Annualized Reduction from Baseline
California phase 1:	**2000 level by 2010**	**4**	**265,312**	**217,650**	**(56,326)**	**(14,081)**	**(47,663)**
California phase 2 (or AB-32):	**1990 level by 2020**	**14**	**167,461**	**240,435**	**41,526**	**2,966**	**72,974**
California phase 3:	**80% below 1990 by 2050**	**44**	**33,492**	**328,649**	**175,494**	**3,989**	**295,156**
Kyoto:	**7% below 1990 in 2008-2012**	**4**	**155,738**	**217,650**	**53,248**	**13,312**	**61,911**

CHAPTER 3: EMISSIONS REDUCTION PROJECTS

There are a wide variety of reduction options available for organizations attempting to reduce their net GHG emissions, from procurement of renewable energy and funding of alternative transportation programs to investments in energy efficiency and the purchase of carbon offsets. In some cases, the smaller required investment is focused on institutional and educational shifts, while capital projects can run in the millions of dollars. The many mitigation options can make decisions about the best path overwhelming, especially since the options appear difficult to compare. However, the encouraging results of our study show that significant emissions reductions can be achieved in areas that result in significant cost savings over the long run.

The CalCAP study first conducted a broad survey across the campus to identify projects that would result in GHG emissions reductions, and then estimated the emissions reductions from those projects. We then further evaluated those projects using the most common metrics used in investment decisions: capital cost and payback. The study then combined the results into a comprehensive dual metric, \$/ $MTCO_2e$, which reflects the net present value of the project (including upfront costs and energy savings over time) and the quantity of GHG emissions reduced by the mechanism. This is a common metric used in cost benefit analysis for GHG reduction project effectiveness, and it was used in the Campus Climate Neutral feasibility study at UC Santa Barbara in 2006 (Ahmed et al., 2006).

3.1 Types of Emissions Reduction Projects

CalCAP broke down the range of mitigation strategies available to UC Berkeley into four main categories. Below are the descriptions of each category along with the types of projects for which the study collected and analyzed data. The campus academic and business units were consulted to ensure implementation feasibility, and conservative estimates were used throughout the assessment process. Many of the projects were already in some stage of conception or implementation, although they had never been explicitly compared for their relative GHG reduction effectiveness.

At present, CalCAP implementation is focused on projects in the first two categories; we expect these to produce monetary savings that can be recycled to fund more projects. The CalCAP team is also developing strategies for the third and fourth categories, but implementation of these strategies will come later.

It is important to note that CalCAP believes that this initial effort represents the tip of the iceberg of the campus's potential for GHG emissions reductions. To realize our greatest potential, the project identification and assessment process must be an ongoing effort that engages the entire campus community to adjust its institutional approach to business operations.

Infrastructure Projects – These infrastructure projects aim to enhance the energy efficiency of campus energy systems. Some have a significant upfront cost, but many have a short payback (less than 5 years) and generate savings that can be further invested. Projects on which we have gathered information include:

- Monitoring-based commissioning: Expand the existing program that analyzes operation of building HVAC systems and lighting to locate and correct inefficiencies.
- CoGeneration plant steam capture and repair: Conduct an energy audit of the cogeneration plant to investigate how much steam is lost in transmission, and repair those inefficiencies in the system.
- Automated lighting controls: Install a variety of lighting controls to reduce operating hours of lighting systems. Included would be motion sensing, light sensing and wireless-based control technologies.
- Fluorescent lighting retrofits: Install high frequency efficient ballast in fluorescent lighting fixtures to save energy.
- On-site photovoltaic system: Install solar panels on the available roof space of campus buildings to generate solar energy.
- Retrofitting bathrooms for better water conservation: Install new technologies or retrofit current infrastructure for higher levels of water conservation in university restrooms.
- Efficient computer settings: Deploy EPA's Energy Star Setting and active sleep/standby mode management (free software available from EPA).

Behavior Projects – These are campus initiatives that will allow and encourage individuals to conserve more energy. These projects require some capital investment and a significant dedication to coordination and planning. They also have a quick payback and an ability to establish a culture of environmentally sustainable practices. These projects include:

- Introduce fleet biking: Reduce the amount of fleet driving by using bikes for transport instead when transporting only one person.
- Expand electric vehicle fleet: The study investigated purchasing a group of electric vehicles (Chrysler GEM) through existing/new vendor contracts to replace a subset of campus fleet.
- Implement high-priority bicycle plan projects & programs: Implement campus bicycle programs and projects aimed at increasing bicycle commuting over the next 15 years, as outlined in the 2020 LRDP.
- Department level energy reduction effort: Following the Harvard Green Campus Model, this project would essentially be an interdepartmental program, working within the decentralized structure of the campus to drive campus energy conservation efforts.
- Increase utilization of videoconference room(s): Investigate how much air travel could be reduced by increasing the utilization of videoconference rooms.
- Increasing occupant awareness and electricity curtailment: The study investigated how to increase building occupant awareness by publishing building data, baseline awards, outreach campaigns, and efficient use of an energy management system.
- Introduce campus composting program: Compostable wastes are generated in kitchens, bathrooms, from grounds operations, and in the form of animal wastes from labs. The study looked into how the campus could provide expanded composting collection for diverting these wastes to composting.

Renewable Energy Credits (RECs) – In many jurisdictions, the markets for energy and the environmental attributes of energy production are separate. The campus can green its electricity supply by making an investment in green power credits, also known as Renewable Energy Credits.

One REC covers the technological and environmental attributes of one megawatt hour of electricity generated from renewable sources (see Appendix U). RECs are third party certified, increase the demand for renewable energy in the utilities market, and are recognized as a sound method for compensating for carbon emissions from essential energy consumption. UC Berkeley will invest in RECs once possible infrastructures improvements have been implemented.

Carbon Offsets – The purchase of carbon offsets reduces net carbon emissions through arrangements with a carbon-offset provider specializing in projects off-campus that retire or capture carbon from the atmosphere (see Appendix V). Examples include investments in renewable energy projects, and carbon capture and sequestration projects. Carbon offsets can be purchased from many organizations, but the lack of formal regulation of this market raises questions about whether the offset credits are only awarded for emissions reductions that would not have otherwise happened, and whether the offsets are permanent. In the coming years, UC Berkeley will investigate local and regional offset opportunities that offer tangible environmental, social and economic benefits to the local community.

3.2 Project Evaluation Criteria and Selection Process

CalCAP identified and collected data for approximately 20 projects. In order to select the projects with a noticeable GHG emissions reduction potential and a quick payback, CalCAP ranked each of the projects based on four criteria:

1. **Project and Operating Costs**: The total investment needed to complete a project, including staff time, and the annual operations and maintenance costs.

2. **Payback or Internal Rate of Return:** The length of time before the accumulated cost savings from a project equals the original investment.

$$Payback\,(years) = \frac{Capital\ \cos t}{Annual\ savings}$$

3. **$/MTCO$_2$e**: Estimated dollar amount per Metric Ton CO_2 equivalent UC Berkeley could recoup at a net present savings over the lifetime of the project

$$\$/MTCO_2e = \frac{(Total\ NPV)}{(Total\ years\ of\ project)} \cdot \frac{1}{Annual\ MTCO_2e\ avoided}$$

$$Total\ NPV = -(Capital\ \cos t) + (Annual\ savings) \cdot \frac{(1+r)^n - 1}{r(1+r)^n}$$

Where r = discount rate, and n = total years of project

4. **Annual GHG Reduction Potential**: This is calculated by multiplying the amount of energy avoided annually (electricity, natural gas or other fossil fuels) by its emissions factor of combustion.

(Terms used here are explained in further detail in the Glossary of Terms, at the back of this report.)

Knowing that public perception of many of these projects may vary regardless of their cost effectiveness (e.g., solar installation remains expensive in the short term but projects a visible image of proactive action towards renewable energy), the team also ranked the projects based on their perception value. After ranking, the (14) projects that were most consistently at the top in their individual category were chosen for the final list of projects for the feasibility study (see Appendix T for the ranking process). The 14 chosen projects were then subjected to financial feasibility analysis.

3.3 Financial Analysis & Results

We used three key metrics for the financial analysis: project cost, payback or internal rate of return, and university investment \$/MTCO$_2$e. For each project we calculated these values using the data on cost and energy saved by implementation. The assumptions on costs and energy savings were verified by staff members in Facilities Services, the Department of Environment, Heath & Safety, and industry research on energy conservation. Please see Appendix S for detailed calculations.

Our financial analysis demonstrated that investing in energy efficiency and energy conservation makes sound economic sense. With the initial investments into the infrastructure projects in the first year in the amount of \$14 million (one time capital) and additional \$1 million (annual operating) cost, the university can break even around the 4th year, and start a **net** savings of approximately \$3 million dollars annually (Figure 3.3).

Figure 3.3: Emissions Reduction Targets and Reduction Amounts

Capital Cost	Annual Operating Cost (HR)	Annual Operating Cost (Other)	Annual Savings (often in avoided costs)	Net Savings	Simple Payback (years)	Total NPV (savings*factor)-cost
\$ 13,995,731	**\$ 126,000**	**\$ 784,310**	**\$ 4,618,165**	**\$ 3,381,310**	***4.1***	**\$ (15,962,979)**

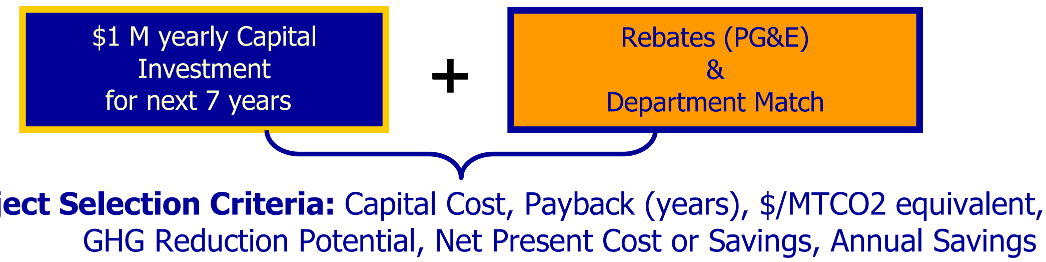
Total annual cost \$ 910,310 **Annual Savings – Annual Cost**

The importance of immediate investment is further emphasized by the finding that, if the university invests today, it can save approximately \$16 million in today's terms in eight years.[5] This is a conservative estimate; the numbers would be more favorable if we chose a cutoff point beyond 2014 because some of the energy efficiency projects have a project lifetime beyond 15 years.

[5] The study used 8 years as the total lifetime of most of the energy efficiency and infrastructure projects.

3.4 Proposed Funding Scenario for Projects

The proposed financial model is depicted below. The financial model will be evaluated and revised during the budget process in summer 2007.



The campus is preparing a grant funding request of $2 M or more for energy efficiency projects from the Higher Education Energy Efficiency Partnership, convened through the UC Office of the President. The funding is earmarked for energy efficiency projects, excluding fleet, transportation, renewable energy and procurement. Projects that will be completed, measured and verified by December 2008 are eligible.

CHAPTER 4: DETERMINATION OF CAL EMISSIONS TARGET

Emissions reduction planning involves tradeoffs between investment in energy consumption reduction and investment in other priorities for the campus. With the emissions inventory and trend analysis in one hand, and the emissions reduction potential of the projects in another, the CalCAP team decided to construct a series of scenarios in order to pick a reduction target for UC Berkeley that would significantly reduce emissions and is also financially feasible.

4.1 Scenario Evaluation

This exercise aimed to determine whether a target more aggressive than AB-32 was feasible. The year 2014 was chosen to match the target the UC Office of the President was considering at the time (Dynes, 2007). Also, while acknowledging the importance of a long-term goal of climate neutrality, we chose to focus on shorter-term targets so that we could focus our efforts on reducing GHG emissions using projects that we can identify today. We considered nine scenarios:

- Do Nothing – Business As Usual
- AB 32 with Projects and Offsets
- AB 32 Using Just Offsets (Least Capital Cost)
- Berkeley Target with Projects and RECs
- Projects Only (without RECs and Offsets)
- Some Projects (balancing annual savings)
- Expand Project List
- Some Projects and all RECs
- Neutrality in 2014

A subset of these scenarios is depicted in Figure 4.1 below (and in Appendix X in greater detail), each with calculations for two important evaluation criteria: total cost in dollars, and total emissions reduction potential in metric tonnes of CO_2e. The study adjusted the percentage of projects in each project category (infrastructure, behavior, renewable energy credits, and offsets) to see how the calculations varied in terms of cost and emissions reduction potential. The study findings suggested that a UC Berkeley-specific target in the year 2014 looked promising in terms of emissions reduction potential and investment requirements; it would achieve 1990 levels by that target year.

Figure 4.1: Emissions Reduction Scenarios (Subset)

	Percent of Identified Investment	Capital Cost	Annual Costs (Savings)	Emissions Reduction	Berkeley Target In 2014			AB 32 in 2020		
					% below 2000	Emissions Level	% below 1990	% below 2000	Emissions Level	% below 1990
Do Nothing										
Capital & Behavioral Projects	0%	$ -	$ -	-						
RECs	0%	$ -	$ -	-						
Offsets	0%	$ -	$ -	-						
Total		**$ -**	**$ -**	**-**	15%	226,451	(35%)	9%	240,316	(44%)
AB 32 with Projects and Offsets										
Capital & Behavioral Projects	100%	$ 13,995,731	$ (3,381,310)	2,677						
RECs	0%	$ -	$ -	-						
Offsets	40%	$ -	$ 865,240	64,348						
Total		**$ 13,995,731**	**$ (2,516,070)**	**67,025**	40%	159,446	5%	35%	173,311	(4%)
AB 32 Using Just Offsets (Least Capital Cost)										
Capital & Behavioral Projects	0%	$ -	$ -	-						
RECs	0%	$ -	$ -	-						
Offsets	48%	$ -	$ 1,038,288	77,218						
Total		**$ -**	**$ 1,038,288**	**77,218**	44%	149,256	11%	38%	163,121	3%
Berkeley Target with Projects and RECs										
Capital & Behavioral Projects	100%	$ 13,995,731	$ (3,381,310)	11,648						
RECs	75%	$ -	$ 3,927,181	47,228						
Offsets	0%	$ -	$ -	-						
Total		**$ 13,995,731**	**$ 545,871**	**58,876**	37%	167,593	(0%)	32%	181,458	(8%)

4.2 Scenario Evaluation – Financial Picture

Based on detailed calculations on cost savings and net present value, we found that investing into energy efficiency was profitable over time. It was also evident that for the profitability to manifest over time, the upfront capital investment into infrastructure projects had to be substantial. The analysis showed that the investment amount was inversely proportional to the payback year and directly proportional to the subsequent savings.

Figure 4.2: Emissions Reduction Scenarios (Subset)

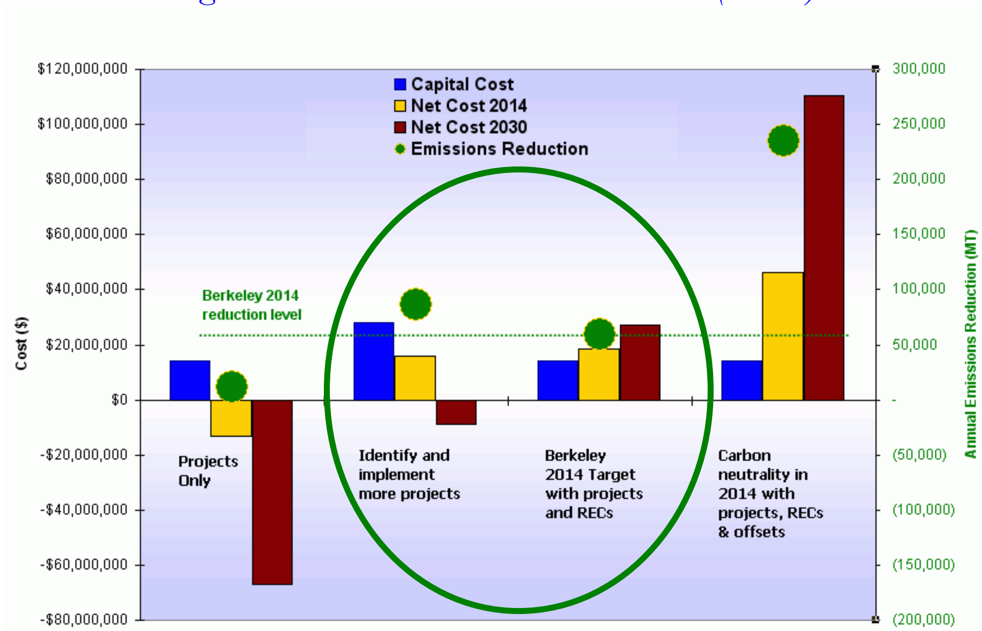


Figure 4.2 above plots both the cost and the reduction metric on the two axes. The cost bars were drawn to show the relative proportion of each type of investment and the resulting savings. The CalCAP Steering Committee narrowed the choices down to the two scenarios that provided the best balance of emissions reduction, capital cost and potential for cost recovery. Instead of choosing one of the two, it was determined that the university will start with $14 million in investment, but move towards the higher investment bracket (closer to $28 million) in order to take advantage of the significant savings over time.

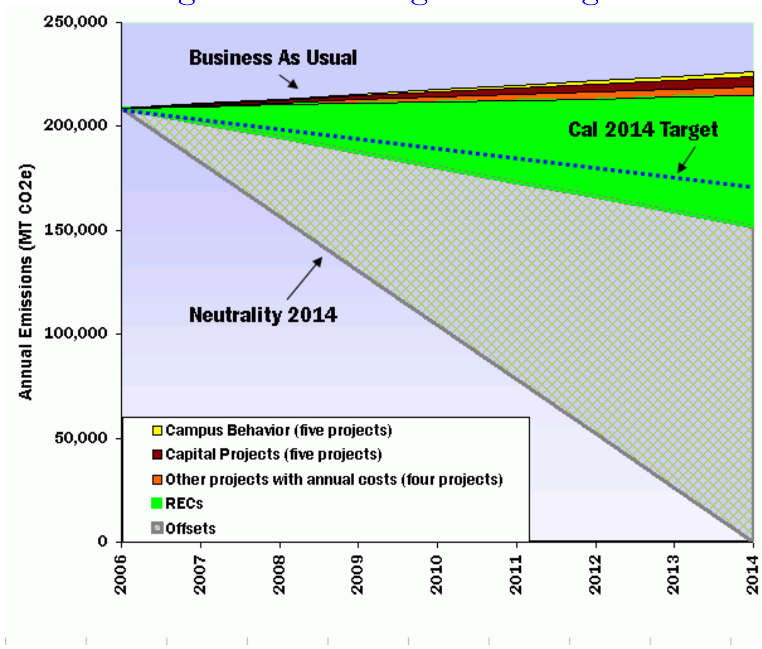
4.3 Reaching the Cal Target – 1990 levels by 2014

Once we chose a reduction scenario with meaningful emissions reduction potential and financial feasibility, an additional analysis was performed to evaluate how the projects identified by the CalCAP Study could follow this scenario (Chapter 3).

One way of looking at the feasibility of meeting long-term targets is to evaluate the total level of emissions reductions that can be achieved through specific mitigation actions. These cumulative reductions can be represented on a chart showing the emissions inventory. Each project is represented by a "stabilization wedge" with an area equal to the total amount of emissions reductions attributable to that action (Pacala & Socolow, 2004). The stabilization wedges are placed on the inventory chart in such a way to illustrate the relative ability of each of these projects to stabilize and reduce greenhouse gas emissions over time.

Figure 4.3.1 depicts how the identified mitigation projects can meet the target of 1990 levels by 2014. The key observation was that, after implementing the current set of identified projects, the university can adjust the number of scalable projects (i.e., offsets or renewable energy credits) to meet targets.

Figure 4.3.1: Meeting the Cal Target

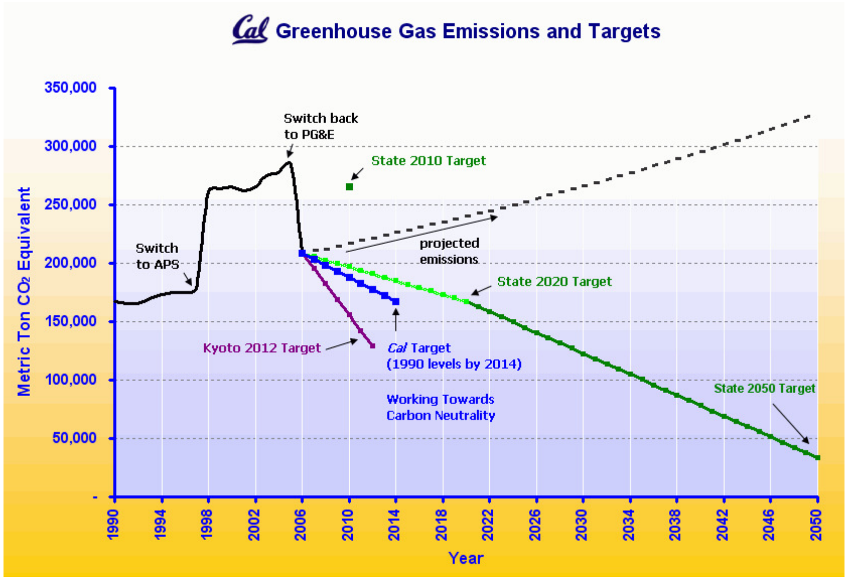


(note: Y axis intersects at 100,000 metric tons CO2e)

The identified energy reduction projects were not nearly as effective in reducing emissions as we had expected. One explanation for this limited reduction potential is the conservative estimates used for energy reduction. The CalCAP study not only considered projects on a smaller scale, but also attributed conservative energy savings numbers on a par with varying measures of success for these new initiatives, which do not have a long history of implementation success. The other explanation is that the study was by no means comprehensive. In a six-month period, with limited staff and resources, it was not possible to perform an in-depth analysis of the energy savings potential of the projects. This emphasizes the need for ongoing research and implementation in order to realize an economy of scale in both project identification and implementation efficiency.

This analysis showed that the target of 1990 levels by 2014 for UC Berkeley was both visionary and practical. Based on the emissions reduction potential of the identified projects, and the costs savings potential of these projects, this target was deemed feasible for UC Berkeley. This target is equivalent to meeting California Assembly Bill 32 six years early. It is also equivalent to meeting the UC Office of President's reduction target with a more stringent baseline--1990 level instead of 2000 level emissions (Figure 4.3.2).

Figure 4.3.2: Emissions Reduction Target for UC Berkeley – 1990 levels by 2014



CalCAP's recommended target was formally presented to the Chancellor and his cabinet in early April, 2007. On April 27, 2007, at the 4th Annual Chancellor's Advisory Committee on Sustainability Summit, UC Berkeley Chancellor Robert Birgeneau officially committed the campus to reducing its greenhouse gas emissions to 1990 levels by year 2014. He also committed the campus to working towards the long-term goal of climate neutrality.

CHAPTER 5: RECOMMENDATIONS & CONCLUSIONS

The CalCAP study was focused on determining an emissions reduction target for the campus. Much of its research and campus interaction was geared to fulfill that goal, but in the process of the study, some critical implementation steps were identified. In this chapter we outline them as final CalCAP recommendations. These recommendations are already being evaluated for implementation planning in anticipation of the formation of the UC Berkeley Office of Sustainability in the fall of 2007.

1. Make a commitment to meet the UC Berkeley target

Through a combination of infrastructure improvements for energy efficiency and Renewable Energy Credits, UC Berkeley can reduce its emissions to 1990 levels by 2014. With $14 M invested over the next 8 years, the university will realize annual savings of $3.4 M through reduced utility expenditures. This is a simple payback of about four years.

2. Make a commitment to meet the long term goal of Climate Neutrality.

The university should make a long-term commitment to *climate neutrality*, defined as net zero emissions and impact on the Earth's climate achieved by minimizing GHG emissions as much as possible, and using carbon offsets or other measures to mitigate the remaining GHG emissions.[6] This aggressive target will allow for the motivation and planning needed to make the significant emissions reduction needed in the long term.

The financial feasibility of this goal is not calculable, given that the technology and implementation planning will all change in scope. We would need to identify additional energy efficiency and conservation projects by then.

3. Continue to identify additional cost-effective GHG mitigation opportunities, such as energy conservation, and leverage the energy and creativity of UC Berkeley students, faculty and staff.

The projects evaluated in our research are by no means exhaustive. There are many other opportunities for energy conservation on campus. The university should continue developing energy efficiency and energy conservation projects, since these types of projects tend to be very cost-effective. We did not get a chance to explore some projects with tremendous energy savings potential:

- Dorm-level competition (student driven)
- Best energy conservation and implementation idea/competition (all campus)
- Lifecycle analysis for the complete GHG footprint
- Green procurement study

---

[6] UCOP Policy Guidelines for Green Building Design, Clean Energy Standards and Sustainable Transportation Services, Draft policy October 6, 2006

- Automated and campuswide GHG information management system--a visible dashboard in UC Berkeley website/dashboard.

4. Include aggregate GHG emissions targets in long-term campus planning documents, such as a Campus Sustainability Plan or the Long-Range Development Plan.

UC Berkeley is committed to inventorying its GHG emissions annually through the California Climate Action Registry. Once adopted, aggregate GHG emission targets should be included in long-term campus planning documents to ensure the commitment of the university to climate change mitigation. Additionally, aggregate GHG emissions can also be used as metrics for broader environmental performance that would be relevant to university stakeholders in judging the desirability of campus growth.

CalCAP Recommendations on Funding

5. Secure funds for energy efficiency projects.

The campus should complete the **grant funding request** of up to $3 M or more for energy efficiency projects from the Higher Education Energy Efficiency Partnership, convened through the UC Office of the President. The funding is earmarked for energy efficiency projects. Projects that will be finished, measured and verified by December, 2008 can qualify. In addition, the following are some alternative funding strategies that rely on capital external to UC Berkeley:

UC Berkeley could be eligible for funding from the California Energy Commission's Energy Efficiency Financing Program. It funds many types of projects (e.g., lighting, building insulation, heating and air conditioning modifications, automated energy management systems/controls, energy generation including renewable energy projects and cogeneration) up to $3 million per application at 3.95% interest (Energy Efficiency Financing, 2007). Many of CalCAP's infrastructure projects fall into this category.

CalCAP Recommendations on Implementation

6. Establish a CalCAP implementation team to coordinate the message and content of GHG emissions reduction.

UC Berkeley's Chancellor's Advisory Committee on Sustainability (CACS) already comprises staff, administrators, students, and faculty who work on a diversity of sustainability issues and are active and visible on campus. In addition, EH&S has placed a FTE request for a Sustainability Specialist to implement CalCAP recommendations. With volunteers from CACS, student interns, faculty advisors, and overall direction from the CalCAP Steering Committee, the CalCAP implementation team and Sustainability Specialist would perform the implementation planning, tracking and monitoring for GHG reduction.

8. Assign Sustainability Coordinators at Department or Building Levels

In addition to an overarching Office/Director of Sustainability, awareness and coordination at the academic departmental level would be helpful in creating a culture of energy conservation among faculty and students that leads to reduced emissions. Every department needs a sustainability coordinator who is trained in principles of energy savings and can manage and communicate sustainability and GHG reduction data on a departmental level. These coordinators can disseminate information from the Director of Sustainability (*to be hired*) and help implement mandates and policies created by administration and governing student bodies; they can also assess what types of policies are most effective. These coordinators need not be new appointees; the Management Services Officers (MSOs), who are responsible for providing management support to deans, directors, department chairs and administrative officers, could be candidates for this role. The Department Safety Coordinators (DSCs) also have the coordination experience to fulfill this type of roles.

9. Create an Integrated Information Management System

The university does not have an integrated system to manage information relevant to GHG emissions generated by campus activities. Data collection from some potentially important sources (e.g., campus fleet, commute, air travel) is manual and often inefficient. This is particularly true for air travel, where there is no system that tracks air travel trips or mileage. Also, information on different GHG emissions sources is not integrated. Before we performed the inventory, we did not realize the relative size of the different sources of emissions on campus. This is typical of most institutions, given that climate change mitigation is a fairly recent interest.

Information about campus GHG emissions sources needs to be better managed, analyzed and communicated across the UC Berkeley campus. CalCAP recommends the creation of an *Energy Management System*, an integrated energy information system that manages and analyzes greenhouse gas data along with energy indicators. This could be a new technological (software) tool that the university invests in. A complete and integrated GHG management system needs to be user friendly and have a web-based computing interface that can be used by staff, students and faculty for transparency and wide accessibility to campus GHG data. This technological tool can help decision makers manage and analyze energy use, and easily compare how disparate energy projects (e.g., fleet versus electricity efficiency) can yield the greatest emissions and cost reductions. Such a system would include:

- Emissions calculator – to instantly calculate cost and GHG emissions comparisons given certain inputs (e.g., electricity use, fuel consumption)
- Implementation schedule – to generate a project implementation schedule, based on different targets and projected campus growth data
- Financial impacts – to calculate cash flow analysis of project implementation schedule.

10. Work with administrators at other UC schools and UCOP to lobby the state legislature to address capital budget funding reform.

Although this may the most difficult recommendation to implement, it may also be one of the most important since funding is probably the most important institutional barrier to emission reduction projects. UC Berkeley should work with other UC schools to push funding reform related to the capital budget on two fronts:

- Allow the capital budget to borrow from the operating budget;

- Ensure savings resulting from change in project scope stay with the campus to fund energy efficiency components that may have been removed during value-engineering.

Other CalCAP Recommendations

11. Student Education to Increase Awareness

The university's academic curriculum needs to demonstrate a more serious commitment towards addressing climate change. Initiatives taken by the Education for Sustainable Living Program can help jumpstart student-led courses at the grassroots level. Additionally, the Academic Senate, the representative body of the university faculty with some influence over academic matters, can create a core curriculum focused on climate change (About UC Governance, 2006). At the least, it should create a "flexible course module" on climate change that all faculty could integrate into relevant existing course offerings.

12. Create incentives for alternative transportation

Developing new policies to reduce single-occupancy vehicle commuters, and consequently emissions, would cause a heated debate on this campus. Yet the benefits of discouraging single drivers are significant, ranging from extensive cost savings related to parking infrastructure, to reduced traffic congestion in the local community. The following strategies can help:

- Assign a "carbon fee" to parking permits. Funds from this fee collection would go to GHG reduction projects on campus.
- Install PV arrays over parking structures with flat roofs.
- Reduce parking permit costs to drivers of alt fuel or high MPG vehicles.
- Remove Central Campus parking and replace with small electric shuttles or "yellow bike" programs to allow off-campus parking commuters to travel to the campus core.
- Create further incentives for the BEAR PASS using the "carbon fee" concept to subsidize low or no-cost sustainable transport to and from campus.

Appendices

Appendix A: AB-32 Global Warming Solutions Act

" Establishes first-in-the-world comprehensive program of regulatory and market mechanisms to achieve real, quantifiable, cost-effective reductions of greenhouse gases (GHG).
Makes the Air Resources Board (ARB) responsible for monitoring and reducing GHG emissions.
Continues the existing Climate Action Team to coordinate statewide efforts.
Authorizes the Governor to invoke a safety valve in the event of extraordinary circumstances, catastrophic events or the threat of significant economic harm, for up to 12 months at a time.
Requires ARB to:

- Establish a statewide GHG emissions cap for 2020, based on 1990 emissions by January 1, 2008.
- Adopt mandatory reporting rules for significant sources of greenhouse gases by January 1, 2008.
- Adopt a plan by January 1, 2009 indicating how emission reductions will be achieved from significant GHG sources via regulations, market mechanisms and other actions.
- Adopt regulations by January 1, 2011 to achieve the maximum technologically feasible and cost-effective reductions in GHGs, including provisions for using both market mechanisms and alternative compliance mechanisms.
- ·Convene an Environmental Justice Advisory Committee and an Economic and Technology Advancement Advisory Committee to advise ARB.
- Ensure public notice and opportunity for comment for all ARB actions.
- Prior to imposing any mandates or authorizing market mechanisms, requires ARB to evaluate several factors, including but not limited to: impacts on California's economy, the environment, and public health; equity between regulated entities; electricity reliability conformance with other environmental laws, and to ensure that the rules do not disproportionately impact low-income communities.
- Adopt a list of discrete, early action measures by July 1, 2007 that can be implemented before January 1, 2010 and adopt such measures."

Source: California Air Resource Board – Fact Sheets
http://www.arb.ca.gov/cc/factsheets/ab32factsheet.pdf

Appendix B: UC Office of the President Policy on Sustainable Practices

III. Climate Protection Practices

a. With an overall goal of reducing greenhouse gas (GHG) emissions while maintaining enrollment accessibility for every eligible student, enhancing research, promoting community service and operating campus facilities more efficiently, the University will develop a long term strategy for voluntarily meeting the State of California's goal, pursuant to the "California Global Warming Solutions Act of 2006" that is: by 2020, to reduce GHG emissions to 1990 levels. In addition, consistent with the Clean Energy Standard sections a., b. and c. of this document, the University will pursue the goal of reducing GHG emissions to 2000 levels by 2014 and provide an action plan for becoming climate neutral as specified in the Implementation Procedures below.

Implementation Procedures for Climate Protection Practices:

- *By December 2008, the University will develop an action plan for becoming climate neutral which will include: a feasibility study for meeting the 2014 and 2020 goals stated in the Policy Guidelines, a target date for achieving climate neutrality as soon as possible while maintaining the University's overall mission, and a needs assessment of the resources required to successfully achieve these goals. Climate neutrality means that the University will have a net zero impact on the Earth's climate, and will be achieved by minimizing GHG emissions as much as possible and using carbon offsets or other measures to mitigate the remaining GHG emissions.*

- *Each UC campus will pursue individual membership with the California Climate Action Registry. The Senior Vice President, Business and Finance, in coordination with campus administration, faculty, students and other stakeholders will form a Climate Change Working Group that will develop a protocol to allow for growth adjustment and normalization of data and accurate reporting procedures. The Climate Change Working Group will monitor progress toward reaching the stated goals for GHG reduction, and will evaluate suggestions for programs to reach these goals.*

(The above excerpt is taken directly from the March 22, 2007 memo from UC President Robert Dynes announcing the UC Policy on Sustainable Practices)

Appendix C: City of Berkeley Measure G

Berkeley Measure G

Should the People of the City of Berkeley have a goal of 80% reduction in greenhouse gas emissions by 2050 and advise the Mayor to work with the community to develop a plan for Council adoption in 2007, which sets a ten year emissions reduction target and identifies actions by the City and residents to achieve both the ten year target and the ultimate goal of 80% emissions reduction?

Passed with 81% of the vote in November 2006

Climate Action in the City of Berkeley

By

Timothy Burroughs
Climate Action Coordinator

Cisco DeVries
Chief of Staff to the Mayor

Global warming is now recognized as one of the most important threats to ecological sustainability and human civilization. Global surface temperatures are on course to increase by between 2.5 and 10.5ºF by the year 2100, with regions in the northern parts of North America and Asia heating by 40 percent above the mean increase. Locally, rising temperatures are compromising the snow pack that supplies our water, increasing the incidence of forest fires, and causing the San Francisco Bay to rise.

A changing climate is not only an environmental threat. It also has implications on social equity, our public health, and our local economy. As such, the solutions our community proposes and implements must be sensitive to a broader set of societal concerns. Addressing climate change locally is not only an opportunity to reduce greenhouse gas emissions, but also an opportunity to build a positive, community-based movement in Berkeley that results in increased civic pride and improved quality of life.

Measure G: A Mandate for Aggressive Action

In November 2006, Berkeley voters issued a call to action on greenhouse gas emissions. The mandate was simple, but bold – reduce our entire community's greenhouse gas emissions by 80 percent by the year 2050. The measure directs the City to develop a Climate Action Plan to reach that target, as well as interim targets, by year-end 2007.

Given the fact that 81 percent of Berkeley voters endorsed Measure G, it is clear that we are committed to taking aggressive actions locally to reduce greenhouse gas emissions. Now our community needs to figure out exactly what those actions should be.

Reaching our goal will require significant changes in our community – in our infrastructure, in our technology, and in the decisions we make as residents, business owners, city officials, etc. In addition, the strategies included in Berkeley's Climate Action Plan must not only reduce greenhouse gas emissions, but also meet the needs of low-income communities. Historically, we have seen poor people throughout the world suffer the most from both the impacts and the suggested mitigations of environmental threats and catastrophes. Our plan must make social justice a priority.

But we do not start from scratch. Berkeley is known throughout the world as a pioneering green city that is willing to lead social change through innovative and creative strategies – from free energy efficiency assistance to low-income residents to curbside recycling to green business programs to biodiesel. Further, we benefit greatly from businesses and residents who care deeply about solving the greenhouse gas crisis and creating a sustainable, socially just city.

Our community is also nourished by the resources and intellectual capital at UC Berkeley. The university's commitment and action to address its own carbon footprint in an inspiration and provides valuable lessons for the community as a whole.

Our community has been hard at work at reducing energy use and improving transportation options for years before the rest of the country accepted the dangers of the climate change crisis. We provide basic energy and water retrofits as a free service to all homeowners; we heavily subsidize lighting and energy retrofits to our businesses; the City pioneered the use of biodiesel in its fleet; and much more. Since 2000, our community has reduced its direct greenhouse gas emissions from electricity, natural gas, and transportation by nearly 9% -- a truly remarkable accomplishment.

While our work so far is impressive we have a long, long way to go. For information on how to get involved in Berkeley's climate protection effort, please visit: www.cityofberkeley.info/sustainable.

Appendix D: California Climate Action Registry

"The California Climate Action Registry (the Registry) was established by California statute as a non-profit voluntary registry for greenhouse gas (GHG) emissions. The purpose of the Registry is to help companies and organizations with operations in the state to establish GHG emissions baselines against which any future GHG emission reduction requirements may be applied.

The Registry encourages voluntary actions to increase energy efficiency and decrease GHG emissions. Using any year from 1990 forward as a base year, participants can record their GHG emissions inventory. The State of California, in turn, will offer its best efforts to ensure that participants receive appropriate consideration for early actions in the event of any future state, federal or international GHG regulatory scheme. Registry participants include businesses, non-profit organizations, municipalities, state agencies, and other entities.

The Registry has developed a General Protocol and additional industry-specific protocols which give guidance on how to inventory GHG emissions for participation in the Registry: what to measure, how to measure, the back-up data required, and certification requirements. When organizations become participants, they agree to register their GHG emissions for all operations in California, and are encouraged to report nationwide. Both gross emissions and efficiency metrics will be recorded. The Registry requires the inclusion of all direct GHG emissions, along with indirect GHG emissions from electricity use. The Registry requires the reporting of only CO_2 emissions for the first three years of participation, although participants are encouraged to report the remaining five GHGs covered in the Kyoto protocol (CH_4, N_2O, HFCs, PFCs, and SF_6). The reporting of all six gases is required after three years of Registry participation.

Specific Registry responsibilities include the following:

- Enable the voluntary recording of GHG (greenhouse gas) emissions in a consistent, certified format.
- Qualify third-party organizations that have the capability to certify reported baseline emissions.
- Maintain a record of all certified GHG emissions baselines and emissions results.
- Adopt industry-specific reporting metrics.
- Encourage voluntary actions to increase energy efficiency and reduce GHG emissions.
- Provide participants with referrals to approved providers for technical assistance and advice on programs to monitor, estimate, calculate, report, and certify GHG emissions; establish emissions reduction goals; and improve energy efficiency.
- Recognize, publicize, and promote participants.
- Recruit broad participation from all economic sectors and regions of the state.
- Biennially report to the Governor and Legislature on Registry successes and challenges.
- Provide additional services for participants such as workshops, training seminars, and "best practices" exchanges" (CCAR, 2006).

The Registry is now joining with other states to develop federal registry standards and protocols for emissions reduction and reporting.

Source: <http://www.climateregistry.org/ABOUTUS/>

Appendix E: Energy Power Mix for UC Berkeley Electricity

Pacific Gas & Electricity

POWER CONTENT LABEL		
Energy Resources	PG&E 2006 Power Mix* (Projected)	2004 CA Power Mix** (For Comparison)
Eligible Renewable	13%	4%
Biomass and waste	5%	0%
Geothermal	2%	3%
Small hydroelectric	4%	1%
Solar	0%	0%
Wind	2%	<1%
Coal	3%	29%
Large Hydroelectric	19%	20%
Natural Gas	42%	45%
Nuclear	23%	2%
Other	<1%	0%
TOTAL	**100%**	**100%**

* At least 95% of PG&E's POWER MIX is provided by the California Department of Water Resources or from PG&E-owned resources, or specifically purchased from individual suppliers.
** Percentages are estimated annually by the California Energy Commission based on the electricity sold to California consumers during the previous year.

For specific information about this electricity product, contact Pacific Gas and Electric Company. For General Information about the Power Content Label, contact the California Energy Commission at 1.800.555.7794 or www.energy.ca.gov/consumer.

Source: http://www.pge.com/customer_service/bill_inserts/2006/jan.html

Arizona Public Services

First Quarter 2006

POWER CONTENT LABEL		
ENERGY RESOURCES	**UC_CSU** (projected)	**2005 CA POWER MIX**** (for comparison)
Eligible Renewable	**20%**	**5%**
-- Biomass & waste	6%	<1%
-- Geothermal	13%	4%
-- Small hydroelectric	1%	1%
-- Solar	<1%	<1%
-- Wind	1%	<1%
Coal	**32%**	**38%**
Large Hydroelectric	**20%**	**24%**
Natural Gas	**28%**	**33%**
Nuclear	**<1%**	**0%**
Other	**<1%**	**0%**
TOTAL	**100%**	**100%**

* 16% of **UC_CSU** is specifically purchased from individual suppliers.
** Percentages are estimate annually by the California Energy Commission based on electricity sold to California consumers during the previous year.

For specific information about this electricity product, contact APS Energy Services. For general information about the Power Content Label, contact the California Energy Commission at 1-800-555-7794 or www.energy.ca.gov/consumer.

Source: T. Michael Lechner, PE, CEM, CCM, LEED AP Senior Account Manager APS Energy Services.

Appendix F: Letter to the Chancellor from Students and Faculty 2005

April 27, 2005

Chancellor Robert J. Birgeneau
Office of the Chancellor
200 California Hall, #1500
Berkeley, CA 94720-1500

RE: KYOTO PROTOCOL and CLIMATE PROTECTION PLAN

Dear Chancellor Birgeneau,

On behalf of the undersigned organizations and individuals who have expressed their concern over the growing effects of global climate change and the absence of federal leadership in addressing its causes, we are writing to urge the University of California, Berkeley, to formally endorse the Kyoto Protocol and adopt its underlying principles. As a practical matter, we urge the University to support the development of a campus Climate Protection Plan that will establish targets and specific steps to monitor and reduce the University's consumption of natural resources and emissions of greenhouse gases. In doing so, the University will demonstrate its commitment to sound environmental stewardship.

As the leader of one of the world's most prestigious institutions, you are in a unique position to establish a precedent setting greenhouse gas emissions policy for the University that can become a model for the UC system and other universities nationally and worldwide. In developing such a policy, you will be acting on one of the University's most important "Community Principles"; namely, that the University's educational mission involve "active participation and leadership in addressing the most pressing issues facing our local and global communities." The rapidly increasing accumulation of gases in the atmosphere that are responsible for global climate change is among the most serious threats to human and ecological existence facing the planet, and is a matter upon which the University can lend substantial weight to the effort to engage the public, corporations, and governments in pioneering solutions.

The University recognizes the opportunities and responsibilities that accompany the prestige it has earned, as evidenced in the in the 2020 Long Range Development Plan: "As one of the world's great research universities, UC Berkeley has a special obligation to serve as a model of how creative design can both minimize resource consumption and enhance environmental quality." We applaud this approach, and propose that the issue of climate change presents a profound opportunity to fulfill this obligation.

Several universities are responding to global climate change by instituting policies that are intended to reduce their energy consumption and greenhouse gas production. UC San Diego, for example, has joined the California Climate Action Registry and has certified and registered its greenhouse gas emissions. Likewise, the Bren School students at UC Santa Barbara have initiated a design project for the entire UCSB campus to achieve climate neutrality – a net zero impact on the Earth's climate. A growing number of northeastern universities have joined Clean Air-Cool Planet's Campuses for Climate Action Program, some of which have committed to and are currently achieving greenhouse gas reduction targets.

Cities throughout the country are also initiating efforts to reduce their greenhouse gases. The City of Berkeley formally endorsed the Kyoto Protocol and has promised to continue to develop its energy policies so that City operations will eventually be climate neutral. Santa Cruz has made a similar endorsement. Berkeley is also supporting the efforts of Seattle Mayor Mike Nichols who is urging the US Conference of Mayors to make global warming one of its top priorities. And the International Council for Local Environmental Initiative's Cities for Climate Protection program now has enrolled over 150 US cities that are engaged in activities that reduce the impacts that city operations have on the production of greenhouse gases.

Developing a Climate Protection Plan will provide the University with opportunities for education, organizational innovation, and technological leadership that will bolster our academic excellence in the interdisciplinary field of climate change. By providing the Cal community with the tools and skills necessary to raise awareness and address this global concern within and beyond the campus boundaries, a Climate Protection Plan is an invaluable educational opportunity for the next generation of climate change leaders.

The University's academic research has contributed significantly to our current understanding of the climate change crisis and the appropriate actions that humanity can and must take in response. Although the University has supported various commendable environmental initiatives, most notably the first-ever Campus Sustainability Assessment, none have dealt explicitly with reducing greenhouse gas emissions. Aggressive actions which move the campus toward climate neutrality will lessen our impact on the environment, while sending the message that workable solutions are achievable.

The undersigned individuals pledge to work with you to draft a Resolution that commits the University to endorse the Kyoto Protocol and to meet or exceed its greenhouse gas reduction targets. We are also prepared to work with the University to establish a Climate Protection Plan that would encompass all elements of the University's operations that are responsible for producing or sequestering greenhouse gases.

We believe that the issue of global climate change offers the University both an extraordinary opportunity and a difficult challenge – an opportunity to become a national leader who will help to develop and demonstrate a rational national response to this problem and a challenge to implement a Climate Protection Plan that will test the University's ability to adopt the greenhouse gas emission policies necessary to realize a difference.

We look forward to working with you and the University on this important initiative.

Sincerely,

Brooke A. Owyang
College of Natural Resources, Class of 2006
brooke@berkeley.edu

Scott Zimmermann
Boalt Hall School of Law, JD Candidate 2007
scottz@boalthall.berkeley.edu

Eli Yewdall
Energy & Resources Group, MA Candidate 2005
eyewdall@berkeley.edu

Thomas Kelly, JD
KyotoUSA
kyotousa@sbcglobal.net

Daniel M. Kammen, Ph.D.
Class of 1935 Distinguished Chair in Energy
Professor in the Energy and Resources Group, and in the Goldman School of Public Policy
kammen@berkeley.edu

Faculty and Administration Signatories

Ruzena Bajcsy
Director Emeritus, Center for Information Technology Research in the Interest of Society

David D. Caron
C. William Maxeiner Distinguished Professor of International Law, Boalt Hall

Alex Farrell
Assistant Professor in the Energy and Resources Group

Inez Fung
Director, Berkeley Atmospheric Sciences Center
Professor in Earth & Planetary Science, and in Environmental Science, Policy & Management

Michael Hanemann
Professor in Agricultural and Resource Economics, and in Public Policy

John Harte
Professor in the Energy and Resources Group, and in Environmental Science, Policy & Management

Robert Holub
Dean, Undergraduate Division, College of Letters and Science

Catherine Koshland
Vice-Provost for Academic Planning and Facilities
Wood-Calvert Professor in Engineering and Professor in the Energy and Resources Group, and in Public Health (Environmental Health Sciences)

Richard B. Norgaard
Professor in the Energy and Resources Group and of Agriculture and Resource Economics

P. David Pearson
Dean, Graduate School of Education

Neil A.F. Popovic
Lecturer in International Environmental Law

Mark Richards
Dean of Physical Sciences, College of Letters and Science
Professor of Earth and Planetary Science

Christine Rosen
Associate Professor, Haas Business and Public Policy Group and Socially Responsible Business

Stephen M. Shortell
Dean and Professor, School of Public Health
Blue Cross of California Distinguished Professor Health Policy and Management
Professor of Organization Behavior

Student Organization Signatories

ASUC President Misha Leybovich

Berkeley Campus Greens

Berkeley Energy Alliance for Renewables

Berkeley Watch

Boalt Hall Committee on Human Rights

Boalt Hall Environmental Law Society

California Student Sustainability Coalition, Berkeley Chapter

Conservation & Resource Studies Student Organization

Ecology Law Quarterly

Energy and Resources Group Climate Change Seminar

Environmental Coalition (ECo)

Green Campus Program

Goldman School of Public Policy Environmental Policy Group

Re-USE Manager David Siddiqui

Students for a Greener Berkeley

Appendix G: CalCAP Committee Letter to the Chancellor 2006

April 14, 2006

Re: Campus Climate Protection Steering Committee

Dear Chancellor Birgeneau:

I am writing to update you on the progress of the working group on Campus Climate Protection. Last November you, Vice-Chancellor Ed Denton, and I met with faculty and student representatives on this topic, and you asked us to work together to develop the process to establish a greenhouse gas mitigation program for campus.

On Friday, April 7, I convened a Steering Committee to provide input on the effort. The Committee consisted of a diverse range of campus stakeholders, including faculty experts in the field of climate change, student leaders, administrators, staff, and representatives from the City of Berkeley, a local environmental group, LBNL, and UCOP, who would be involved in implementing the campus's climate change mitigation plan. The complete list of participants is included in Attachment B.

The Committee recognized that this greenhouse gas mitigation effort provides an opportunity for UC Berkeley to demonstrate its leadership in applying first-class research activities to the problem of climate change mitigation at the community level. The government and public are increasingly calling on our University for help in addressing the problems associated with this issue, and now is the time to demonstrate our leadership in this area.

The Committee recommends that UC Berkeley make a public statement announcing the Campus Climate Protection activities, specifically: (a) formation of the Campus Climate Protection Working Group; (b) commencement of a feasibility study over the next year to identify mitigation, research, and funding opportunities; and (c) the University's goal of achieving the UCOP and State of California's greenhouse gas emissions reduction targets. Although modest, the UCOP targets represent an initial goal that should be adopted until the results of the feasibility study can be used to substantially strengthen our emissions reduction targets.

To complete the feasibility study, the Committee recommends that the University supplement department resources by approving CACS's funding request. University support will be matched by a broad commitment of resources to this effort from across campus. Faculty members have shown an interest in collaborating on campus greenhouse gas mitigation research projects. The Berkeley Institute of the Environment has committed to support a Graduate Student Researcher position for next year, and students are planning a fee referendum in spring '07 to support sustainability projects and staff on the campus.

The Steering Committee's detailed recommendations are outlined in Attachment A.

There is a great deal of enthusiasm and commitment from all corners of campus, and I support the Committee's recommendations to implement a campus-wide climate protection plan. The Sustainability Summit on April 27th provides you an opportune moment to announce the initiation of the program.

Thank you for your interest and support.

Sincerely,

Catherine P. Koshland
Vice Provost-Academic Planning & Facilities
Wood-Calvert Professor in Engineering
Professor, Environmental Health Sciences
Professor, Energy and Resources
Encs

Appendix H: CalCAP Steering Committee Membership 2006-2007

Administration	
Brostrom, Nathan	Vice Chancellor of Administration
Denton, Ed	Vice Chancellor of Facilities Services
Fraker, Harrison	Dean, College of Environmental Design; Professor, Architecture
Koshland, Cathy *	Vice-Provost, Academic Planning and Facilities; Professor, Public Health; CACS member
Nathe, Sarah *	Director, Disaster-Resistant University Initiative
Richards, Mark	Dean, Physical Science, College of Letters and Sciences; Professor, Earth and Planetary Sciences

Staff	
Ahmed, Fahmida *	CalCAP Project Manager
Bauer, Lisa *	Manager, Campus Recycling and Refuse Services; Member and former Co-Chair, CACS
Black, Paul *	Manager, Utilities and Engineering
Chess, Judy *	Project Manager, Capital Projects; Co-chair CACS
Cockrell, Cathy	UC Berkeley Public Affairs
Freiberg, Mark	Director, Office of Environment, Health & Safety
Haet, Greg *	Associate Director, Environmental Protection
Pine, Tim *	Environmental Specialist, Environmental Health & Safety
Rasanayagam, Sharima *	Academic Coordinator, Berkeley Institute of the Environment
Robinson, Eric	Vehicle Purchases, Fleet Services
Shaff, Christine	Communications Manager, Capital Projects

Organizations	
DeVries, Cisco	Chief of Staff, Berkeley Mayor's Office
Kelly, Tom	KyotoUSA
Levine, Mark	Director, Environmental Energy Technologies Division and Senior Scientist, LBNL
Munn, Maric	Associate Director, Energy and Utility Services, UCOP
St. Clair, Matt	Sustainability Specialist, UCOP; CACS member

Faculty and Researchers	
Arens, Ed	Professor, Environmental Design
Bajcsy, Ruzena	Professor, Electrical Engineering and Computer Science
Cohen, Ron	Associate Professor, Chemistry
Fung, Inez	Director, Berkeley Atmospheric Sciences Center; Professor, Dept of Earth & Planetary Science and ESPM
Horvath, Arpad	Assistant Professor, Civil Engineering; Director, Consortium on Green Design and Manufacturing; CACS member
Kammen, Dan *	Professor Energy and Resources Group and Goldman School of Public Policy; CACS member
Madanat, Samer	Professor, Civil Engineering; Director, Institute of Transportation Studies
Nazaroff, William	Chair, Energy and Resources Group; Professor, Civil Engineering
Norgaard, Richard	Professor, Energy and Resources Group and Agriculture and Resource Economics
Payne, Cymie	Associate Director, California Center for Environmental Law and Policy (Boalt); Lecturer, Boalt Hall
Riley, William	Scientist, Lawrence Berkeley National Laboratory
Rosen, Christine	Associate Professor, Haas Business School
Smith, Kirk	Professor, Environmental Health Sciences, School of Public Health

Students	
Arons, Sam *	Master's student, Energy and Resources Group; CACS Co-Chair
Barge, Rachel *	Senior; ASUC Sustainability Team Coordinator; CACS member
Coleman, Will	Haas Business School; ERG; Founder, Berkeley Energy and Resources Collaborative; Net Impact
Gennet, Sasha *	PhD candidate, ESPM; CACS member and former co-chair
Guenther, Joel *	PhD candidate, Chemistry; CACS member
Harley, Gabriel	Graduate Student, Materials Science and Engineering; Students for a Greener Berkeley
Kane, Eleanor Sara	Goldman School of Public Policy; GSPP Environmental Policy Group
Martin, Leslie	PhD candidate, ARE; GSPP Environmental Policy Group
Riley, Dana *	Junior, Environmental Sciences/Environmental Economics & Policy; CACS member; CalCAP intern
Zimmermann, Scott *	Boalt Hall School of Law; ERG; Environmental Law Society; CACS CalCAP Subcommittee Chair

* CACS CalCAP Subcommittee Members

Appendix I: Inventory Calculation – Electricity & Natural Gas Sources

Method:

California Climate Action Registry Protocol for Required Sources

Power Source:

In 2005, 100% of the campus electricity came from Arizona Public Services (APS).
In 2006, 12% of the campus electricity came from APS and 88% came from PG&E.
For both years, 100% of the natural gas came from PG&E.

Data Source:

For years 2005 and 2006 we received electronic records for all accounts from PG&E represented in kWH and therms. PG&E's service to the account holders have made the process of data gathering significantly easier. The APS records on electricity were obtained from UC Berkeley Physical Plants.

Total electricity consumption in 2005:	207,652,458 kWh
Total electricity consumption in 2006:	212,827,845 kWh

Total gas consumption in 2005:	244,009 MMBTU
Total gas consumption in 2006:	238,879 MMBTU

We requested and obtained data for the accounts relevant to the geographic boundary defined by this project for the campus inventory (See Section 2.2 on Emissions Sources.)

The data were audited against the campus billing records to ensure its accuracy and relevance. The reconciliation process required significantly longer time than obtaining the records from utility providers.

Emissions Factor: Electricity

Both APS and PG&E provided us with information on their fuel mix for the relevant years (See Appendix E). We input these numbers in Clean Air Cool Planet worksheet (Version 5). The relative percentage of the fuel type was pre calculated for year 2005 (88% PG&E and 12% APS) and then entered into the tool.

MODULE	Input							
WORKSHEET	Custom Fuel Mix							
UNIVERSITY	University of California, Berkeley							
		Enter your fuel mix in the green cells below: Totals for each year should add up to 100. (These are						
Fiscal Year	Total Electric Purchased by University	% source of Electricity Production Coal	% source of Electricity Production Natural Gas	% source of Electricity Production Nuclear	% source of Electricity Production Hydro-Electric	% source of Electricity Production Renewable (wind, solar)	% source of Electricity Production Biomass	Total Percentage
	(kWh)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
2005	207652458.00	39.33%	37.99%	22.61%	0.04%	0.00%	0.03%	100.00%
2006	212827845.00	7.00%	41.50%	23.00%	20.20%	3.60%	4.70%	100.00%

The input calculated the following emissions factors for electricity:

Electricity Emissions Factor in 2005: 0.680 kg CO_2 / kWh
Electricity Emissions Factor in 2006: 0.301 kg CO_2 / kWh

Emissions Factor: Natural Gas

The emissions factor used for CalCAP calculations were taken for the default value in Clean Air Cool Planet Calculator tool that is derived from EPA statewide averages, which is identical to the state average factor used by California Action Registry Reporting Online Tool. The value is 52.79 Kg CO2 /Mmbtu or 5.2785 kg CO2 /therm.

Note

A discussion on lifecycle calculation for electricity is available in Appendix R.

Appendix J: Inventory Calculation – Purchased Steam

UCB Greenhouse Emissions from Steam Generation

By Aaron Parsons
for Cal Climate Action Partnership
January, 2007

1 Summary

1.1 Summary of Facilities and Operational Modes

The University of California, Berkeley campus (hereafter UC Berkeley) relies on Delta Power (formerly known as Pure Energy Berkeley) for generating the steam it uses to heat its buildings. This steam is the cogenerated by-product of the electricity generation facility owned and operated by Delta Power in a building leased from UC Berkeley. Responsibility for the total emissions generated by the facility operating in this mode is shared by UC Berkeley (the exclusive consumer of the steam generated) and the off-campus consumers of the electricity generated. When the cogenerated steam is insufficient to meet campus demands (at a threshold of approximately 70 klbs/hr), an auxiliary duct burner is fired within the electricity generation facility to generate extra steam. UC Berkeley is solely responsible for the additional emissions generated by the facility operating in this mode. Finally, for steam demands in excess of 120 klbs/hr, UC Berkeley can fire one of up to three auxiliary boilers which it owns. These boilers are housed in the same building used by Delta Power. Although never used at capacity, these boilers have a potential-to-pollute which causes UC Berkeley to be listed among the top polluters in the state of California. Efforts have been made to sell these boilers to Delta Power, but UC Berkeley currently retains their ownership.

1.2 Summary of Emissions

In the 2005 calendar year, UC Berkeley consumed 890,054 klbs of steam for the purposes of heating its buildings. By weight, 94.7% of this steam was produced by the Delta Cogeneration Plant, and 5.30% by auxiliary boilers. UC Berkeley's fractional share of the cogeneration plant's greenhouse gas emission was computed from the fractional steam energy consumed compared to the total energy output (both steam and electrical) of the plant, as described in the California Climate Action Registry General Reporting Protocol [1]. The shortcomings of this method are discussed below. The total emissions of the Delta Cogeneration Plant were computed using the measured natural gas consumption and an estimated emission factor of 53 kg $CO2$ equivalent per MMBtu of natural gas burned. Emissions from the auxiliary boilers were similarly computed using the measured natural gas consumption and the same emission factor. It was found that through steam generation, the UC Berkeley campus was responsible for 80,136,460 kg of $CO2$ equivalent emissions. A preliminary attempt was also made to establish an annual growth rate of emissions. The initial result is that campus emissions from steam generation are growing approximately 1.89% per year.

2 The Delta Cogeneration Plant

To assess the fraction of emissions from a cogeneration plant (which produces both steam and electricity) which are attributable to steam, we must calculate the fractional steam energy output by the plant as compared to electrical energy. The steam energy output by the plant is the difference between the thermal energy content of the output steam and that of the returned condensate.

$$f_{emissions,steam} = T_{emissions} \frac{E_{steam,out} - E_{condensate,in}}{E_{elec} + (E_{steam,out} - E_{condensate,in})}$$

equation [1]

We assume that the energy content of the condensate (*E condensate,in*) is that of boiling water, but actual measurements of the temperature of the condensate still need to be obtained.

A shortcoming of equation 1 not discussed in [1] is that the more efficient power generation path in a cogeneration plant (which in most cases is steam, because it does not require inefficient mechanical turbines), is penalized by being attributed a larger fraction of the total emissions as a result of its greater contribution to the power *output*. If it were possible to independently calculate the fractional efficiency of each power generation path (and thus assess the power *inpu*t to each path), this would allow an accurate (and fair) assessment of the fractional emissions of each energy component of a cogeneration plant. However, since this information is not readily available for this plant, equation 1 will be used despite this shortcoming.

We have measured values for the input energy (MMBtus of natural gas), so we can bypass any steps for estimating this value. To calculate the total emissions from the cogeneration plant, we use the input natural gas energy (*ENG*) and the emission factors provided in Appendix C of [1]. We express the emission in an effective weight of *CO2* (*CO2e*).

$$T_{emissions} = \left(52.78 \frac{kg\ CO_2}{MMBtu} + .0059 \frac{kg\ CH_4}{MMBtu} \times 21 \frac{CO_2e}{CH_4} + .0001 \frac{kg\ NO_2}{MMBtu} \times 310 \frac{CO_2e}{NO_2}\right) E_{NG} \quad (2)$$

equation [2]

Finally, we must know the fraction of the steam generated by the plant which was purchased by UCB. For now, we assume that all the steam generated is purchased by UCB.

3 Auxiliary Boilers

Accounting for the emissions from the auxiliary boilers used by the University of California, Berkeley to generate steam is simple because we have measured values for the input energy (in MMBtus of natural gas), and all of the steam generated is used by UCB. Thus, we may simply use equation 2 to calculate the emissions. We do not have the measured enthalpy of the steam delivered by these boilers, so for purposes of comparing UCB's fractional energy dependence on them, we have assumed a 75% energy efficiency converting natural gas to steam, and estimated the average enthalpy accordingly.

4 Extrapolating Data

For cases when data are missing or unobtainable, or for predicting future trends, it is useful formulate a method of extrapolation. Currently we have collected monthly data for the Delta Cogeneration plant for years 2004 and 2005, and for UCB's auxiliary boilers from June 2002 until Dec. 2006. Estimated values of total steam consumption were obtained by modeling annual growth as an exponential. For the cogeneration plant, annual growth of steam generation (based on 2004 and 2005 data) was founded to be 1.56%. Data for individual months were estimated as the average of the values measured for that month, extrapolated to the year in question using the estimated annual growth rate. From these extrapolated values of steam consumption, the corresponding amount of natural gas burned was calcuated assuming a fixed ratio between natural gas burned and steam generated. This ratio was measured from the data. Similarly, the average annual growth of steam consumption from the auxiliary boilers was measured to be 20.2%. This ratio was used to extrapolate steam consumption in 2002 in the same manner described for the cogeneration data.

A shortcoming of the methodology of assuming exponential growth for both cogenerated steam and auxiliary steam is that the majority of the annual growth in steam consumption is probably provided by the auxiliary boilers. This is because the cogeneration plant (with the exception of the duct burner) produces a relatively fixed amount of steam as part of its constant generation of electricity. However, because of the relatively limited distance we are extrapolating, an exponential model for the auxiliary boiler does not introduce much additional error. It should also be noted that for this analysis, the majority of the extrapolation relies upon the data collected from the cogeneration plant for 2004 and 2005. Several more years of data are needed to produce a reliable extrapolation.

5. Concluding Remarks

It may be noticed in the attached spreadsheets that the fractional energy contribution of the auxiliary boilers is higher than their fractional contribution to the emission of greenhouse gases. Based on these numbers, one could reach the fallacious conclusion that these boilers are more environmentally friendly than the Delta cogeneration plant in producing the steam UCB uses to heat its buildings. This example illustrates precisely how equation 1 fails to adequately reward the steam generation path of cogeneration plants; steam users are held accountable for ineffciencies in the electricity generation path.

References

[1] California Climate Action Registry: General Reporting Protocol, Version 2.1, June 2006.

Total UCB Steam Generation

Gray = Estimated

Constants

101.89% Estimated Annual Growth Rate of Emissions

3.41E-003 MMBtu/kWh

53 CO2e/MMBtu Natural Gas

BY YEAR

	Steam Weight (kLbs)	Steam % Weight CoGen	Steam % Weight Aux	Steam Energy (MMBtu)	Steam % Energy CoGen	Steam % Energy Aux	Steam Emissions (kg CO2e)	Steam % Emis CoGen	Steam % Emis Aux
2002	843,703	95.36%	4.64%	1,001,587	95.83%	4.17%	76,241,664	96.13%	3.87%
2003	850,263	96.10%	3.90%	1,011,141	96.41%	3.59%	77,002,770	96.67%	3.33%
2004	882,753	94.01%	5.99%	1,044,886	94.75%	5.25%	79,503,388	95.13%	4.87%
2005	890,054	94.70%	5.30%	1,055,714	95.24%	4.76%	80,136,460	95.58%	4.42%
2006	917,052	93.34%	6.66%	1,079,367	94.61%	5.39%	82,086,653	95.00%	5.00%

BY MONTH

Year	Mon	Steam Weight (kLbs)	Steam % Weight CoGen	Steam % Weight Aux	Steam Energy (MMBtu)	Steam % Energy CoGen	Steam % Energy Aux	Steam Emissions (kg CO2e)	Steam % Emis CoGen	Steam % Emis Aux
2002	1	98,856	94.81%	5.19%	117,179	95.43%	4.57%	8,137,974	95.35%	4.65%
2002	2	80,478	93.72%	6.28%	95,265	94.46%	5.54%	6,800,077	94.52%	5.48%
2002	3	72,938	95.03%	4.97%	86,480	95.62%	4.38%	6,346,148	95.79%	4.21%
2002	4	71,919	95.05%	4.95%	85,273	95.64%	4.36%	6,186,845	95.76%	4.24%
2002	5	63,643	98.55%	1.45%	75,789	98.73%	1.27%	6,046,319	98.87%	1.13%
2002	6	58,030	97.13%	2.87%	68,985	97.47%	2.53%	5,642,965	97.82%	2.18%
2002	7	55,650	97.65%	2.35%	66,302	97.78%	2.22%	5,597,421	98.14%	1.86%
2002	8	56,390	97.30%	2.70%	67,470	97.02%	2.98%	5,699,380	97.51%	2.49%
2002	9	54,309	98.07%	1.93%	64,602	98.35%	1.65%	5,418,650	98.61%	1.39%
2002	10	65,401	94.86%	5.14%	77,642	95.33%	4.67%	6,224,994	95.88%	4.12%
2002	11	75,877	92.07%	7.93%	89,392	93.23%	6.77%	6,555,138	93.49%	6.51%
2002	12	90,212	93.38%	6.62%	107,207	93.74%	6.26%	7,585,752	93.75%	6.25%
2002TOT		**843,703**	**95.36%**	**4.64%**	**1,001,587**	**95.83%**	**4.17%**	**76,241,664**	**96.13%**	**3.87%**
2003	1	97,127	98.01%	1.99%	115,755	98.11%	1.89%	8,035,460	98.08%	1.92%
2003	2	88,958	86.12%	13.88%	104,665	87.32%	12.68%	7,464,779	87.45%	12.55%
2003	3	71,914	97.89%	2.11%	86,060	97.59%	2.41%	6,320,325	97.68%	2.32%
2003	4	71,931	96.52%	3.48%	85,552	96.82%	3.18%	6,209,135	96.90%	3.10%
2003	5	64,033	99.48%	0.52%	76,259	99.65%	0.35%	6,090,353	99.69%	0.31%
2003	6	58,575	97.73%	2.27%	70,369	97.05%	2.95%	5,752,734	97.45%	2.55%
2003	7	56,458	97.75%	2.25%	67,334	97.78%	2.22%	5,684,578	98.15%	1.85%
2003	8	55,727	100.00%	0.00%	66,482	100.00%	0.00%	5,644,315	100.00%	0.00%
2003	9	55,434	97.58%	2.42%	66,008	97.76%	2.24%	5,531,286	98.12%	1.88%
2003	10	65,641	95.99%	4.01%	77,840	96.57%	3.43%	6,250,563	96.99%	3.01%
2003	11	76,262	93.04%	6.96%	90,106	93.94%	6.06%	6,609,344	94.17%	5.83%
2003	12	88,202	97.00%	3.00%	104,711	97.47%	2.53%	7,409,897	97.48%	2.52%
2003TOT		**850,263**	**96.10%**	**3.90%**	**1,011,141**	**96.41%**	**3.59%**	**77,002,770**	**96.67%**	**3.33%**
2004	1	103,358	91.17%	8.83%	121,971	92.17%	7.83%	8,878,333	92.40%	7.60%
2004	2	88,455	94.14%	5.86%	105,071	94.55%	5.45%	7,520,955	94.62%	5.38%
2004	3	78,655	85.57%	14.43%	91,470	87.79%	12.21%	6,757,527	88.33%	11.67%
2004	4	72,493	95.25%	4.75%	85,729	96.09%	3.91%	6,301,399	96.25%	3.75%
2004	5	68,805	96.03%	3.97%	81,566	96.64%	3.36%	6,333,316	96.95%	3.05%
2004	6	57,950	97.87%	2.13%	68,922	98.17%	1.83%	5,542,940	98.40%	1.60%
2004	7	57,384	97.96%	2.04%	68,267	98.24%	1.76%	5,595,414	98.48%	1.52%
2004	8	54,928	99.47%	0.53%	65,475	99.55%	0.45%	5,450,402	99.62%	0.38%
2004	9	52,346	95.30%	4.70%	62,285	95.55%	4.45%	5,247,502	96.27%	3.73%
2004	10	67,465	96.69%	3.31%	80,143	97.10%	2.90%	6,353,005	97.42%	2.58%
2004	11	81,134	95.33%	4.67%	97,021	95.11%	4.89%	7,149,842	95.32%	4.68%
2004	12	99,780	90.10%	9.90%	116,966	91.70%	8.30%	8,372,752	91.82%	8.18%
2004TOT		**882,753**	**94.01%**	**5.99%**	**1,044,886**	**94.75%**	**5.25%**	**79,503,388**	**95.13%**	**4.87%**
2005	1	113,633	88.61%	11.39%	137,884	87.12%	12.88%	9,757,751	87.15%	12.85%
2005	2	75,704	97.05%	2.95%	89,754	97.66%	2.34%	6,587,509	97.75%	2.25%
2005	3	79,920	96.19%	3.81%	94,666	96.88%	3.12%	7,004,382	97.02%	2.98%
2005	4	83,892	87.14%	12.86%	97,075	89.84%	10.16%	7,100,051	90.19%	9.81%
2005	5	65,354	98.39%	1.61%	77,704	98.73%	1.27%	6,222,864	98.88%	1.12%
2005	6	62,601	96.63%	3.37%	74,175	97.29%	2.71%	5,891,691	97.59%	2.41%
2005	7	58,087	97.72%	2.28%	68,740	98.51%	1.49%	5,639,296	98.72%	1.28%
2005	8	60,702	97.98%	2.02%	72,127	98.38%	1.62%	5,857,485	98.59%	1.41%
2005	9	61,899	98.43%	1.57%	73,531	98.85%	1.15%	5,802,566	98.97%	1.03%
2005	10	64,177	99.32%	0.68%	76,451	99.46%	0.54%	6,035,385	99.52%	0.48%
2005	11	75,782	89.50%	10.50%	88,765	91.15%	8.85%	6,577,729	91.57%	8.43%
2005	12	88,304	96.47%	3.53%	104,844	96.93%	3.07%	7,659,752	97.04%	2.96%
2005TOT		**890,054**	**94.70%**	**5.30%**	**1,055,714**	**95.24%**	**4.76%**	**80,136,460**	**95.58%**	**4.42%**
2006	1	105,521	94.51%	5.49%	124,894	95.26%	4.74%	8,674,076	95.19%	4.81%
2006	2	85,443	93.93%	6.07%	100,760	95.02%	4.98%	7,192,859	95.08%	4.92%
2006	3	97,550	75.60%	24.40%	110,375	79.72%	20.28%	8,048,165	80.37%	19.63%
2006	4	77,717	93.59%	6.41%	91,289	95.05%	4.95%	6,622,178	95.19%	4.81%
2006	5	66,734	100.00%	0.00%	79,613	100.00%	0.00%	6,360,857	100.00%	0.00%
2006	6	61,440	97.61%	2.39%	72,891	98.15%	1.85%	5,968,167	98.41%	1.59%
2006	7	59,917	96.50%	3.50%	70,861	97.34%	2.66%	5,977,938	97.78%	2.22%
2006	8	59,372	98.33%	1.67%	70,605	98.65%	1.35%	5,980,620	98.87%	1.13%
2006	9	57,634	98.33%	1.67%	68,667	98.45%	1.55%	5,760,528	98.70%	1.30%
2006	10	66,061	99.92%	0.08%	78,828	99.90%	0.10%	6,356,387	99.91%	0.09%
2006	11	82,888	89.68%	10.32%	96,734	91.67%	8.33%	7,089,033	91.98%	8.02%
2006	12	96,776	92.62%	7.38%	113,850	93.92%	6.08%	8,055,844	93.93%	6.07%
2006TOT		**917,052**	**93.34%**	**6.66%**	**1,079,367**	**94.61%**	**5.39%**	**82,086,653**	**95.00%**	**5.00%**

Delta Co-Generation Plant

Gray = Estimated

1.19 Avg. Measured Enthalpy (MMBtu/kLbs)
101.56% Estimated Annual Growth

Year	Mon	Natural Gas Energy (MMBtu)	Natural Gas Emissions (kg CO2e)	Electricity Net (kWh)	Electricity Parasitic (kWh)	Electricity Total (kWh)	Electricity Total (MMBtu)	Steam Total (kLbs)	Steam Total (MMBtu)	Energy Total (MMBtu)	Electricity % Total	Steam % Total	Electricity Emissions (kg CO2e)
2002	1	236,444	12,516,124	19,316,441	765,874	20,082,315	68,541	93,729	111,819	180,360	38.00%	62.00%	4,756,409
2002	2	199,430	10,556,791	16,292,554	645,980	16,938,534	57,811	75,428	89,985	147,796	39.12%	60.88%	4,129,335
2002	3	192,216	10,174,947	15,703,244	622,615	16,325,859	55,720	69,315	82,693	138,413	40.26%	59.74%	4,096,071
2002	4	185,848	9,837,831	15,182,965	601,986	15,784,952	53,874	68,359	81,553	135,427	39.78%	60.22%	3,913,586
2002	5	200,783	10,628,435	16,403,124	650,364	17,053,488	58,204	62,719	74,823	133,027	43.75%	56.25%	4,650,281
2002	6	189,435	10,027,742	15,476,059	613,607	16,089,667	54,914	56,362	67,240	122,154	44.95%	55.05%	4,507,936
2002	7	193,625	10,249,532	15,818,355	627,179	16,445,533	56,129	54,340	64,827	120,956	46.40%	53.60%	4,756,211
2002	8	196,209	10,386,315	16,029,455	635,549	16,665,004	56,878	54,869	65,459	122,337	46.49%	53.51%	4,828,884
2002	9	187,128	9,905,577	15,287,519	606,132	15,893,651	54,245	53,259	63,538	117,783	46.05%	53.95%	4,562,007
2002	10	201,942	10,689,788	16,497,812	654,119	17,151,931	58,540	62,039	74,013	132,553	44.16%	55.84%	4,720,959
2002	11	193,811	10,259,349	15,833,505	627,780	16,461,284	56,182	69,862	83,345	139,527	40.27%	59.73%	4,131,055
2002	12	219,370	11,612,333	17,921,598	710,570	18,632,168	63,592	84,236	100,494	164,086	38.76%	61.24%	4,500,375
2003	1	240,140	12,711,798	19,618,430	777,847	20,396,277	69,612	95,195	113,567	183,180	38.00%	62.00%	4,830,770
2003	2	202,548	10,721,833	16,547,268	656,079	17,203,347	58,715	76,607	91,392	150,107	39.12%	60.88%	4,193,892
2003	3	195,221	10,334,019	15,948,745	632,349	16,581,094	56,591	70,399	83,986	140,577	40.26%	59.74%	4,160,108
2003	4	188,753	9,991,633	15,420,332	611,398	16,031,730	54,716	69,428	82,828	137,544	39.78%	60.22%	3,974,770
2003	5	203,922	10,794,597	16,659,567	660,532	17,320,099	59,113	63,699	75,993	135,107	43.75%	56.25%	4,722,982
2003	6	192,397	10,184,513	15,718,009	623,200	16,341,209	55,773	57,243	68,291	124,064	44.95%	55.05%	4,578,412
2003	7	196,652	10,409,771	16,065,655	636,984	16,702,639	57,006	55,189	65,841	122,847	46.40%	53.60%	4,830,568
2003	8	199,277	10,548,692	16,280,056	645,485	16,925,540	57,767	55,727	66,482	124,249	46.49%	53.51%	4,904,378
2003	9	190,053	10,060,438	15,526,521	615,608	16,142,129	55,093	54,092	64,532	119,625	46.05%	53.95%	4,633,328
2003	10	205,099	10,856,910	16,755,736	664,345	17,420,080	59,455	63,009	75,170	134,625	44.16%	55.84%	4,794,765
2003	11	196,841	10,419,741	16,081,042	637,594	16,718,636	57,061	70,954	84,648	141,709	40.27%	59.73%	4,195,639
2003	12	222,800	11,793,878	18,201,780	721,679	18,923,459	64,586	85,553	102,065	166,651	38.76%	61.24%	4,570,733
2004	1	244,344	12,934,325	18,310,916	680,663	18,991,579	64,818	94,230	112,416	177,235	36.57%	63.43%	4,730,342
2004	2	213,861	11,320,711	16,545,302	650,253	17,195,555	58,688	83,269	99,340	158,028	37.14%	62.86%	4,204,276
2004	3	185,406	9,814,448	14,439,682	717,041	15,156,723	51,730	67,308	80,298	132,028	39.18%	60.82%	3,845,389
2004	4	190,008	10,058,054	15,146,341	745,254	15,891,595	54,238	69,052	82,379	136,617	39.70%	60.30%	3,993,125
2004	5	204,998	10,851,549	16,926,170	796,233	17,722,403	60,487	66,076	78,829	139,315	43.42%	56.58%	4,711,422
2004	6	194,399	10,290,492	16,801,929	778,022	17,579,951	60,000	56,716	67,662	127,663	47.00%	53.00%	4,836,448
2004	7	200,502	10,613,553	17,507,641	688,958	18,196,599	62,105	56,215	67,064	129,169	48.08%	51.92%	5,103,021
2004	8	202,133	10,699,890	17,824,560	712,723	18,537,283	63,268	54,635	65,180	128,447	49.26%	50.74%	5,270,317
2004	9	187,888	9,945,832	16,266,173	626,196	16,892,369	57,654	49,885	59,513	117,166	49.21%	50.79%	4,894,008
2004	10	212,054	11,225,057	17,883,403	669,746	18,553,149	63,322	65,230	77,819	141,141	44.86%	55.14%	5,036,031
2004	11	214,978	11,379,839	17,461,813	648,004	18,109,817	61,809	77,349	92,277	154,086	40.11%	59.89%	4,564,811
2004	12	228,383	12,089,431	17,350,114	644,946	17,995,060	61,417	89,905	107,257	168,674	36.41%	63.59%	4,401,977
2005	1	246,900	13,069,627	18,227,674	668,294	18,895,968	64,492	100,686	120,118	184,610	34.93%	65.07%	4,565,755
2005	2	199,816	10,577,240	15,896,060	608,343	16,504,403	56,330	73,471	87,651	143,980	39.12%	60.88%	4,138,138
2005	3	214,599	11,359,777	17,368,699	677,361	18,046,060	61,591	76,874	91,711	153,302	40.18%	59.82%	4,563,951
2005	4	196,326	10,392,497	15,336,806	579,523	15,916,329	54,322	73,100	87,208	141,531	38.38%	61.62%	3,988,856
2005	5	212,216	11,233,633	17,875,160	684,456	18,559,616	63,344	64,304	76,715	140,059	45.23%	54.77%	5,080,607
2005	6	199,289	10,549,343	17,006,743	642,169	17,648,912	60,236	60,492	72,167	132,403	45.49%	54.51%	4,799,355
2005	7	202,063	10,696,185	17,602,308	677,421	18,279,729	62,389	56,763	67,718	130,107	47.95%	52.05%	5,129,020
2005	8	205,326	10,868,911	17,659,443	679,616	18,339,059	62,591	59,477	70,956	133,547	46.87%	53.13%	5,094,064
2005	9	198,663	10,516,206	17,029,505	671,043	17,700,548	60,412	60,928	72,687	133,099	45.39%	54.61%	4,773,172
2005	10	207,745	10,996,961	17,814,157	697,260	18,511,417	63,179	63,740	76,042	139,221	45.38%	54.62%	4,990,488
2005	11	187,803	9,941,333	14,825,478	594,589	15,420,067	52,629	67,821	80,910	133,539	39.41%	60.59%	3,917,947
2005	12	227,296	12,031,891	17,760,719	663,549	18,424,268	62,882	85,188	101,629	164,511	38.22%	61.78%	4,599,013
2006	1	251,580	13,317,368	20,553,020	814,903	21,367,923	72,929	99,730	118,978	191,906	38.00%	62.00%	5,060,900
2006	2	212,197	11,232,604	17,335,553	687,334	18,022,887	61,512	80,256	95,746	157,258	39.12%	60.88%	4,393,683
2006	3	204,521	10,826,315	16,708,518	662,473	17,370,991	59,287	73,752	87,987	147,274	40.26%	59.74%	4,358,289
2006	4	197,745	10,467,618	16,154,932	640,524	16,795,456	57,323	72,735	86,773	144,096	39.78%	60.22%	4,164,121
2006	5	213,637	11,308,835	17,453,202	691,999	18,145,200	61,930	66,734	79,613	141,543	43.75%	56.25%	4,947,978
2006	6	201,562	10,669,687	16,466,789	652,889	17,119,678	58,429	59,970	71,545	129,974	44.95%	55.05%	4,796,520
2006	7	206,021	10,905,676	16,830,997	667,329	17,498,326	59,722	57,818	68,977	128,699	46.40%	53.60%	5,060,689
2006	8	208,770	11,051,215	17,055,611	676,235	17,731,846	60,519	58,382	69,649	130,168	46.49%	53.51%	5,138,014
2006	9	199,107	10,539,701	16,266,180	644,935	16,911,114	57,718	56,669	67,606	125,323	46.05%	53.95%	4,854,052
2006	10	214,870	11,374,116	17,553,952	695,993	18,249,945	62,287	66,011	78,751	141,038	44.16%	55.84%	5,023,180
2006	11	206,218	10,916,121	16,847,117	667,968	17,515,085	59,779	74,334	88,680	148,459	40.27%	59.73%	4,395,513
2006	12	233,413	12,355,719	19,068,884	756,059	19,824,942	67,663	89,629	106,927	174,590	38.76%	61.24%	4,788,475

Steam Emissions (kg CO2e)	Ratio of NG (MMBtu) to Steam (kLbs)	Ratio of NG (MMBtu) to Net Electricity (kWh)	Ratio of Net Electricity to Parasitic
7,759,715			
6,427,455			
6,078,876			
5,924,245			
5,978,154			
5,519,806			
5,493,322			
5,557,431			
5,343,570			
5,968,830			
6,128,294			
7,111,958			
7,881,028			
6,527,941			
6,173,912			
6,016,863			
6,071,615			
5,606,101			
5,579,203			
5,644,315			
5,427,110			
6,062,145			
6,224,102			
7,223,145			
8,203,984	2.59	0.01	26.9
7,116,435	2.57	0.01	25.44
5,969,059	2.75	0.01	20.14
6,064,930	2.75	0.01	20.32
6,140,126	3.1	0.01	21.26
5,454,044	3.43	0.01	21.6
5,510,532	3.57	0.01	25.41
5,429,574	3.7	0.01	25.01
5,051,824	3.77	0.01	25.98
6,189,026	3.25	0.01	26.7
6,815,028	2.78	0.01	26.95
7,687,454	2.54	0.01	26.9
8,503,872	2.45	0.01	27.27
6,439,102	2.72	0.01	26.13
6,795,826	2.79	0.01	25.64
6,403,641	2.69	0.01	26.46
6,153,026	3.3	0.01	26.12
5,749,989	3.29	0.01	26.48
5,567,165	3.56	0.01	25.98
5,774,848	3.45	0.01	25.98
5,743,034	3.26	0.01	25.38
6,006,473	3.26	0.01	25.55
6,023,386	2.77	0.01	24.93
7,432,878	2.67	0.01	26.77
8,256,468			
6,838,921	1.02		
6,468,027			
6,303,497			
6,360,857			
5,873,167			
5,844,987			
5,913,201			
5,685,649			
6,350,936			
6,520,608			
7,567,244			

Auxilliary Boiler

Gray = Estimated Yellow = Strange

2763.91
4406.91
3934.16
5085.96

Assumptions Need Meas. Enthalpy... Assume 75% eff.

0.75 Boiler Efficiency
1.01 Equivalent Assumed Avg. Enthalpy
120.20% Estimated Annual Growth
1.37 Average NG/Steam Ratio

Year	Mon	Natural Gas Volume (kscf)	Natural Gas Meas. Btu/scf	Natural Gas Energy (MMBtu)	Natural Gas Emissions (kg CO2e)	Steam Total (kLbs)	Steam Total (MMBtu)	Estimated Enthalpy (MMBtu/kLbs)	Ratio of NG (kscf) to Steam Total (kLbs)
2002	1	7,006	1,020	7,146	378,260	5,127	5,359	1.05	
2002	2	6,901	1,020	7,039	372,621	5,051	5,279	1.05	
2002	3	4,950	1,020	5,049	267,272	3,623	3,787	1.05	
2002	4	4,864	1,020	4,961	262,600	3,559	3,721	1.05	
2002	5	1,262	1,020	1,288	68,165	924	966	1.05	
2002	6	2,281	1,020	2,327	123,159	1,668	1,745	1.05	1.37
2002	7	1,928	1,020	1,967	104,100	1,311	1,475	1.13	1.47
2002	8	2,629	1,020	2,682	141,949	1,521	2,011	1.32	1.73
2002	9	1,396	1,016	1,418	75,079	1,050	1,064	1.01	1.33
2002	10	4,749	1,019	4,839	256,164	3,362	3,629	1.08	1.41
2002	11	7,921	1,018	8,064	426,845	6,016	6,048	1.01	1.32
2002	12	8,775	1,020	8,951	473,794	5,975	6,713	1.12	1.47
2003	1	2,863	1,019	2,917	154,432	1,933	2,188	1.13	1.48
2003	2	17,385	1,018	17,698	936,838	12,351	13,273	1.07	1.41
2003	3	2,717	1,018	2,766	146,413	1,515	2,074	1.37	1.79
2003	4	3,561	1,020	3,632	192,271	2,503	2,724	1.09	1.42
2003	5	343	1,032	354	18,738	334	265	0.79	1.03
2003	6	2,692	1,029	2,770	146,633	1,331	2,078	1.56	2.02
2003	7	1,944	1,024	1,991	105,375	1,269	1,493	1.18	1.53
2003	8	0	1,025	0	0	0	0	#VALUE!	
2003	9	1,920	1,025	1,968	104,176	1,342	1,476	1.10	1.43
2003	10	3,476	1,024	3,559	188,418	2,632	2,670	1.01	1.32
2003	11	7,121	1,022	7,278	385,242	5,308	5,458	1.03	1.34
2003	12	3,449	1,023	3,528	186,752	2,649	2,646	1.00	1.3
2004	1	12,465	1,022	12,739	674,350	9,128	9,554	1.05	1.37
2004	2	7,492	1,020	7,642	404,520	5,186	5,731	1.11	1.44
2004	3	14,603	1,020	14,895	788,469	11,347	11,171	0.98	1.29
2004	4	4,371	1,022	4,467	236,469	3,441	3,350	0.97	1.27
2004	5	3,578	1,020	3,650	193,189	2,729	2,737	1.00	1.31
2004	6	1,640	1,024	1,679	88,897	1,234	1,260	1.02	1.33
2004	7	1,569	1,022	1,604	84,882	1,169	1,203	1.03	1.34
2004	8	385	1,022	393	20,828	293	295	1.01	1.31
2004	9	3,617	1,022	3,697	195,678	2,461	2,772	1.13	1.47
2004	10	3,037	1,020	3,098	163,979	2,235	2,323	1.04	1.36
2004	11	6,201	1,020	6,325	334,814	3,785	4,744	1.25	1.64
2004	12	12,655	1,023	12,946	685,299	9,875	9,710	0.98	1.28
2005	1	23,200	1,021	23,687	1,253,880	12,947	17,765	1.37	1.79
2005	2	2,754	1,018	2,804	148,407	2,233	2,103	0.94	1.23
2005	3	3,874	1,017	3,940	208,556	3,046	2,955	0.97	1.27
2005	4	12,898	1,020	13,156	696,409	10,792	9,867	0.91	1.2
2005	5	1,296	1,018	1,319	69,838	1,050	989	0.94	1.23
2005	6	2,604	1,028	2,677	141,702	2,109	2,008	0.95	1.23
2005	7	1,332	1,023	1,363	72,131	1,324	1,022	0.77	1.01
2005	8	1,532	1,019	1,561	82,637	1,225	1,171	0.96	1.25
2005	9	1,108	1,015	1,125	59,532	971	843	0.87	1.14
2005	10	536	1,019	546	28,912	437	410	0.94	1.23
2005	11	10,287	1,018	10,472	554,343	7,961	7,854	0.99	1.29
2005	12	4,206	1,019	4,286	226,874	3,116	3,214	1	1
2006	1	7,742	1,019	7,889	417,609	5,791	5,917	1.02	1.34
2006	2	6,607	1,012	6,686	353,938	5,186	5,015	0.97	1.27
2006	3	29,294	1,019	29,851	1,580,138	23,798	22,388	0.94	1.23
2006	4	5,908	1,019	6,020	318,681	4,982	4,515	0.91	1.19
2006	5	0	1,019	0	0	0	0	#VALUE!	
2006	6	1,748	1,027	1,795	95,001	1,469	1,346	0.92	1.19
2006	7	2,458	1,022	2,512	132,950	2,099	1,884	0.90	1.17
2006	8	1,247	1,021	1,274	67,419	990	955	0.96	1.26
2006	9	1,385	1,021	1,415	74,879	965	1,061	1.10	1.43
2006	10	101	1,020	103	5,452	50	77	1.54	2.02
2006	11	10,548	1,018	10,738	568,425	8,554	8,054	0.94	1.23
2006	12	9,067	1,018	9,230	488,600	7,147	6,923	1	1

Appendix K: Inventory Calculation – Campus Fleet

Method:

The team used California Climate Action Registry Protocol and more specific emissions factor analysis.

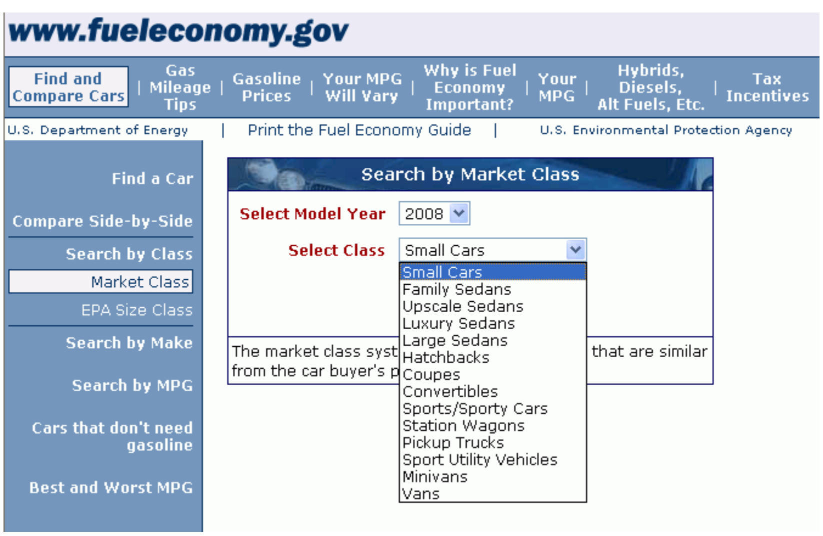
Data Source:

UC Berkeley fleet is quite decentralized. Every department owns their vehicular fleet and maintains their own records for fuel purchase and vehicle servicing.

Initially CalCAP approached the individual departments for their detailed records, but due to varying formats in recordkeeping and differences in vehicle use, CalCAP approached the central feet services (record) manager Eric Robinson. A query was performed on an Access database of on odometer (mileage) reading of campus vehicles captured during vehicle purchase and servicing, applicable for 2004 and 2005 records.

Calculation:

- Estimated the **annual mileage** per vehicle based on odometer mileage readings. In cases were more or less than a year's records were present, a yearly value was calculated.
- Categorized all vehicles in major **vehicle types** in order to match them with the vehicle types available in EPA's vehicle efficiency calculations. For a limited number of vehicles that were missing mileage data, we ascribed the average mileage value for the group.
- Extracted **EPA's Miles Per Gallon** values from <www.fueleconomy.gov> for each category of vehicle.



For "model year" we chose an earlier year when the vehicle was bought and a more recent year matching the odometer reading, to get a closer estimate on the MPG for that vehicle. An average of the two MPGs was chosen (listed as City MPG in the figure below).

- Made an assumption that the campus fleet would mostly fall under the category for "city MPG" since these vehicles are operating within and around the City of Berkeley perimeter under city traffic conditions.
- Calculated total gallons (miles divided by MPG) used by campus fleet. Of the 100,650 gallons calculated for year 2005, about 3,390 gallons were ascribed to diesel fleet and the rest to gasoline fleet.
    - The diesel fleet gallons was determined by matching vehicle numbers to diesel fleet records.

Category	Total Miles	City MPG	City Gallons	Chosen Model Year	EPA description
bus	**60,807**	17.0	**3,577**	1994 and 2001	vans
full size van	**336,739**	16.5	**20,408**	1995 and 2001	vans
mini van	**293,495**	21.0	**13,976**	1995 and 2000	mini van
motorcycle	**91,773**	61.0	**1,504**	2003	small cars
motorschooter	**318**	61.0	**5**	2002	small cars
pickup	**717,998**	23.5	**30,553**	1986 and 2001	pickup
sedan	**361,789**	27.0	**13,400**	1994 and 2003	family sedan
truck	**150,829**	23.5	**6,418**	1994 and 2001	standard pickup trucks
utility	**194,952**	25.0	**7,798**	1998 and 2003	sports utility vehicles
wagon	**84,364**	28.0	**3,013**	1997 and 2001	station wagons
ALL CATEGORIES TOTAL	2,293,064		**100,653**		

97,263	**gasoline gallons**
3,390	**diesel gallons**

- Input the gallon values into the Clean Air Cool Planet calculator tool.

Emissions Factor:

The emissions factor used for CalCAP calculations were taken for the default value in Clean Air Cool Planet Calculator tool that is derived from EPA statewide averages, which is identical to the state average factor used by California Action Registry Reporting Online Tool. The values were:

diesel fleet: 9.99 Kg CO_2 /gallon
gasoline fleet: 8.72 Kg CO_2/gallon

Note

The 2006 Fleet data were derived from assigning a 2.8% annual growth calculated by the Fleet Manager (Robinson, 2006.)

Appendix L: Inventory Calculation - Refrigerants

Method:

CalCAP did not use California Climate Action Registry Protocol, where the refrigerant emissions are entered directly into its own emissions category. Instead, CalCAP used the raw data of refrigerant emissions, entered them into the Clean Air Cool Planet calculator to derive a CO_2 equivalent calculation. For the purposes of the feasibility study, CalCAP made this distinction between Registry Protocol and campus inventory calculation. This was observed and noted by the 3rd party Registry Certifier SGS America.

Data Source:

CalCAP received data from Refrigerant Compliance Manager database for UCB maintained by PP-CS (leak and accidental release report limited to 2005). The categories most relevant for our emissions inventory are the emissions of HFCs from air conditioning systems. Most commonly used HFCs are: R404A, R22 (highest use), R12, R134A, R404A, R408A and R416A.

Calculation:

HFC amounts in pounds were entered into the input sheet of the Clean Air Cool Planet Calculator. We assumed chemical equivalence between R and HFC names?

Fiscal Year	Refrigeration and other Chemicals (PFCs, HFCs, SF6)						
	All other greenhouse gases (click chemical name below to select)						
	HFC-404a	HCFC-22	C5F12	HFE-143a	HFC-404a	Others	Sum
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	kg
2005	**18.00**	**1226.00**	**13.00**	**75.00**	**129.00**	**56.00**	**689.545**
2006	**18.21**	**1239.98**	**13.15**	**75.86**	**130.47**	**56.64**	**697.406**

Emissions Factor:

The emissions factor used in the calculator are captured below for years 2005 and 2006.

MODULE	**Emission Factors**											
WORKSHEET	**Refrigerants**											
UNIVERSITY	**University of California, Berkeley**											
	Refrigeration and other Chemicals (PFCs, HFCs, SF6)											
Fiscal Year	HFC-404a		HCFC-22		C5F12		HFE-143a		HFC-404a		Others	
	GWP	MTCDE / pound emitted	GWP	MTCDE / pound emitted	GWP	MTCDE / pound emitted	GWP	MTCDE / pound emitted	GWP	MTCDE / pound emitted	GWP	MTCDE / pound emitted
2005	3,260	1.48	1,700	0.77	8,900	4.04	750	0.34	3,260	7.17	0	0.00
2006	3,260	1.48	1,700	0.77	8,900	4.04	750	0.34	3,260	7.17	0	0.00

Note:
R408A and R416A data were entered into the "Other category".

Appendix M: Inventory Calculation – Commute

Method:

CalCAP applied California Climate Action Registry Optional Reporting Protocol and more specific emissions factor analysis.

Data Source:

The initial calculations were based on transportation surveys with data on travel mode split and trip distance from 1990, 1992, 1996, 1997, 1998, 2000, 2001, 2004, and 2005.

Student, faculty, and staff population numbers and number of work/school days were obtained from the UC Berkeley IST and Budget Office.

Calculation:

Student commute:

- Determine the number of students in each calendar year from campus records
- Obtain parameters on the percentage of students that drive alone and that carpool from student transportation studies
- Determine an average weighted trip distance (based on the percentage of student drivers in each distance category, from "less than 0.9 miles" to "greater than 50 miles") using trip distance by mode split from student transportation studies
- Assume two trips per day (to and from campus)
- Generate an estimate of the number of days that this trip is made each year by assuming that this is equivalent to the number of school days for students
- Calculate total student commute mileage using the following formula (with a "divide by 2" metric to account for carpooling):
  Total Distance = ((Total # of Students x % Drive Alone) + (Total # of Students x % Carpool)/2) x Trips/Day x Days/Year x Miles/Trip
- Calculate student fuel consumption using the following formula:
  Fuel Consumption = Total Distance/mpg
- Given that there is no obvious trend between survey years, fuel consumption for the years in between surveys is estimated by taking the mean of the fuel consumption numbers in the two survey years on either side of them

Staff and Faculty commute:

- Determine the number of staff and faculty in each calendar year from campus records, counting a part-time staff or faculty as ½ instead of 1
- Obtain parameters on the percentage of staff and faculty that drive alone and that carpool from faculty/staff transportation studies
- Determine an average weighted trip distance (based on the percentage of staff and faculty drivers in each distance category, from "less than 0.9 miles" to "greater than 50 miles") using trip distance by mode split from faculty/staff transportation studies
- Assume two trips per day (to and from campus)

- Generate an estimate of the number of days that this trip is made each year by assuming that this is equivalent to the number of work days for staff and faculty (obtained from the campus Budget Office)
- Calculate total staff and faculty commute mileage using the following formula (with a "divide by 2" metric to account for carpooling):
  Total Distance = ((Total # of Faculty or Staff x % Drive Alone) + (Total # of Faculty or Staff x % Carpool)/2) x Trips/Day x Days/Year x Miles/Trip
- Calculate staff and faculty fuel consumption using the following formula:
  Fuel Consumption = Total Distance/mpg
- Given that there is no obvious trend between survey years, fuel consumption for the years in between surveys is estimated by taking the mean of the fuel consumption numbers in the two survey years on either side of them

Emissions Factor

The team applied an emissions factor for auto commuting from the EPA, listed as Adjusted Gasoline Automobile Emissions. For 2005 and 2006, the factor is 8.72 KG CO_2 equivalent per gallon of gasoline powered vehicles (cars and trucks).

Note

Emissions associated with public transportation are not included in the current analysis due to limitations in the way that commuting information is reported.

Appendix N: Inventory Calculation – Air Travel

By Ryan Firestone
for Cal Climate Action Partnership
January, 2007

Executive Summary

This paper describes the method and reports results of an estimate of greenhouse gas emissions from air travel in 2005 at the University of California, Berkeley. The same or very similar procedures could be used to estimate emissions from prior years or to develop a protocol for future estimation. Two main sources of data were used: 1) the University's Travel and Entertainment office for statistics on air travel of employees and students, and 2) publicly available estimates of emissions per mile of air travel. Carbon dioxide emissions from reimbursed air travel for 2005 are estimated at 23,000 metric tons per year. Total climate forcing effects of air travel, which accounts for the overall global warming impact of air travel, including contrails, are estimated at 47,000 metric tons of carbon dioxide equivalent per year.

Introduction

In recent years there has been mounting theory and evidence of global anthropogenic climate forcing. Climate forcing is caused by super-natural levels of greenhouse gases (GHGs) such as carbon dioxide, methane, and nitrous oxide in the atmosphere. For reference, of all GHG emissions worldwide in 2000, 60% was from fossil fuel consumption for energy (carbon dioxide and methane emissions), 18% was from land use changes such as deforestation (carbon dioxide emissions), 14% was from agriculture including soil erosion (nitrous oxide) and livestock (methane), and 8% was from other sources (Baumert, Herzog, and Pershing 2005).

Many countries have signed and ratified the Kyoto Protocol, and United Nations organized agreement to manage and reduce global GHG emissions. Notably, the United States (U.S.), the world's largest GHG emitter, has refused to ratify the treaty; the Bush administration cites the harm it could do to the U.S. economy and the inequity of not limiting emissions from developing countries such as China and India.

Many U.S. regional governments and private organizations have taken it upon themselves to reduce their GHG emissions. In the past year, California and seven northeastern U.S. states have passed legislation to restrict GHG emissions, although the economic and regulatory mechanisms for achieving these reductions have yet to be determined. Many businesses and organizations, motivated by internal objectives or public perception, are voluntarily reducing their climate forcing footprint.

In November 2006, the University of California, Berkeley (UCB) signed onto the California Climate Action Registry, committing to report and reduce GHG emissions. The Cal Climate Action Partnership (CalCAP) is currently conducting the first ever UCB campus-wide GHG emissions inventory. The work described in this report estimates the GHG emissions from air travel attributable to UCB for the calendar year 2005. Concurrently, other research for CalCAP is estimating GHG emissions from other aspects of campus operations.

Method

The method of estimating GHG emissions is to
1) collect data on commonly assumed emissions rates per kilometer of air travel;
2) collect data on air travel attributable to UCB; and
3) determine UCB air travel emissions, based on emissions rates and total UCB air travel.

The equation used to determine the total amount of GHG emissions attributable to air travel is

$$Emissions = RatePerTrip * NumberOfTrips \quad (1)$$

where

- *Emissions* is the total annual amount of GHG emissions (metric tons of CO_2 or CO_2 equivalent) attributable to air travel at UCB.
- *RatePerTrip* is the emissions rate (metric tons per trip) for a statistically average UCB air trip.
- *NumberOfTrips* is the annual total number of trips.

GHG Emissions Rate per Mile

Data on air travel emissions rates were obtained from WBCSD (2007) and are reported in Table 1.

Table 1. carbon dioxide emission rates for air travel

	short haul	*medium haul*	*long haul*
definition	*less than*	*less than*	*greater than*
	500 km	1600 km	1600 km
or	310 miles	990 miles	990 miles
emissions (kg CO_2 / km)	0.15	0.12	0.11
emissions (kg CO_2 / mile)	0.24	0.19	0.18

source: WBCSD (2007)

The decreasing emissions rates as trip length increases reflects the decrease (proportionally) in energy spent gaining altitude.

In addition to carbon dioxide emissions, airplanes cause further climate forcing from nitrous oxide emissions (which cause ozone formation) and water vapor emissions (which form contrails). The radiative forcing index (RFI) is the multiple of the climate forcing from carbon dioxide that describes the *total* climate forcing effect of air travel. Penner et al. 1999 estimates the RFI to be in the range of 2 to 4. A conservative estimate of 2 is used in this analysis; both the CO_2 emissions and the CO_2 equivalent emissions (total forcing effect) are reported.

Statistical Characteristics of UCB Air Travel

Records were obtained for all UCB travel booked through Carlson Wagonlit Travel in 2005, 8,584 tickets in all. Here, a *ticket* describes an entire itinerary for a single person, and is itemized by each individual leg of air travel. For each leg of air travel, the departure and destination cities are listed, as is the distance between the two cities. Approximately 0.1% of the travel legs did not contain a mileage value; the author estimated these distances using internet-based mileage estimators. Summary statistics from the dataset and resulting GHG emissions data are shown in Table 2. From this data, assuming that the Carlson Wagonlit dataset is statistically similar to the entire set of UCB attributable air travel, it is concluded that an average ticket for UCB travel in 2005 resulted in 0.74 metric tons of carbon dioxide emissions and an overall climate forcing equivalent to 1.47 metric tons of carbon dioxide emissions. These are the *RatePerTrip* values required for Equation (1).

Table 2. air travel statistics from the Carlson Wagonlit sample of tickets in 2005

	short haul (<500 km)	medium haul (500< x < 1600 km)	long haul (>1600 km)	total	average per trip***
number of travel legs	2,204	10,098	10,820	23,122	2.69
distance traveled (miles)*	447,168	5,393,728	29,172,819	35,013,715	4,079
distance traveled (km)*	719,940	8,683,902	46,968,239	56,372,081	6,567
CO_2 emissions only					
emissions factor (kg CO_2 / km)**	0.15	0.12	0.11		
CO_2 emissions (kg)	107,991	1,042,068	5,166,506	6,316,566	736
CO_2 emissions (metric tons)	108	1,042	5,167	6,317	0.74
total climate forcing					
emissions factor (kg CO_2 equivalent / km)**	0.30	0.24	0.22		
CO_2 equivalent emissions (kg)	215,982	2,084,136	10,333,012	12,633,131	1,472
CO_2 equivalent emissions (metric tons)	216	2,084	10,333	12,633	1.47

** data from Carlson Wagonlit*
*** emissions factors from WBCSD (2007) and Penner et al. (1999)*
**** 8,584 tickets for UCB were handled by Carlson Wagonlit in 2005*

Total UCB Air Travel

In 2005, the UCB Department of Travel and Entertainment reimbursed a total of 28,617 air travel trips[7]. This is estimated to be 90% of the total air travel for the campus: certain student travel under grants is reimbursed by a different office. Therefore, the total number of UCB air travel trips in 2005 is estimated to be 32,000. This is the *NumberOfTrips* value required for Equation (1).

[7] personal communications with Tina Chan, UCB Department of Travel and Entertainment. January 2007.

This estimate of total trips, combined with the average emissions per trip shown in Table 2 lead to the conclusion that UCB air travel in 2005 was responsible for 23,400 metric tons of direct carbon dioxide emissions and a total climate forcing effect equivalent to 46,800 metric tons. This data is restated in Table 3.

Table 3. summary of 2005 UCB air travel GHG emissions

	CO_2 only	total climate forcing
emissions per trip (CO_2 or CO_2 equivalent)	0.74	1.47
Total CO2 emissions (metric tons/year)*	23,398	46,796

**31,797 trips taken in 2005*

References

Baumert, Kevin A., Timothy Herzog, and Jonathan Pershing. 2005. "Navigating the Numbers: Greenhouse Gas Data and International Climate Policy" World Resource Institute, Washington D.C.

available at http://www.wri.org/climate/pubs_description.cfm?pid=4093

J.E.Penner, D.H.Lister, D.J.Griggs, D.J.Dokken, M.McFarland 1999. "Aviation and the Global Atmosphere: A Special Report of IPCC Working Groups I and III in collaboration with the Scientific Assessment Panel to the Montreal Protocol on Substances that Deplete the Ozone Layer" Cambridge University Press, UK. pp 373

WBCSD [World Business Council for Sustainable Development], 2007. "CO2 Emissions From Business Travel"

available at http://www.ghgprotocol.org

Acknowledgments

The author would like to thank Tina Chan of the UCB Department of Travel and Entertainment and Jan Tomlinson of Carlson Wagonlit Travel for providing useful data. Thanks also to Scott Zimmermann and Fahmida Ahmed of CalCAP and to Arpad Horvath of the UCB Civil and Environmental Engineering Department who provided useful discussion and suggestions.

Appendix O: Inventory Calculation - Water Consumption

By Scott Zimmermann
for Cal Climate Action Partnership
May 2007

Using the best research and data available to date, CalCAP developed a rough estimate of GHG emissions that result from campus waster consumption and wastewater discharges. At the time of the study, the California Climate Action Registry had not developed an official protocol for this calculation, so the latest research materials available from the US EPA and CEC were used to develop the estimate. The East Bay Municipal Utilities District (EBMUD) provides both water supply and treatment for the campus.

The emissions calculation is broken into two pieces:

1. CO_2 Emissions from Associated Electricity Consumption from Water Supply and Wastewater:

   The California Energy Commission released a report in December 2006 which documents electricity consumption associated with the various stages of the water and wastewater systems in the state: supply, conveyance, supply treatment, distribution, wastewater collection, wastewater treatment, and wastewater disposal. CalCAP relied on the expertise of Jen Stokes (UC Berkeley Research Fellow, PhD in Civil Engineering Department) and Susan Suzuki (EBMUD staff) to determine which factors from this report best fit UC Berkeley's (and EBMUD's) water systems. Once the electricity consumption was determined, the average electricity emissions factor used throughout the CalCAP study was applied to determine net GHG emissions.

2. N_2O and CH_4 Emissions from Human Sewage and Wastewater Treatment:

   In its annual inventory of US greenhouse gas emissions, the US EPA publishes a methodology for calculating N_2O and CH_4 emissions from human sewage and wastewater treatment. Those results were used to determine per capita emissions, and that factor was then used to develop an estimate of emissions from the UC Berkeley campus. It is assumed that 25 percent of each individual person's total emissions can be attributed to campus activities.

Table 1 shows the overall results of the GHG emissions associated with water and wastewater consumption, and projected emissions through 2020. Table 1 also details the electricity emissions calculations. Table 2 documents the non-CO_2 emissions from sewage and wastewater..

All assumptions and references are documented in detail below.

TABLE 1: UC Berkeley Inventory for Water and Wastewater Consumption

	Water (CCF)	Wastewater (CCF)	Water (MG)	Wastewater (MG)	Electricity Consumed - Water	Electricity Consumed - Wastewater	Emissions from Electricity (metric tons)	Emissions from CH2 and N2O (MT CO2e)	Total Emissions (MT CO2e)
1990	674,005	510,896	504	382	736,067	558,703	473	1055	1,528
1991	583,322	410,659	436	307	637,034	449,086	396	1073	1,469
1992	645,649	462,930	483	346	705,100	506,250	442	1103	1,545
1993	675,370	478,837	505	358	737,558	523,645	460	1120	1,581
1994	680,557	476,390	509	356	743,222	520,968	461	1126	1,588
1995	678,187	462,524	507	346	740,634	505,805	455	1150	1,605
1996	723,020	467,071	541	349	789,596	510,778	475	1179	1,653
1997	633,211	443,248	474	332	691,517	484,725	429	1217	1,646
1998	583,716	395,759	437	296	637,465	432,793	391	1261	1,652
1999	547,922	395,052	410	295	598,375	432,019	376	1308	1,684
2000	656,405	439,135	491	328	716,847	480,227	437	1326	1,763
2001	611,234	397,302	457	297	667,516	434,480	402	1372	1,774
2002	650,773	429,510	487	321	710,696	469,702	431	1436	1,867
2003	658,232	435,749	492	326	718,841	476,525	436	1454	1,890
2004	617,745	402,152	462	301	674,627	439,784	407	1428	1,835
2005	605,660	423,962	453	317	661,429	463,635	411	1465	1,876
2006	612,322	428,626	458	321	668,705	468,735	415	1505	1,920
2007	619,058	433,340	463	324	676,061	473,891	420	1525	1,945
2008	625,867	438,107	468	328	683,497	479,104	424	1545	1,970
2009	632,752	442,926	473	331	691,016	484,374	429	1566	1,995
2010	639,712	447,799	479	335	698,617	489,702	434	1586	2,020
2011	646,749	452,724	484	339	706,302	495,088	439	1607	2,045
2012	653,863	457,704	489	342	714,071	500,534	443	1628	2,071
2013	661,056	462,739	494	346	721,926	506,040	448	1648	2,097
2014	668,327	467,829	500	350	729,867	511,607	453	1669	2,123
2015	675,679	472,975	505	354	737,896	517,234	458	1691	2,149
2016	683,112	478,178	511	358	746,012	522,924	463	1712	2,175
2017	690,626	483,438	517	362	754,219	528,676	468	1733	2,202
2018	698,223	488,756	522	366	762,515	534,492	473	1755	2,228
2019	705,903	494,132	528	370	770,903	540,371	479	1777	2,255
2020	713,668	499,568	534	374	779,383	546,315	484	1799	2,283

Water Consumption - Sources and Assumptions:

- No water consumption data was provided for 1994 and 1997. The average of the previous 2 years and following 2 years was used to estimate.
- No wastewater discharge data was provided for 1994, 1007, or 2005. A 70% return was assumed for those years, which is the average return from the other 22 years for which data was provided.
- Consumption/discharge for 2006-2020 assumes BAU increases of 1.1% per year. This is based on the LRDP projection of 20% increase from 2002 to 2020.
- Water consumption (1990-2004) - Paul Black, Main Water Use History.XLS
- Water consumption (2005) - Paul Black, email dated 1/23/2007
- Wastewater discharges (1990-2004) - Paul Black, Main Water Use History.XLS

Electricity - Energy Usage Factors

Water

0	Supply (Surface Water)
160	Conveyance (Mokelumne Aqueduct)
100	Treatment (EPRI Average)
1200	Distribution (EPRI Average)
1460	**Total (kWh/MG)**

Wastewater

140	Wastewater Collection (Average)
1322	Wastewater Treatment (Activated Sludge)
0	Wastewater Disposal (Gravity Discharge)
1462	**Total (kWh/MG)**

Electricity - Sources and Assumptions:

- Electricity used in water and wastewater - Table 9, Urban Water Intensity Matrix, CEC - Refining Estimates of Water Related Energy Use in California, http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2006-118.html
- Wastewater treatment type - Discussion with Susan Suzuki, EBMUD, 1/23/2007
- Other matrix selections - Discussion with Jenn Stokes, UCB, 1/18/2007
- GHG Emissions Factor - Average EF for California taken from California Climate Action Registry Protocol.
- 0.365 GHG Emissions Factor for Electricity (kg CO2e/kWh)

TABLE 2: UC Berkeley Inventory for Non-Electricity Emissions Associated with Water and Wastewater

	US Population (million)	Total US N2O Emissions from Human Sewage (Tg CO2e)	Total US CH4 Emissions from Domestic WW Treatment (Tg CO2e)	Emissions per capita (metric tons/person)	Students	Faculty	Staff	Campus Population	Total Emissions, unweighted (MT CO2e)	Total Emissions, weighted (MT CO2e)
1990	254	12.9	11.4	0.096	30638	5458	8025	44120	4221	1055
1991				0.098	30372	5494	8067	43933	4292	1073
1992				0.100	30622	5530	8109	44262	4413	1103
1993				0.102	30341	5567	8152	44060	4481	1120
1994				0.104	29634	5604	8195	43433	4505	1126
1995				0.106	29630	5641	8238	43509	4601	1150
1996				0.108	29797	5678	8282	43757	4715	1179
1997				0.110	30290	5716	8325	44331	4866	1217
1998	280	14.9	16.4	0.112	31011	5754	8369	45134	5045	1261
1999	283	15.4	17.1	0.115	31347	5792	8413	45552	5231	1308
2000	286	15.5	17.8	0.116	31277	5830	8457	45565	5305	1326
2001	289	15.6	18.5	0.118	32128	5869	8502	46499	5487	1372
2002	292	15.6	19.1	0.119	33145	6514	8691	48350	5746	1436
2003	295	15.8	19.8	0.121	33076	6706	8418	48200	5817	1454
2004	297	16	20	0.121	32814	6068	8249	47131	5713	1428
2005				0.122	33558	6075	8251	47884	5861	1465
2006				0.124	33933	6256	8511	48700	6019	1505
2007				0.125	34026	6297	8556	48878	6100	1525
2008				0.126	34119	6339	8600	49058	6181	1545
2009				0.127	34212	6380	8645	49237	6262	1566
2010				0.128	34305	6422	8691	49418	6344	1586
2011				0.130	34399	6465	8736	49600	6427	1607
2012				0.131	34493	6507	8782	49782	6510	1628
2013				0.132	34587	6550	8828	49965	6594	1648
2014				0.133	34681	6593	8874	50149	6678	1669
2015				0.134	34776	6636	8921	50333	6763	1691
2016				0.136	34871	6680	8968	50519	6848	1712
2017				0.137	34966	6724	9015	50705	6934	1733
2018				0.138	35061	6768	9062	50892	7020	1755
2019				0.139	35157	6813	9109	51079	7107	1777
2020				0.140	35253	6858	9157	51268	7195	1799

Non-Electricity Emissions: Assumptions and Sources:

- Emissions per capita for 1991-1997 were linearly extrapolated from 1990 and 1998 data.
- Emissions per capita increases for 2005 and later were extrapolated from the running average of 2000-2004 changes.
- United States N2O and CH4 emissions are reported in INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990-2004 (April 2006) USEPA #430-R-06-002, http://epa.gov/climatechange/emissions/usinventoryreport.html
- Student, Faculty, and Staff populations are from https://osr2.berkeley.edu/menu_control/Topics/student_data/institutional_data.phtml. LRDP growth projection was applied to years before 1994 beyond 2005.
- On campus fraction of emissions for each person is 25% of their total. 75% of each person's waste is not attributed to campus activities.

Appendix P: Inventory Calculation - Landfilled Solid Waste

Method:

CalCAP applied the California Climate Action Registry Optional Reporting Protocol and more specific emissions factor analysis.

Data Source:

Lisa Bauer, Campus Recycling and Refuse Manager, provided us with annual waste disposal data for fiscal years FY 95-96 to FY 06-07. This data included the total tonnage of municipal solid waste that was sent to landfill each month.

Calculation:

The data was broken down by month, so we were able to sum monthly tonnage subtotals in order to generate numbers for each calendar year 1995 - 2006. For year 1995, data was only available for the second half of the year, so this number was doubled to generate an estimate for the entire year.

Emissions Factor

CalCAP applied an emissions factor from the EPA for landfilled waste with methane recovery and electric generation. This emissions factor is .1467 Metric Tons of CO_2 equivalent / Short Ton.

Note

All campus municipal solid waste is disposed of by landfill with methane recovery and electric generation (verified by Geoff Harrison of West Contra Costa Sanitary Landfill, where the campus sends its waste).

Appendix Q: Energy Intensity – 2006

The CalCAP study calculated a ranking for energy intensity based on KWh/gross square footage to identify the most energy intensive buildings on campus. This data is based on a utilities benchmarking report in 2006 complemented by GSF data from FDX. These are first 30 of 120 buildings on this list.

	Service Address	Total KWH in 2005	% of Total kwh usage	Building Area (GSF)	kWh/sq.ft.
1	KOSHLAND	9,555,661	4.60%	153700	62.17
2	SRB1 (2195 HEARST)	3,820,829	1.84%	69032	55.35
3	MCCONE	6,499,351	3.13%	123612	52.58
4	SILVER EXPAN	2,104,228	1.01%	43252	48.65
5	HILDEBRAND	5,674,532	2.73%	127494	44.51
6	BARKER	3,661,973	1.76%	86091	42.54
7	CORY	8,540,422	4.11%	206054	41.45
8	LSA	8,317,660	4.01%	201824	41.21
9	SODA	4,398,062	2.12%	109014	40.34
10	HEARST MINING	4,946,017	2.38%	141461	34.96
11	NW ANIMAL	1,805,212	0.87%	52845	34.16
12	TAN	3,844,407	1.85%	116121	33.11
13	LATIMER	6,030,561	2.90%	182943	32.96
14	SILVER	1,266,336	0.61%	44316	28.58
15	BIDWELL RD SS E/DOTY, RD 2M HAT CREEK	72,320	0.03%	2560	28.25
16	LSB	11,764,563	5.67%	418707	28.10
17	GILMAN	1,092,404	0.53%	44182	24.73
18	ETCHEVERRY	4,374,402	2.11%	177281	24.67
19	BIRGE	2,315,914	1.12%	97768	23.69
20	OXFORD TRACT	2,529,016	1.22%	109268	23.15
21	2554 HASTE ST, BERKELEY- People's park	16,666	0.01%	748	22.28
22	KING UNION - MLK	2,239,777	1.08%	110111	20.34
23	2607 HEARST EXT, BERKELEY	239,360	0.12%	12157	19.69
24	UNIV ART CTR	1,998,443	0.96%	102794	19.44
25	2108 ALLSTON EXT # 2NDFL, BERKELEY	351,760	0.17%	19403	18.13
26	NS SO 47TH HOFFMAN BLV, RICHMOND	4,565,785	2.20%	253660	18.00
27	TANG CENTER	1,350,788	0.65%	75228	17.96
28	HAAS PAVILION	4,066,170	1.96%	237845	17.10
29	MORGAN	930,543	0.45%	56637	16.43
30	HAAS BUSINESS	3,399,202	1.64%	213820	15.90

Appendix R: Lifecycle Analysis – UC Berkeley Climate Footprint

Christopher M. Jones
Berkeley institute of the Environment
May 2007

UC Berkeley's total climate impact extends well beyond the *direct* greenhouse gas (GHG) emissions from the burning of fossil fuels for energy and transportation. A full accounting will also include emissions resulting from the production of goods and services consumed, including food and on-site construction, plus the lifecycle of fossil fuels burned for energy and transportation.

The University's responsibility for these *lifecycle* emissions is not the same as its responsibility for direct emissions and is therefore a separate calculation in this report. The University directly burns fossil fuels in its campus vehicle fleet and is clearly directly responsible for those emissions. However, drilling, refining, processing and transporting those same fossil fuels also results in significant greenhouse gas emissions. To the extent that it would be difficult or impossible for an oil company to produce gasoline without producing these emissions, the University may consider itself to be *indirectly* responsible for these emissions[8]. The same is also true for other goods and services consumed by the University; just as gasoline requires the burning of fossil fuels for its production, so does food, construction materials, electronics, furniture, services, and everything else the University consumes.

CalCAP defines UC Berkeley's *climate footprint* as the sum of all direct and lifecycle emissions of greenhouse gases resulting from the production of everything consumed by the University. We have estimated this to be roughly 480,000 metric tons of carbon dioxide equivalent gases for 2006.

This appendix describes the lifecycle assessment methodology[9] in detail in order to make the assumptions of the calculation clear, and with the hope that the description of this methodology can facilitate replication at other institutions.

Lifecycle Emissions from Procurement

Estimating the environmental impact of goods and services requires a "lifecycle assessment" (LCA) approach. LCA methodologies allow for the incorporation of environmental impacts, including greenhouse gases, from all stages of a product's lifecycle, including mining, refining, manufacturing, transportation, retail, the "use" phase and end of life. From the standpoint of procurement for this greenhouse gas inventory, we are interested in all emissions occurring prior to the purchase of goods and services consumed by the University.

A standard approach to capture these emissions is to use Economic Input-Output Lifecycle Assessment (eiolca) to determine emissions coefficients for categories of purchases. EIOLCA is a

[8] Similarly, if the University were to switch to vehicles power by hydrogen or biofuels, the lifecycle greenhouse gas emissions from the production of those fuels should also clearly be considered.
[9] Jones (2005) provides additional information on the methodology and results of a climate footprint of the typical U.S. household.

free online tool developed by Carnegie Mellon University[10], and is available online at http://www.eiolca.net. EIOLCA provides greenhouse gas emissions estimates for 492 sectors of the U.S. economy.

A simple explanation of EIOLCA is as follows. All sectors of the U.S. economy are connected to all other sectors through a series of inputs and outputs. EIOLCA uses economic input-output tables provided by the U.S. Bureau of Economic Analysis to determine what fraction of emissions from all of these sectors can be attributed to the final sale of a product or service from any given sector. This provides an emissions value for a typical product or service from that sector (in grams of pollution per $). Interpreting these emissions factors requires understanding of a few basic simplifying assumptions of the calculation.

1) All estimates are for typical goods or services from that sector of the economy, rather than from specific individual products or services
2) All emissions are attributed to the consumer of the good or service
3) All emissions are estimated at the time of sale, rather than when they were actually emitted throughout the value chain
4) Imported goods are assumed to have the same emissions value as domestic goods
5) Emissions from transport to market and retail/wholesale trade are assumed to be the same as emissions from production[11]

To the extent that goods and services procured by the University are typical, on the aggregate, of similar goods and services in the U.S. economy, this approach provides a simple and cost-effective means of estimating emissions from campus procurement.

The UC Berkeley office of Procurement Services prepares an annual report of campus purchases in 130 categories of goods and services. The most recent report was for the fiscal year 2004-2005. By mapping University expenditures to the appropriate sectors in EIOLCA we get a good first approximation of emissions related to (or embodied in) goods and services consumed by the University.

The full spreadsheet used for this calculation is included on the following pages. GWP (for global warming potential) is the sum of all greenhouse gases included in the software tool (CO_2, CH_4, N_2O and CFCs) in units of carbon dioxide, based on their relative contribution of these gases to the greenhouse effect in the atmosphere (IPCC 2001). Total greenhouse gas emissions for each line item (measured in grams of GWP, or gGWP) are easily calculated by multiplying dollars spent by the emissions factor provided by EIOLCA (in grams of GWP per dollar, or GWP/$). Grams of CO_2/$ are also provided in the table below to show the relative contribution of carbon dioxide to other greenhouse gases.

---

[10] UC Berkeley professor and CalCAP member, Arpad Horvath, is one of the co-creators of this software. He has played an important advisory role in this research.

[11] Thee Berkeley Institute of the Environment's Lifecycle Environmental Assessment and Footprinting (LEAF) model corrects for this by providing separate emissions factors for transportation, wholesale and retail trade for 1,100 categories of consumers goods and services; however, this model was not available at the time of this study. See http://bie.berkeley.edu for more information on this model.

Item	Level 1 Category	Level 2 Category	Est. FY '04-05 Spend	I-O Code	EIOLCA Category	gGWP/$	gGWP	gCO2/$
1	ADMINISTRATIVE SERVICES	SECURITY SERVICES	842,104	561600	Investigation and security services	183	154,105,067	165
2	ADMINISTRATIVE SERVICES	ACCOUNTS RECEIVABLE SERVICES	744,164	52A000	Monetary authorities and depository credit intermediation	115	85,578,867	93
3	ADMINISTRATIVE SERVICES	RECORDS MANAGEMENT	164,151	541200	Accounting and bookkeeping services	146	23,966,030	123
4	ADMINISTRATIVE SERVICES	OTHER ADMINISTRATIVE SERVICES	90,493	561400	Business support services	325	29,410,082	294
5	ADMINISTRATIVE SERVICES	MEDICAL REVENUE RELATED	2,994	524100	Insurance carriers	84	252,411	69.2
6	ASSOCIATIONS, FOUNDATIONS & CHARIT	ASSOCIATIONS	4,266,444	813B00	Civic, social, professional and similar organizations	428	1,826,038,066	367
7	ASSOCIATIONS, FOUNDATIONS & CHARIT	INSTITUTES	971,344	541700	Scientific research and development services	284	275,861,665	239
8	ASSOCIATIONS, FOUNDATIONS & CHARIT	FOUNDATIONS	630,884	813A00	Grantmaking and giving and social advocacy organizations	294	185,479,814	258
9	ASSOCIATIONS, FOUNDATIONS & CHARIT	CHARITIES	481,217	813A01	Grantmaking and giving and social advocacy organizations	294	141,477,898	258
10	LIBRARY & BOOKX	LIBRARY INFORMATION SERVICES	6,062,913	514100	Information services	234	1,418,721,612	203
11	LIBRARY & BOOKX	BOOKSELLERS	2,186,586	511130	Book publishers	327	715,013,681	290
12	CONSTRUCTION	GENERAL CONTRACTING	144,069,464	230220	Commercial and institutional buildings	599	86,297,608,894	538
13	CONSTRUCTION	CONSTRUCTION MANAGEMENT	17,605,167	541610	Management consulting services	168	2,957,668,083	139
14	CONSTRUCTION	ARCHITECTURE	13,353,563	541300	Architectural and engineering services	144	1,922,913,115	125
15	CONSTRUCTION	ENGINEERING	4,797,519	541300	Architectural and engineering services	144	690,842,696	125
16	CONSTRUCTION	INTERIOR DESIGN	704,824	541400	Specialized design services	200	140,964,864	170
17	CONSTRUCTION	INDUSTRIAL EQUIPMENT	513,501	333120	Construction machinery manufacturing	683	350,721,122	587
18	CONSTRUCTION	DEMOLITION	84,471	230340	Other maintenance and repair construction	821	69,350,691	745
19	FACILITIES - goods	FURNITURE	5,819,437	337127	Institutional furniture manufacturing	626	3,642,967,600	537
20	FACILITIES - services	ELECTRICAL SERVICES	3,880,608	811200	Electronic equipment repair and maintenance	231	896,420,540	190
21	FACILITIES services	JANITORIAL PRODUCTS & SERVICES	3,279,944	561700	Services to buildings and dwellings	447	1,466,135,062	369
22	FACILITIES - services	HVAC/MECHANICAL SERVICES	1,264,869	561700	Services to buildings and dwellings	477	603,342,709	369
23	FACILITIES - goods	FLOORING & CARPETING	1,226,916	321918	Other millwork, including flooring	1,104	1,354,106,055	556
24	FACILITIES - services	PARKING	1,088,930	5419A0	All other miscellaneous professional and technical services	131	142,649,813	112
25	FACILITIES - services	WASTE DISPOSAL	961,742	562000	Waste management and remediation services	7,310	7,030,332,558	1500
26	FACILITIES - services	ROOFING SERVICES	823,018	230320	Maintenance and repair of nonresidential buildings	430	353,897,723	360
27	FACILITIES - services	PAINTING	750,545	230320	Maintenance and repair of nonresidential buildings	430	322,734,449	360
28	FACILITIES - services	LANDSCAPING	395,641	561700	Services to buildings and dwellings	447	176,851,742	369
29	FACILITIES - goods	WATER TREATMENT SUPPLIES & EQUIPME	170,030	333298	All other industrial machinery manufacturing	564	95,896,768	476
30	FACILITIES services	PLUMBING SERVICES	107,820	230340	Other maintenance and repair construction	821	88,520,015	745
31	FACILITIES - construction	MODULAR BUILDINGS	21,741	230210	Manufacturing and industrial buildings	588	12,783,943	530
32	FACILITIES - services	FACILITIES MANAGEMENT	227	541610	Management consulting services	168	38,146	139
33	FINANCIAL SERVICES	LEASING	3,117,046	52A000	Monetary authorities and depository credit intermediation	115	358,460,338	93
34	FINANCIAL SERVICES	BANKS	483,643	522A00	Monetary authorities and depository credit intermediation	211	102,048,570	186
35	FINANCIAL SERVICES	FINANCIAL SERVICES	94,657	522A00	Monetary authorities and depository credit intermediation	211	19,972,608	186
40	FOOD RELATED PRODUCTS & SERVICES	FOOD PRODUCERS & DISTRIBUTORS	11,789,175	722000	Food services and drinking places	816	9,619,966,857	501
41	FOOD RELATED PRODUCTS & SERVICES	CATERING	4,022,684	722000	Food services and drinking places	816	3,282,509,858	501
42	FOOD RELATED PRODUCTS & SERVICES	FOOD & DIETARY SERVICES	235,462	722000	Food services and drinking places	816	192,137,016	501
43	FOOD RELATED PRODUCTS & SERVICES	EQUIPMENT & SUPPLIES	141,211	722000	Food services and drinking places	816	115,228,078	501
44	FREIGHT, SHIPPING, & MAIL	COURIER	2,834,751	492000	Couriers and messengers	1,030	2,919,793,376	943
45	FREIGHT, SHIPPING, & MAIL	MOVING & STORAGE	1,556,099	493000	Warehousing and storage	1,330	2,069,612,202	1270
46	FREIGHT, SHIPPING, & MAIL	POSTAGE MACHINES	1,057,085	33331A	Automatic vending, commercial laundry and drycleaning machine	601	635,307,875	520
47	FREIGHT, SHIPPING, & MAIL	MAIL SERVICES	172,838	491000	Postal service	257	44,419,281	197
48	FREIGHT, SHIPPING, & MAIL	FREIGHT	74,630	484000	Truck transportation	2,120	158,214,900	2010
49	GENERAL MEDICAL SUPPLIES & EQUIPMI	MEDICAL SURGICAL SUPPLY DISTRIBUTION	2,834,886	339113	Surgical appliance and supplies manufacturing	433	1,227,505,577	342
50	GENERAL MEDICAL SUPPLIES & EQUIPMI	STERILIZATION EQUIPMENT & SERVICES	66,604	339114	Surgical appliance and supplies manufacturing	433	28,839,623	342
51	GENERAL MEDICAL SUPPLIES & EQUIPMI	HOSPITAL BEDS, TABLES & EQUIPMENT	27,881	337127	Institutional furniture manufacturing	626	17,453,725	537
52	INFORMATION TECHNOLOGY & TELECON	IT MANUFACTURERS - Goods	20,234,728	334111	Electronic computer manufacturing	416	8,417,646,956	287
53	INFORMATION TECHNOLOGY & TELECON	IT DISTRIBUTORS - Goods	4,607,694	514100	Electronic computer manufacturing	416	1,916,800,696	287
54	INFORMATION TECHNOLOGY & TELECON	LOCAL & LONG DISTANCE - Services	4,394,597	513300	Telecommunications	179	786,632,927	155
55	INFORMATION TECHNOLOGY & TELECON	NETWORK HARDWARE & INTEGRATION PR	4,346,238	514200	Electronic computer manufacturing	416	1,808,034,808	287
56	INFORMATION TECHNOLOGY & TELECON	IT PROFESSIONAL SERVICES - services	1,486,690	514100	Information services	234	347,885,502	203
57	INFORMATION TECHNOLOGY & TELECON	EQUIPMENT & INSTALLATION - services	1,208,981	514100	Information services	234	282,901,559	203
58	INFORMATION TECHNOLOGY & TELECON	CABLE TV PROVIDER - services	1,042,183	513200	Cable networks and program distribution	192	200,099,194	167
59	INFORMATION TECHNOLOGY & TELECON	WIRELESS - services	908,267	514100	Information services	234	212,534,586	203
60	INFORMATION TECHNOLOGY & TELECON	IT CONTRACT LABOR - services	334,995	514100	Information services	234	78,388,860	203
61	INFORMATION TECHNOLOGY & TELECON	DATA - services	49,594	514200	Data processing services	154	7,637,434	132
62	INSURANCE & BENEFITS	PROPERTY/CASUALTY	5,786,510	524098	Insurance carriers	84	487,802,796	69.2
63	INSURANCE & BENEFITS	HEALTH INSURANCE	2,823,544	524099	Insurance carriers	84	238,024,781	69.2
64	INSURANCE & BENEFITS	INSURANCE SERVICES	80,299	524100	Insurance carriers	84	6,769,191	69.2
65	INSURANCE & BENEFITS	OTHER BENEFITS	14,556	524101	Insurance carriers	84	1,227,037	69.2
66	LINENS & APPAREL	PURCHASES & RENTALS	1,087,452	812300	Drycleaning and laundry services	675	748,166,838	548
67	LINENS & APPAREL	APPAREL	331,753	315200	Cut and sew apparel manufacturing	688	223,933,370	557
68	MEDICAL SERVICES	REFERRAL LABS	403,409	621A00	Offices of physicians, dentists, and other health practioners	169	272,301,048	138

69	MEDICAL SERVICES	MEDICAL CONTRACTED SERVICES	120,599	621A01	Offices of physicians, dentists, and other health practioners	169	20,381,150	138
70	MEDICAL SERVICES	PATIENT TRANSPORTATION SERVICES	8,420	621B00	Other ambulatory health care services	378	3,182,760	310
71	MRO SUPPLIES & PRODUCTS	ELECTRICAL EQUIPMENT & LIGHTING	2,175,174	335120	Lighting fixture manufacturing	624	1,357,308,769	530
72	MRO SUPPLIES & PRODUCTS	GENERAL MRO SUPPLIERS	1,802,525	332500	Hardware manufacturing	615	1,108,553,004	519
73	MRO SUPPLIES & PRODUCTS	HVAC EQUIPMENT	1,074,605	333415	AC, refrigeration, and forced air heating	676	726,432,642	545
74	MRO SUPPLIES & PRODUCTS	PUMPS, COMPRESSORS & POWER GENER/	880,119	333911	Pump and pumping equipment manufacturing	561	493,747,028	477
75	MRO SUPPLIES & PRODUCTS	SECURITY	604,344	335999	Miscellaneous electrical equipment manufacturing	600	362,606,394	495
76	MRO SUPPLIES & PRODUCTS	TOOLS & HARDWARE	575,148	332212	Hand and edge tool manufacturing	624	358,892,177	530
77	MRO SUPPLIES & PRODUCTS	PLUMBING SUPPLIES	280,623	32619A	Plastics plumbing fixtures and all other plastics products	814	228,427,423	683
78	MRO SUPPLIES & PRODUCTS	PIPES, VALVES & FITTINGS	172,991	332996	Fabricated pipe and pipe fitting manufacturing	836	144,620,117	731
79	MRO SUPPLIES & PRODUCTS	INDUSTRIAL MATERIAL HANDLING	167,906	332500	Hardware manufacturing	615	103,262,393	519
80	MRO SUPPLIES & PRODUCTS	LUMBER & CARPENTER SUPPLIES	161,953	332500	Hardware manufacturing	615	99,601,187	519
81	MRO SUPPLIES & PRODUCTS	SAFETY SUPPLIES	131,515	332500	Hardware manufacturing	615	80,882,026	519
82	MRO SUPPLIES & PRODUCTS	PAINT	130,390	325510	Paint and coating manufacturing	1,180	153,859,716	972
83	MRO SUPPLIES & PRODUCTS	INDUSTRIAL PLUMBING	67,667	32619A	Plastics plumbing fixtures and all other plastics products	814	55,080,726	683
84	MRO SUPPLIES & PRODUCTS	FIXTURE PLUMBING	53,042	32619A	Plastics plumbing fixtures and all other plastics products	814	43,176,098	683
85	MRO SUPPLIES & PRODUCTS	ADHESIVES, SEALANT & TAPE	40,903	325520	Adhesive manufacturing	1,120	45,811,819	917
86	MRO SUPPLIES & PRODUCTS	WIRE & RIGGING SUPPLY	12,884	335930	Wiring device manufacturing	605	7,795,062	511
87	MRO SUPPLIES & PRODUCTS	PNEUMATICS & HYDRAULICS	11,790	326210	Tire manufacturing	1,090	12,851,460	940
88	MRO SUPPLIES & PRODUCTS	OUTDOOR EQUIPMENT	5,945	333298	All other industrial machinery manufacturing	564	3,352,997	476
89	OFFICE EQUIPMENT	COPIERS & FAXES	3,040,654	334210	Telephone apparatus manufacturing	300	912,196,329	234
90	OFFICE EQUIPMENT	AUDIO/VISUAL	1,765,159	334300	Audio and video equipment manufacturing	574	1,013,201,025	464
91	OFFICE RELATED PRODUCTS	OTHER OFFICE SUPPLY COMPANIES	2,047,061	339940	Office supplies, except paper, manufacturing	605	1,238,472,002	531
92	OFFICE RELATED PRODUCTS	MAJOR RETAIL OFFICE SUPPLY COMPANIE	1,856,906	339940	Office supplies, except paper, manufacturing	605	1,123,428,118	531
93	OFFICE RELATED PRODUCTS	PAPER SUPPLIERS	1,287,734	3221A0	Paper and paperboard mills	1,940	2,498,203,611	1750
94	PHARMACEUTICALS	PHARMACEUTICAL MANUFACTURERS & DIS	297,216	325400	Pharmaceutical and medicine manufacturing	449	133,450,119	369
95	PHARMACEUTICALS	BIOPHARMACEUTICAL DISTRIBUTOR	91,023	325400	Pharmaceutical and medicine manufacturing	449	40,869,273	369
96	PRINTED MATERIALS & PUBLISHING	COMMERCIAL PRINTING	2,615,313	32311A	Commercial printing	730	1,909,178,519	642
97	PRINTED MATERIALS & PUBLISHING	PUBLISHERS	1,369,950	511130	Book publishers	327	447,973,745	290
98	PRINTED MATERIALS & PUBLISHING	PRINT JOURNALS	771,023	511120	Periodical publishers	305	235,161,881	267
99	PRINTED MATERIALS & PUBLISHING	DOCUMENT SERVICES	747,742	511120	Periodical publishers	305	228,061,356	267
100	PRINTED MATERIALS & PUBLISHING	PUBLISHING SERVICES	621,752	511130	Book publishers	327	203,312,848	290
101	PRINTED MATERIALS & PUBLISHING	BOOKBINDING MACHINERY	247,517	333293	Printing machinery and equipment manufacturing	491	121,530,641	412
102	PRINTED MATERIALS & PUBLISHING	UNIVERSITY PRESS	126,626	511130	Book publishers	327	41,406,777	290
103	PROFESSIONAL SERVICES	CONSULTING	5,588,263	541610	Management consulting services	168	938,828,125	139
104	PROFESSIONAL SERVICES	ADVERTISING & MARKETING	4,278,811	541800	Advertising and related services	195	834,368,051	162
105	PROFESSIONAL SERVICES	LEGAL SERVICES	2,550,808	541100	Legal services	135	344,359,027	116
106	PROFESSIONAL SERVICES	EXECUTIVE SEARCH	505,844	541610	Management consulting services	168	84,981,740	139
107	REAL ESTATE	LEASING/RENT	6,188,486	531000	Real estate	236	1,460,482,729	383
108	REAL ESTATE	REAL ESTATE BROKERAGE MANAGEMENT	34,110	5419A0	All other miscellaneous professional and technical services	131	4,468,410	112
110	SCIENTIFIC SUPPLIES & EQUIPMENT	LABORATORY EQUIPMENT, SUPPLIES, & CH	17,909,876	334516	Analytical laboratory instrument manufacturing	383	6,859,482,443	324
111	SCIENTIFIC SUPPLIES & EQUIPMENT	LABORATORY SUPPLIES MANUFACTURERS	6,181,158	334516	Analytical laboratory instrument manufacturing	383	2,367,383,656	324
112	SCIENTIFIC SUPPLIES & EQUIPMENT	LABORATORY SUPPLIES DISTRIBUTION	5,218,374	334516	Analytical laboratory instrument manufacturing	383	1,998,637,418	324
113	SCIENTIFIC SUPPLIES & EQUIPMENT	GASES	1,227,701	325180	Other basic inorganic chemical manufacturing	2,120	2,602,726,692	1970
114	SCIENTIFIC SUPPLIES & EQUIPMENT	ANIMAL CARE	753,057	541940	Veterinary services	408	307,247,346	320
115	SPECIALTY MEDICAL SUPPLIES & EQUIPI	CLINICAL DIAGNOSTIC EQUIPMENT & SUPP	771,222	339111	Laboratory apparatus and furniture manufacturing	523	403,349,347	444
116	SPECIALTY MEDICAL SUPPLIES & EQUIPI	MEDICAL DEVICE MANUFACTURERS	221,289	339113	Surgical appliance and supplies manufacturing	433	95,818,289	342
117	SPECIALTY MEDICAL SUPPLIES & EQUIPI	MEDICAL SUPPLIES & DISTRIBUTION	217,749	339113	Surgical appliance and supplies manufacturing	433	94,285,282	342
118	SPECIALTY MEDICAL SUPPLIES & EQUIPI	SURGICAL INSTRUMENTATION & SUPPLIES	212,010	339111	Laboratory apparatus and furniture manufacturing	523	110,881,382	444
119	SPECIALTY MEDICAL SUPPLIES & EQUIPI	IMAGING SUPPLIES	136,319	339112	Surgical and medical instrument manufacturing	362	49,347,359	308
120	SPECIALTY MEDICAL SUPPLIES & EQUIPI	RADIATION ONCOLOGY & NEUROSURGERY	16,757	334510	Electromedical apparatus manufacturing	392	6,568,920	328
121	SPECIALTY MEDICAL SUPPLIES & EQUIPI	ORTHOPEDIC SUPPLIES & EQUIPMENT	6,540	339112	Surgical and medical instrument manufacturing	362	2,367,589	308
122	SPECIALTY MEDICAL SUPPLIES & EQUIPI	IMAGING EQUIPMENT	3,165	334510	Electromedical apparatus manufacturing	392	1,240,484	328
123	SPECIALTY MEDICAL SUPPLIES & EQUIPI	RESPIRATORY & ANESTHESIA PRODUCTS	587	339112	Surgical and medical instrument manufacturing	362	212,371	308
124	TEMPORARY LABOR & SERVICES	ADMINISTRATIVE LABOR	302,633	561300	Employment services	41	12,468,489	36
125	TEMPORARY LABOR & SERVICES	NURSING & ALLIED HEALTH STAFFING	716	561300	Employment services	41	29,499	36
126	TRAVEL & ENTERTAINMENT	CONFERENCE & EVENTS	8,079,410	713A00	Other amusement, gambling, and recreation industries	324	2,617,728,846	272
127	TRAVEL & ENTERTAINMENT	ENTERTAINMENT	4,617,685	713A00	Other amusement, gambling, and recreation industries	324	1,496,129,998	272
128	OTHER	BLOOD & BLOOD PRODUCTS	5,376	621B00	Other ambulatory health care services	378	2,032,075	310
129	OTHER	DONOR PRODUCTS & SERVICES	4,638	813B00	Civic, social, professional and similar organizations	428	1,984,906	367
130	OTHER	Not Otherwise Categorized	36,687,903			533	19,571,092,986	410
	Grand Total		422,098,122				208,125,683,899	

The following items were not included in the calculation for procurement:

Item	Level 1 Category	Level 2 Category	Est. FY '04-05 Spend
	GOVERNMENT	LOCAL	1,816,682
	GOVERNMENT	FEDERAL	996,586
	GOVERNMENT	STATE	604,024
	GOVERNMENT	INTERNATIONAL	10,273
	PASS-THRU		43,198,778
	PAYMENTS TO INDIVIDUALS		2,985,572
	TRAVEL & ENTERTAINMENT	TRAVEL CARD	551,943
	TRAVEL & ENTERTAINMENT	AIRLINES	401,679
	TRAVEL & ENTERTAINMENT	CAR RENTAL	218,041
	TRAVEL & ENTERTAINMENT	AGENCY	195,721
	TRAVEL & ENTERTAINMENT	TRANSPORTATION	89,293
	UNIVERSITIES, MEDICAL CENTERS & NAT	UC SYSTEM	8,008,223
	UNIVERSITIES, MEDICAL CENTERS & NAT	NON T&E EXPENDITURES	3,924,074
	UNIVERSITIES, MEDICAL CENTERS & NAT	OUTSIDE UC SYSTEM	2,363,721
	UTILITIES	ELECTRICITY	25,818,189
	UTILITIES	WATER & SEWAGE	3,528,694
	UTILITIES	NATURAL GAS	1,576,877
36	FLEET	MAINTENANCE & PARTS	600,668
37	FLEET	FUEL & LUBRICANTS	565,983
38	FLEET	CHARTER BUSES	558,012
39	FLEET	VEHICLES	420,840
109	RESEARCH		69,678,373

Explanation:

- <u>Government:</u> Taxes and other money spent on the government sector are not considered providers of services for this calculation. Estimating the portion of US government emissions attributable to UC Berkeley would require further study.
- <u>Payments to Individuals:</u> Employees are not considered service providers that provide inputs as a separate sector in this analysis and are therefore not included.
- <u>Travel:</u> The Office of Procurement Services may only account for a small portion of total travel expenses by faculty, staff and students. This area requires further study in future calculations. Indirect emissions from air travel are described below.
- <u>Universities, Medical Centers & Nature Reserves:</u> Payments to other Universities are not included in this assessment in order to avoid double counting. It is hoped that other Universities will apply a similar methodology, in which case UC Berkeley exports of services to other universities with their own accounting would be counted twice.
- <u>Utilities:</u> Lifecycle emissions from utilities are described below.
- <u>Fleet:</u> Lifecycle emissions from fuel from the UC Berkeley fleet are described below. Emissions from maintenance, charter services were excluded from this calculation, but should be included in future climate footprint estimates
- <u>Research:</u> Research was ultimately not included in this assessment in order to avoid double counting should other universities undertake similar assessments. Inclusion of research could have added an additional 19,000 metric tons of CO_2e to the total UCB climate footprint.

Lifecycle Emissions from Electricity

Electricity

For calculating the lifecycle emissions for purchased electricity, a separate electricity emissions factor was calculated from 40 years of plant operations from different power plants in lower Colorado basin (Pacca and Horvath, 2002).

An alternative commensurate method using EIOLCA is also possible as follows. EIOLCA estimates total GHG emissions at 10,500 grams GWP per dollar for the Power Generation and Supply sector. Emissions estimates from this sector represent the U.S. average of all "direct" emissions from the burning of fossil fuels at power plants, plus all lifecycle emissions from mining, refining and processing the fuel, and the portion of emissions from all other sectors of the economy attributable to the Power generation and supply sector.

We calculate an inflation factor to estimate UC Berkeley's lifecycle emissions based on a comparison of EIOLCA values and average direct emissions factors for electricity in the United States.

EIOLCA (lifecycle + direct)
10,050g CO_2/\$ = 1,050 gCO_2e/kWh at an average price of \$0.10 per kWh.

U.S. Average Direct Emissions
The U.S. energy mix is estimated to have direct emissions of about 600 gCO_2/kWh (EPA 2002).

1,050/600 = 1.75

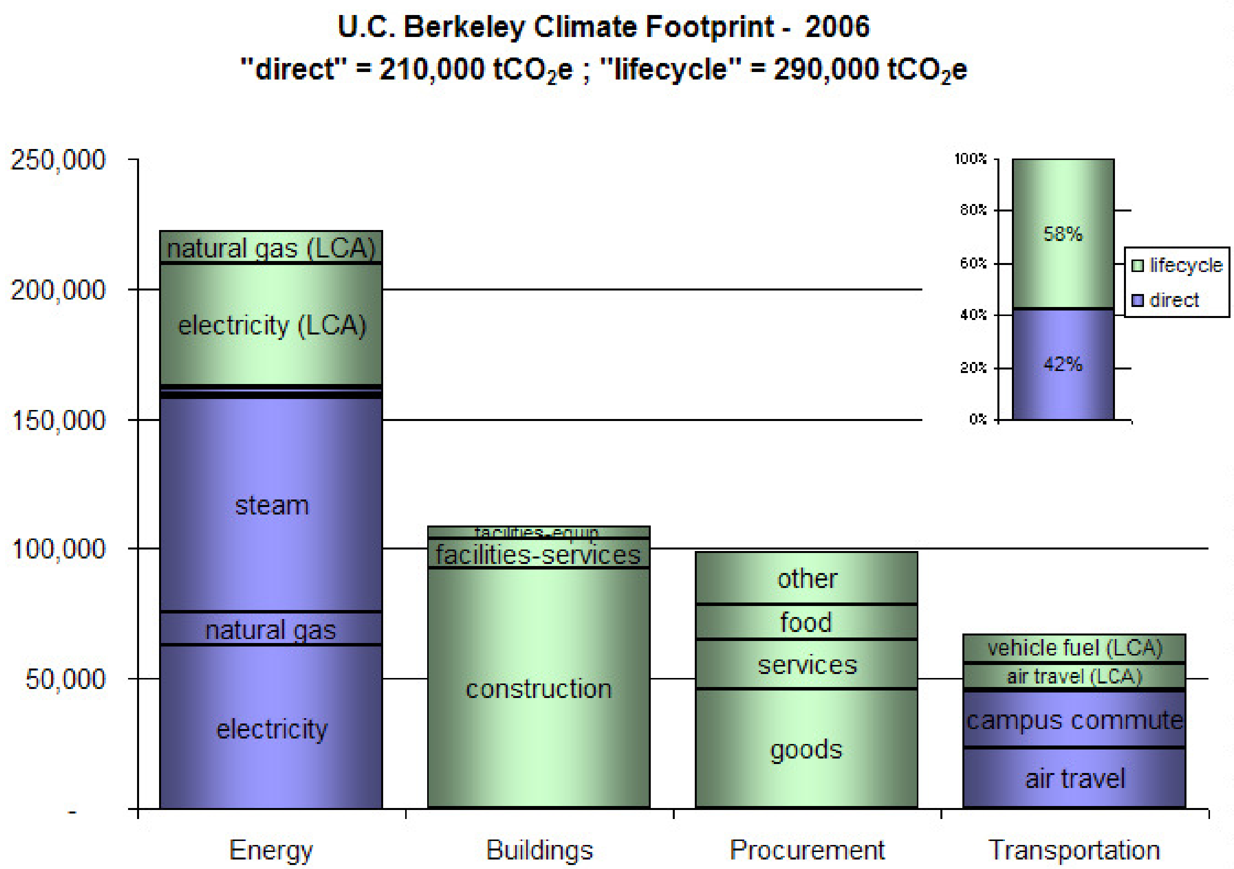
We therefore multiply UC Berkeley's direct emissions from electricity by 1.75 to account for all direct and lifecycle emissions from electricity.

63,000 tCO_2 x 1.75 = 110,000 tCO_2 (63,000 tCO_2 from the direct burning of fossil fuels and transmission and 47,000 additional tCO2e from the lifecycle of fuel and power plant operations)

Towards a Full Climate Footprint:

Lifecycle Emissions from gasoline (campus fleet + commute), air transportation and natural gas are not included in the above assessment for lack of data at the time of publication. The figure below is a first attempt to calculate the full climate footprint of UC Berkeley using the following lifecycle inflation factors (in addition to lifecycle work described above):

Category	Lifecycle GWP inflation factor
Gasoline	1.5
Air transport	1.4
Natural gas	2



The total climate footprint, according to this methodology, is roughly 500,000 metric tons of carbon dioxide equivalent gases for 2006. Lifecycle emissions account for 58% of the total.

Discussion and Recommendations

An important lesson from this study is that every dollar spent by the University indirectly results in the emission of greenhouse gases. Understanding the relative contribution of those decisions to the University's overall climate footprint can lead to a range of mitigation strategies for decision-makers (i.e. everyone) at the University.

An obvious way to reduce lifecycle emissions would simply be to reduce the amount of goods and services consumed. In some case this may be a viable approach, particularly when the consumption is wasteful, i.e. it provides no additional value to the user. Printing on both sides of paper is an example of a simple way to reduce waste. In other cases, such as the construction of a new building, reducing consumption may not be a viable alternative. In either case, including the environmental impacts in this decision-making process can be helpful, particularly in the context of University-wide policy to reduce greenhouse gas emissions from campus activities.

Another way to reduce impact is to consider the goods and service providers themselves. All similar goods and services are not produced under the same manufacturing conditions (as is assumed with the current methodology). Purchasing locally-produced goods, food and services reduces greenhouse gas emissions from transport. Products manufactured using energy produced largely from coal (e.g. in China or large areas of the United States) will have a larger impact than products manufactured in places with less carbon-intensive fuel mixes (e.g. France or California). Manufacturers may also make different investments in energy efficiency or renewable energy, or produce goods with less carbon-intensive materials or processes. Over time, the University may begin to incorporate this information into decision-making.

Finally, we hope that this climate footprint methodology will help University students, staff and faculty understand the relative contribution to the campus's greenhouse gas impact and also to think about how personal decisions may influence the total.

Individuals may also find the Berkeley Institute of the Environment's "Lifecycle Climate Footprint Calculator" (available at http://bie.berkeley.edu) to be a useful way to monitor their own personal climate footprints. This calculator incorporates emissions factors based on consumer decisions at the retail level (i.e. based on consumer dollars spent) and includes emissions from production, transport to market, and wholesale and retail trade.

References:

BIE (2007). Berkeley Institute of the Environment website: http://bie.berkeley.edu

CalCAP (2007). CalCAP website: http://calcap.berkeley.edu

Cicas, G., Matthews, H.S., & Hendrickson, C. (2006). "The 1997 Benchmark Version of the Economic Input-Output Life Cycle Assessment (EIO-LCA) Model". Green Design Institute, Carnegie Mellon University. Downloaded 5/2007 at: http://www.eiolca.net/data.html

Jones, C.M. (2005). "A Lifecycle Assessment of U.S. Household Consumption: The Methodology and Inspiration Behind the "Consumer Footprint Calculator" (December 1, 2005). University of California International and Area Studies. Breslauer Symposium.Paper 8. http://repositories.cdlib.org/ucias/breslauer/8

Junnila, S. and A. Horvath (2003). "Environmental Sensitivity Analysis of the Life-cycle of an Office Building," *2nd International Symposium "Integrated Life Cycle Design of Materials and Structures - ILCDES,"* 2003, Kuopio, Finland.

EPA (2003). EGRID 2002 version 2.01. U.S. Environmental Protection Agency, Washington, DC. http://www.epa.gov/cleanenergy/egrid.htm
IPCC (2001). "Third Assessment Report (TAR) "Climate Change 2001" Intergovernmental Panel on Climate Change. Available online at: http://www.ipcc.ch/pub/reports.htm

Appendix S: CalCAP Projects

Annual Scalable Projects: Offsets and Renewable Energy Credits

Category (by emissions source)	UC Department	Specific Projects	Description / Calculation Method	Capital Cost	Annual Operating Cost (HR)	Annual Operating Cost (Other)	Annual Savings (often in avoided costs)	Annual Net Cost (excluding one time capital)	Simple Payback (years)	n= total years in the project	Total NPV	Levelized Annual Cost	NPV $ / Annual MT CO2e	Annual $ / Annual MT CO2e	Annual GHG Reduction Potential (metric ton CO2 e)
all	all	**Purchase Carbon Offsets for campus energy use** (to reach neutrality in 2014)	Local and national carbon offsets ranking was estimated from "A Consumer Guide to Carbon Offsets", 2006 using the US and UK average from the top certified providers.	$ -	$ 2,000	$ 2,162,000	$ -	$ 2,163,000	n/a	n/a	$ 36,053,000	$ 2,163,000	$ 0.000	$ 13	$ 161,000
electricity	Facilities Services	**Purchase Off-site Renewables -** Renewable Energy Credits or Greentags (to reach 100% of 2006 level of energy consumption)	Renewable Energy Credit Purchases for the main campus electricity account. (About 45% of UC Berkeley's non renewable energy portfolio for main campus (~80,000,000 KWh)	$ -	$ 3,000	$ 5,233,000	$ -	$ 5,236,000	n/a	n/a	$ 87,271,000	$ 5,236,000	$ 1.000	$ 83	$ 63,000
			Annual	**$ -**	**$ 5,000**	**$ 7,395,000**	**$ -**	**$ 7,399,000**			**$ 123,324,000**	**$ 7,399,000**			**$ 224,000**

Capital Projects

Category (by emissions source)	UC Department	Specific Implementation Recommendation	Description / Calculation Method	Capital Cost	Annual Operating Cost (HR)	Annual Operating Cost (Other)	Annual Savings (often in avoided costs)	Annual Net Cost (excluding one time capital)	Simple Payback (years)	n= total years in the project	Total NPV	Levelized Annual Cost	NPV $ / Annual MT CO2e	Sorted by Annual $ / Annual MT CO2e	Annual GHG Reduction Potential (metric ton CO2 e)
electricity	Facilities Services	**Capital Projects :** Less energy use through better water conservation technology (SCALABLE)	Install new technologies or retrofit current infrastructure for higher levels of water conservation in university restrooms (**~75%** of campus toilets are non low flow toilet. If retrofitted, they can yield a saving of 100,000 CCF, with 3 metric tons CO2e per 1000 CC.)	$ 1,142,000	$ -	$ -	$ 298,000	$ (298,000)	3.8	8	$ (711,359)	$ (114,554)	$ (284)	$ (366)	313
electricity	IST	**Capital Projects - Install Energy Star** (EPA) computer settings (SCALABLE, assuming about 10,000 computers campus wide)	Energy Star Setting and active sleep/standby mode management (free software available from EPA). Assume **10000 computers** * (245 watts – 10 watts saved) * 10 hours/day * 365.	$ -	$ 5,000	$ 5,000	$ 772,000	$ (762,000)	0.0	n/a	$ (12,706,000)	$ (762,000)	$ (5,000)	$ (295)	2,582
electricity	Facilities Services	**Capital Projects - Monitoring based commissioning** (SCALABLE, currently at 50% capacity)	Expand existing program that analyzes operation of building HVAC systems to locate and correct inefficiencies. (**5,000,000 GSF**, $.25 /GSF, saves up to 4,000,000 kwh annually).	$ 1,250,000	$ 6,000	$ 6,000	$ 360,000	$ (347,000)	3.6	8	$ (906,000)	$ (146,000)	$ (0,000)	$ (121)	1,204
Steam	Facilities Services	**Capital Projects - Perform survey of CoGen plant** steam capture and repair	Steam trap survey and repair (**1200 trap placement**, with a potential savings of 80,000 therms or 8000 BBTU)	$ 50,000	$ 3,000	$ 3,000	$ 56,000	$ (50,000)	1.0	8	$ (258,000)	$ (42,000)	$ (5,000)	$ (66)	632
electricity	Facilities Services	**Capital Projects - Install Automated Lighting Controls** (SCALABLE)	Install a variety of lighting controls to reduce operating hours of lighting systems. Included would be motion sensing, light sensing and wireless based control technologies. (**25% of campus total load of 30000 units**, 1000 reduced run time, $1000 /unit).	$ 7,500,000	$ 5,000	$ 5,000	$ 675,000	$ (665,000)	11.3	15	$ 1,037,000	$ 107,000	$ 0,000	$ 47	2,258
electricity	Facilities Services	**Capital Projects – Fluorescent lighting retrofits** (SCALABLE, CURRENTLY 50% OF CAMPUS)	Installation of high frequency efficient ballast in fluorescent lighting fixtures (**50,000 units**, saves 36 kWh per unit installed).	$ 1,750,000	$ 6,000	$ 6,000	$ 162,000	$ (149,000)	11.7	15	$ 301,000	$ 31,000	$ 0,000	$ 57	542
renewable -solar	Facilities Services	**Capital Projects - Install on-site PV System** (MMA Renewable Ventures) - SCALABLE	PV Power generation (~7612 kW maximum capacity unit system, 4,788,000 KWh savings with a MMA Renewable PPA quote of $0.12/KWh). Estimation based on roof space.	$ -	$ 6,000	$ 575,000	$ 431,000	$ 150,000	n/a	n/a	$ 2,501,000	$ 150,000	$ 2,000	$ 104	1,441
			Annual	**$ 11,692,000**	**$ 32,000**	**$ 600,000**	**$ 2,754,000**	**$ (2,122,000)**	**5.5**		**$ (10,743,000)**	**$ (777,000)**			**8,971**

Behavioral Projects

Category (by emissions source)	UC Department	Specific Projects	Description / Calculation Method	Capital Cost	Annual Operating Cost (HR)	Annual Operating Cost (Other)	Annual Savings (often in avoided costs)	Annual Net Cost (excluding one time capital)	Simple Payback (years)	n= total years in the project	Total NPV	Levelized Annual Cost	NPV $ / Annual MT CO2e	sorted by Annual $ / Annual MT CO2e	Annual GHG Reduction Potential (metric ton CO2 e)
Fleet	Administration	**Campus Behavior - Introduce Fleet Biking** (VERY SCALABLE)	Reduce amount of fleet driving. Purchase **15 bicycles** to replace 15 sedans and supply to interest departments.	$ 4,000	$ -	$ 0,000	$ 86,000	$ (85,000)	0.0	8	$ (527,000)	$ (85,000)	$ (25,000)	$ (31,657)	3
Fleet	Administration	**Campus Behavior - Expand electric vehicle fleet** (VERY SCALABLE)	Purchase **20 smaller** all electric vehicles (Chrysler GEM) through existing/new vendor contracts.	$ 210,000	$ -	$ 10,000	$ 205,000	$ (195,000)	1.1	8	$ (1,000,000)	$ (161,000)	$ (8,000)	$ (9,696)	17
commuting	Administration	**Campus Behavior:** Implement High Priority Bicycle Plan Projects & Programs (VERY SCALABLE)	Campus Bicycle Plan identifies bicycle programs and projects aimed at increasing bicycle commuting over the next 15 years, as outlined in the 2020 LRDP. This will introduce **500 bicycles** replacing 125 cars.	$ 450,000	$ -	$ 50,000	$ 212,000	$ (162,000)	2.8	8	$ (557,000)	$ (90,000)	$ (1,000)	$ (727)	123
electricity	all	**Campus Behavior - Department Level Energy Reduction Effort**	Following the Harvard model, this would be an interfaculty program, working within the decentralized structure of the campus to drive campus energy conservation efforts.	$ 1,340,000	$ 70,000	$ 100,000	$ 700,000	$ (530,000)	2.5	8	$ (1,951,000)	$ (314,000)	$ (0,000)	$ (628)	500
air travel	Administration	**Campus Behavior - Increase utilization of videoconference room(s)**	The Dwinelle Hall videoconference Room is **90% underutilized**. Complete usage of the room can save up to 75 K/year in air travel.	$ -	$ 18,000	$ 18,000	$ 75,000	$ (40,000)	0.0	n/a	$ (664,000)	$ (40,000)	$ (6,000)	$ (348)	114
electricity	Facilities Services	**Campus Behavior**: Increasing occupant awareness and electricity curtailment (VERY SCALABLE)	Increase occupant awareness by building public data, baseline awards, outreach campaign and efficient use of energy management system (**saves 3%** of ~180,000,000 kWh main campus energy use).	$ 300,000	$ 6,000	$ 6,000	$ 486,000	$ (473,000)	0.6	15	$ (4,296,000)	$ (442,000)	$ (0,000)	$ (272)	1,625
Solid waste	Facilities Services	**Campus Behavior - Introduce Campus Composting program** (SCALABLE)	Compostable wastes are generated in kitchens, bathrooms, from Grounds operations, and in the form of animal wastes from labs. Providing expanded composting collection for these wastes can divert up to 2000 tons of waste to composting.	$ -	$ -	$ 327,000	$ 100,000	$ 227,000	n/a	n/a	$ 3,776,000	$ 227,000	$ 13,000	$ 770	294
			Annual	**$ 2,304,000**	**$ 94,000**	**$ 511,000**	**$ 1,864,000**	**$ (1,259,000)**	**1.8**		**$ (5,220,000)**	**$ (906,000)**			**2,677**
		All 14 Projects	**Annual Total (rounded to nearest million)**	**$14,000,000**	**$126,000**	**$ 1,000,000**	**$5,000,000**	**$ (3,000,000)**	**4.1**		**$(16,000,000)**	**$(2,000,000)**			**11,648**

(Please visit website to access the spreadsheet)

Appendix T: CalCAP Project Ranking

Each project was ranked according to the 6 key criteria:

1. $/Metric ton GHG reduction (snapshot below of the 19 projects CalCAP completed collecting data for)
2. Capital Cost
3. Annual Savings
4. Simple payback
5. total Net Present Value
6. Annual GHG Reduction Potential

SORTED by $ /Metric Ton

Capital Projects	Capital Cost	Annual Savings (often in avoided costs)	Simple Payback (years)	Total NPV (net cost*factor) + one time capital cost	University $ / Metric Tonne CO2 e	Annual GHG Reduction Potential (metric ton CO2 e)
Introduce Fleet Biking	3750	85618	0	-526991	-24573	3
Expand electric vehicles fleet	210000	204907	1	-1000335	-7527	17
Perform survey of CoGen plant steam capture and repair cracks	50000	56000	1	-258006	-5194	632
Behavior Modification: Implement High Priority Bicycle Plan Projects & Programs	450000	212226	3	-557390	-564	123
Conserve water: less energy use through better water conservation	1141981	298454	4	-711359	-284	313
Promote Conservation: Increasing occupant awareness and electricity curtailment	300000	486000	1	-4295836	-176	1625
Promote conservation - Monitoring based commissioning (electricity)	1250000	360000	4	-906040	-94	1204
Install Automated Lighting Controls	7500000	675000	11	1037470	31	2258
Promote Conservation – Fluorescent lighting retrofits.	1750000	162000	12	300932	37	542
Replace CRT computer monitors replace with LCD monitors	600000	63000	12	288268	171	211
Department Level Energy Reduction Effort	1340000	700000	3	1340000	335	500
Convert the sedan class into sedan hybrids	120000	6978	n/a	156154	803	24
Annual Capital Projects						
Increase utilization of videoconference room	0	75064	0	-664400	-5807	114
Install Energy Star (EPA) computer settings (10000 computers campus wide)	0	771975	0	-12706250	-4921	2582
Go 100% PG&E	0	0	0	12612633	1328	9495
Install on-site PV System (MMA Renewable Ventures)	0	430920	0	2500667	1735	1441
Reducing direct construction emissions contributed by transportation - changing contract	0	0	0	41667	2083	20
Introduce Campus Composting program	0	100000	0	3775750	12825	294
Continue and expand AC Transit Bear Pass (Alameda Contra Costa Transit Unlimited Ric	0	0	0	2650000	19166	138

Based on this raking, numbers were assigned to the projects (1 being the most attractive). This produced a scorecard with ranking for all 6 criteria.

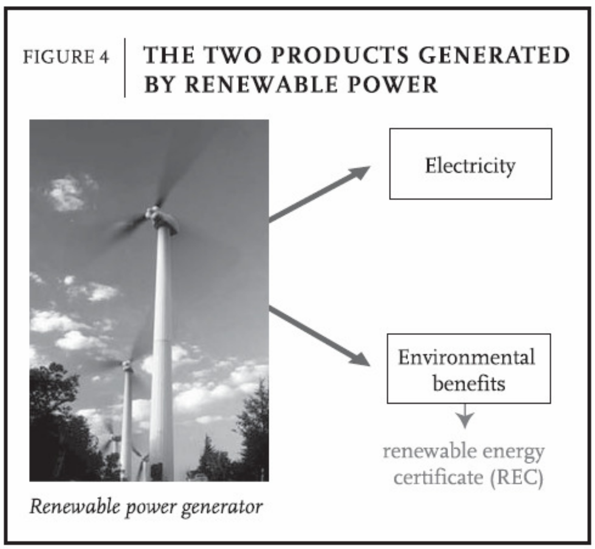
REC Instead

High Potential Projects Report Card - 1 means most favorable								SUBJECTIVE	
Capital and Campus Projects	Capital Cost	Annual Savings (often in avoided costs)	Simple Payback (years)	Total Net Present Value	University $ / Metric Ton CO2 e	Annual GHG Reduction Potential (metric	Average Ranking	Bonus point for Campus Visibility (to be subtracted)	Final Ranking
Increasing occupant awareness and electricity curtailment	5	3	2	1	6	2	3	2	1
Expand electric vehicles fleet	4	7	2	2	2	11	5	2	3
Implement High Priority Bicycle Plan Projects & Programs	6	6	3	5	4	9	6	2	4
Introduce Fleet Biking	1	9	1	6	1	12	5	1	4
Monitoring based commissioning (electricity)	9	4	4	3	7	3	5	1	4
Less energy use through better water conservation	8	5	4	4	5	7	6	1	5
Install Automated Lighting Controls	12	2	5	11	8	1	7	2	5
Perform survey of CoGen plant steam capture and repair	2	11	2	7	3	4	5	0	5
Department Level Energy Reduction Effort	10	1	3	12	11	6	7	2	5
Fluorescent lighting retrofits.	11	8	6	10	9	5	8	2	6
~~Replace CRT computer monitors replace with LCD monitor~~	~~7~~	~~10~~	~~7~~	~~9~~	~~10~~	~~8~~	~~9~~	~~2~~	~~7~~
~~Convert the sedan class into sedan hybrids~~	~~3~~	~~13~~	~~8~~	~~8~~	~~13~~	~~10~~	~~9~~	~~1~~	~~8~~
Annual Projects									
Install Energy Star (EPA) computer settings		1		1	2	2	2	2	-1
Install on-site PV System (MMA Renewable Ventures)		2		4	4	3	3	2	1
Increase utilization of videoconference room		4		2	1	6	3	1	2
Introduce Campus Composting program		3		6	6	5	5	2	3
Go 100% PG&E		5		7	3	1	4	1	3
~~Continue and expand AC Transit Bear Pass~~		~~5~~		~~5~~	~~7~~	~~4~~	~~5~~	~~1~~	~~4~~
~~Reducing construction emissions contributed by transportation~~		~~5~~		~~3~~	~~5~~	~~7~~	~~5~~	~~0~~	~~5~~

An average of all the ranks were calculated to see the relative ranking of the projects based on the quantitative criteria. However, knowing that not all decisions are based on qualitative considerations, we applied +1 or +2 points to projects that would have great appeal to the campus community. Ranking both the criteria into account, a final ranking was determined. We removed the bottom two performers from each category, plus the 100% PG&E possibility in favor of Renewable Energy Credits.

Appendix U: Renewable Energy Credits

"Renewable energy certificates (RECs), also known as "green tags," "green certificates," and "renewable energy credits," are a relatively new but increasingly popular method of supporting green power. Renewable energy generates two products: electricity and the technology and environmental benefits associated with renewable energy generation (see figure 4 below). These benefits are generally referred to as environmental "attributes" and may include a reduction in the air pollution and particulate matter that would have been generated by burning fossil fuels as well as a reduction of greenhouse gas emissions. The electricity and attributes can be sold together, in retail green power programs, or they can be sold separately. RECs represent the technology and environmental attributes of renewable energy and allow customers greater flexibility in "greening" their electricity. That is, customers can continue to purchase their electricity from their existing suppliers and "green" it by supporting a renewable energy source of their choosing" (WRI, 2006).



"Renewable power facilities sell the electricity they generate into the wholesale power market, where it is then bought by retail electricity providers and sold to customers. RECs are sold either directly to retail electricity providers or to third-party REC suppliers. When retail electricity providers sell electricity plus RECs to a customer, the product being sold is green power. If RECs are not sold along with the electricity, the product being sold is conventional electricity. In other words, the "greenness" of renewable power follows the REC. If a company can claim ownership of the REC, it also can claim the environmental benefits of the associated green power" (WRI, 2006).

Special note: As of 2006, UC Santa Cruz is 100% green using RECs.

(Source: The above excerpts are taken directly from a report by World Resources Institute, *SWITCHING TO GREEN: A RENEWABLE ENERGY GUIDE FOR OFFICE AND RETAIL COMPANIES*, published in October 2006.)

Appendix V: Carbon Offsets Analysis

By Anna Motschenbacher
Master's Candidate 2008
Energy Resource Group

Offsets are described as the process of reducing the net carbon emissions through arrangements with a carbon-offset provider specializing in projects that retire or capture carbon from the atmosphere.

Types of Offsets
Offset vendors may sell carbon offsets in different ways, including:

- Renewable energy projects
- Energy efficiency projects
- Bio-sequestration projects, such as forestation.

Vendors sell offsets in specific units, provide on-site emission calculators, or allow you to enter in the amount of carbon to offset.

Why Offsets are Controversial
Voluntary offsets can be purchased from many organizations, but the lack of formal regulation of this market means that all voluntary offsets are not equal. Purchasing voluntary offsets requires due diligence to ensure:

- **Additionality** – offset credits are only awarded to projects that would not have otherwise happened.
- **Permanence** – offsets cannot be reversed, this consideration is especially important for sequestration projects.
- **Ownership** – offsets are only counted and sold once, they should receive credit under multiple accounting schemes.
- **Verification** – offset projects can be monitored and their quality verified by independent parties.

Plus, vendors use different standards to guarantee the quality of their offsets, including:

- Clean Development Mechanism (CDM)
  - A flexible compliance mechanism of the Kyoto Protocol, CDM supports offset projects in developing countries,
  - Stringent and robust standards with strict additionality requirements,
  - High transaction costs, so projects are usually large.
- Voluntary Gold Standard
  - Developed by a group of NGOs,
  - Designed to have higher standards than CDM - does not certify sequestration projects,
  - Certifies offset projects in developing countries,
  - Requires third party monitoring and verification of projects with strict additionality requirements,

    - High transaction costs, so projects are usually large.
- Green-e
    - Run by US non-profit Center for Resource Solutions,
    - Sets standards and verifies renewable energy projects in US,
    - Certifies Renewable Energy Credits (RECs),

<u>All Offsets are not Made Equal</u>

Since climate change is a global issue, the geographic location of an offset does not affect its efficacy to offset emissions leaving quality the most important factor for adjudicating offsets. Differences among offset vendors complicate generalizations. Offset vendors may:

- Offset carbon emissions in different ways, including:
    - Renewable energy,
    - Energy efficiency,
    - Bio-sequestration, such as forests.
- Sell offsets in specific units, provide on-site emission calculators, or allow you to enter in the amount of carbon to offset.
- Use different standards to guarantee the quality of their offsets, including:
    - Clean Development Mechanism (CDM)
        - A flexible compliance mechanism of the Kyoto Protocol, CDM supports offset projects in developing countries,
        - Stringent and robust standards with strict additionality requirements,
        - High transaction costs, so projects are usually large.
    - Voluntary Gold Standard
        - Developed by a group of NGOs,
        - Designed to have higher standards than CDM - does not certify sequestration projects,
        - Certifies offset projects in developing countries,
        - Requires third party monitoring and verification of projects with strict additionality requirements,
        - High transaction costs, so projects are usually large.
    - Green-e
        - Run by US non-profit Center for Resource Solutions,
        - Sets standards and verifies renewable energy projects in US,
        - Certifies Renewable Energy Credits (RECs),

- Calculate emissions in different ways. Numerous factors affect the quantity of emissions from air travel, including distance, type of plane, multiplier for radiative forcing, and more. The Tufts Climate Initiative found **atmosfair**, **climate friendly**, **myclimate** (Swiss site), and **NativeEnergy** to have either excellent or very good calculators. Many other calculators underestimate emissions.
- Offer different degrees of transparency into their selection of projects and overhead costs.

Comparison of Offset Vendors

Two recent reports, from the Tufts Climate Initiative and Clean Air-Cool Planet have examined a number of offset vendors. While these comparisons included different vendors (the latter being more inclusive because it was not limited to air travel offsets) and ranked the vendors on somewhat different criteria, including quality of offsets and price per ton of carbon offset, their findings offer

Tufts Climate Initiative

Atmosfair*†

Better World Club

CarbonCounter.org

Carbonfund

CarbonNeutral Company

Cleanairpass

Climate Care

Climate Friendly

Myclimate/Sustainable Travel

NativeEnergy

Offsetters

SELF - Solar Electric Light Fund

Terrapass

* Italics indicate evaluation by both reports.
† Bold indicates the vendor received the report's highest ranking.

Clean Air-Cool Planet

AgCert/DrivingGreen

Atmosclear

Atmosfair

Bonneville Environmental Foundation

Carbon Clear

Carbon Neutral Company

Carbon Planet

Carbonfund

Certified Clean Car

Climate Care

Climate Friendly

Climate Neutral Group

Climate Trust

ClimateSAVE

co2balance

Conservation Fund: Go Zero

DriveNeutral

e-BlueHorizons

Envirotrade/Plan Vivo

Greenfleet

Leonardo Academy

Myclimate/Sustainable Travel

NativeEnergy

Natsource/Dupont/BlueSource

Offsetters

SELF – Solar Electric Light Fund

Terrapass

TIST – Int'l Small Group & Tree Planting Service

World Land Trust

Of the 4 vendors that received the Tufts Climate Iniative's recommendation without reservation and the 8 best vendors identified by the Clean Air-Cool Planet report, 3 received the support of both: Atmosfair, Myclimate/Sustainable Travel, and NativeEnergy.

Atmosfair – www.atmosfair.de – $55.64/ton CO2 (2.120 tons of CO2)[12]
A German non-profit that focuses on air travel offsets. Projects comply with CDM and meet the Gold Standard. Projects include both renewable energy and energy efficiency. This website is the least user friendly and has a few translation errors.

Myclimate/Sustainable Travel – www.sustainabletravelinternational.org – $15.25/ton CO2 (1.51 tons of CO2)
Myclimate is based in Switzerland, Sustainable Travel is the North American distributor; information here pertains to Sustainable Travel where the two differ. Projects comply with CDM and meet the Gold Standard. The Tufts Climate Institute notes that the Swiss site provides a better calculator and has more expensive offsets.

NativeEnergy – www.nativeenergy.com – $14.25/ton CO2 (2.526 tons of CO2)
NativeEnergy is a for-profit, Native American energy company that supports Native American, farmer-owned, and community-run renewable energy projects. NativeEnergy offers both Renewable Energy Credits and offsets. Projects have Green-e certification.

Additional Useful References

Voluntary Offsets for Air-Travel Carbon Emissions: Evaluations and Recommendations of Voluntary Offset Companies, a report from the Tufts Climate Initiative that provides a more extensive examination of air travel offsets, available at www.tufts.edu/tie/tci/pdf/TCI_Carbon_Offsets_Paper_Jan07.pdf.

A Consumer's Guide to Retail Carbon Offset Providers, a report from Clean Air-Cool Planet that examines the quality of specific voluntary offset vendors, available at www.cleanair-coolplanet.org/ConsumersGuidetoCarbonOffsets.pdf.

[12] All values are based on a roundtrip flight between San Francisco (SFO) and Washington, DC (DCA) based on the calculators provided by the website. The values are given to show the variability in online calculators. Price for atmosfair converted from Euros.

Appendix W: Water Conservation Project Analysis

by Kristen Durham
Energy Resource Group

Install new technologies or retrofit current infrastructure for higher levels of water conservation in university restrooms, laboratories, residence halls and dining facilities, in addition to improving heating, ventilating and air conditioning (HVAC) and irrigation systems

Facts and Assumptions

Replacing and upgrading water infrastructure at UCB is a cost-effective way to reduce water consumption and associated greenhouse gas emissions. When coupling foregone utilities expenses with conservation programs offered through the East Bay Municipal Utilities District (EBMUD), most opportunities presented within this report have a short payback period (less than four years) and long-term environmental benefits.

The content of this report largely reflects the findings of a water audit conducted by Ms. Jubilee Daniels (Master of Landscape Architecture 2005) during her study at UCB, whose results were presented in "A Sustainable Water Plan for the University of California Berkeley".[13]

Quantitative Evaluation

Water consumption had been on a general decline at UC Berkeley from 1979 to 2003, though during the period 1999-2003 main campus water use increased by 20 percent (110,310 CCF (100 cubic feet)) (Daniels 2005). Normalized, this is a 3 gallon per person per day increase (up from 26 to 29 gallons). Additionally, there is an anticipated 20 percent increase in consumption above 2002 levels by 2020 (totaling 782036 CCF/year). With 85 percent of the campus gross square feet planned for 2020 already built, the focus of water conservation efforts needs to be placed on existing infrastructure. As the quantitative findings of the work by Ms. Daniels focus primarily upon restroom upgrades and retrofits, so too does this short evaluation. While this leaves out a wide array of areas for potential savings that must also be considered (laboratory upgrades, irrigation improvements, etc.), it does highlight what can be considered the most immediately significant and long-lasting opportunities for savings. In total, improvements presented below are estimated to provide water savings of 100,839 CCF per year at a deferred utilities savings of $298,454 per year.[14]

The water audit of the University of California Berkeley's main campus restrooms shows the potential for UC Berkeley to reduce its water consumption and wastewater production on the main campus by 13 percent (166,191 gallons per day (gpd)), resulting in more than $235,000 in saved

[13] Daniels, Jubilee. "A Sustainable Water Plan for the University of California Berkeley: a Professional Report for the Chancellor's Advisory Committee on Sustainability." May 2005

[14] This savings calculation is based on utilities rates as of the writing of "A Sustainable Water Plan for the University of California Berkeley." It can be reasonably assumed that water rates will increase in the future as supply is anticipated to decrease, making savings more valuable in terms of deferred payments for water and wastewater service.

utilities spending with payback period of 4.5 years. Residential halls have 28,789 gpd savings potential, worth greater than $47,000 a year and having an overall payback period of 3.4 years.

1. Water and Monetary Savings Available from Main Campus New Low-flow/No-flow Toilet and Urinal Installations

Currently, toilets at UC Berkeley use from 1.6 gallons per flush (gpf) to 7 gpf. With high-efficiency, low-flow technology using just 1.6 gpf, main campus restrooms have the potential to reduce water consumption by 50,537 CCF per year. Likewise, installing no-flow urinals can save 30,560 CCF per year in water consumption.

	Total population	Female/male population	Population using non-low-flow toilets and/or urinals	Water consumption 3.5 gpf toilets or 2.0 gpf urinals	Water consumption 1.6 gpf toilets or 0 gpf urinals	Annual water savings, CCF	Annual water savings, gallons	$ annual savings	Hardware costs ($400/fixture)	Labor costs ($74/hour, 4 hours/fixture)	Hardware and labor costs	Payback period without EBMUD rebate, years
Female Toilets	47,034	23,517	16,227	68,334	31,239	37,096	27,747,708	107,578	237,200	177,900	415,100	3.9
Male Toilets	47,034	23,517	17,638	25,089	11,469	13,441	10.053518	38,978	167,200	125,400	292,600	7.5
Male Urinals	47,034	23,517	19,049	30,937	0	30,560	22,858,524	88,623	202,400	151,800	354,200	4.0
Totals				**124,360**	**42,708**	**81,096**	**60,659,750**	**235,178**	**606,800**	**455,100**	**1,061,900**	**4.5**

(Based upon the following assumptions: Water and Wastewater costs $2.90/CCF, Restroom User Rate (female): 3x per day, Restroom User Rate (male): 1x per day toilet, 2x per day urinal[15], Year: 300 days, Toilets/Urinals Hardware Costs: $400/fixture, Labor: $74/hour, 4 hours/replacement, Combined Hardware and Labor Costs: $700/fixture)

2. Water and Monetary Savings Available from Main Campus Toilet Maintenance

Significant savings can be realized through maintenance of previously installed water conserving devices. Of the 1.6 gpf toilets installed on the main campus, many do not function at their optimum due to age, use and other deterioration factors. By installing new flush-valve kits and performing other general maintenance, 5,702 CCF of water can be saved per year, amounting to $16,537 in annual utility bills. With such a high level of water savings over costs, the payback period for performing these upgrades is estimated to only be roughly half of a year.

	Total population	Female/male population	Population using leaking 1.6 gpf toilets	Water consumption with leaks	Water consumption with maintenance	Annual water savings, CCF	Annual water savings, gallons	$ annual savings	Hardware costs ($15/repair kit)	Labor costs ($74/hour, 1 hour/ repair)	Hardware and labor costs	Payback period without EBMUD rebate, years
Female	47,034	23,517	1,750	7,368	3,368	4,000	2,991,927	11,600	930	4,588	5,518	0.5
Male	47,034	23,517	2,234	3,136	1,434	1,702	1,273,446	4,937	780	3,848	4,628	0.9
Totals						**5,702**	**4,265,372**	**16,537**	**1,710**	**8,436**	**10,146**	**0.6**

(Based upon the following assumptions: Water and Wastewater costs $2.90/CCF, Restroom User Rate (female): 3x per day, Restroom User Rate (male): 1x per day toilet, 2x per day urinal, Year: 300 days, Toilets/Urinals Repair Kit Costs: $15/kit, Labor: $74/hour, 1 hour/repair, Combined Hardware and Labor Costs: $89/fixture)

[15] For all water use data (times toilet used per day, length of faucet used per day): Vickers, Amy. Handbook of Water Use and Conservation. Amherst, MA: Water Plow Press. 2001.

3. Water and Monetary Savings Available from Residential Hall New Low-flow Toilet Installations

Similar to savings available through new toilet installations on the main campus, residential halls have the same opportunity to reduce water consumption. By upgrading current infrastructure, 7,520 CCF water can be saved at a value of $24,568 per year.

	# toilets per unit	% of toilets that use >1.6 gpf	# of students using toilets >1.6 pf	Excess water use per year CCF	Excess utility spending/year	Cost of 1st year maintenance	Savings 1st year	Savings 2nd year	Payback period
Unit 1	120	49	464	1,801	6,125	3,445	2,680	6,125	0.56
Unit 2	120	24	233	904	2,072	1,690	1,383	3,073	0.55
Unit 3	162	100		4,815	16,371	64,800	16,371	16,371	3.96
Totals				**7,520**	**24,568**	**69,935**	**20,434**	**25,569**	**2**

(Based upon the following assumptions: Water and Wastewater costs $3.40/CCF, Restroom User Rate: 5.1x per day, Year: 300 days, Toilets Hardware Costs: $15/repair kit (Units 1 & 2), $250/fixture (Unit 3), Labor: $50/hour, 1 hour/replacement kit (Units 1 & 2), 3 hours/replacement (Unit 3), Combined Hardware and Labor Costs: $700/fixture)

4. Water and Monetary Savings Available from Residential Hall Faucet Upgrades

High levels of faucet use in residential halls provides another opportunity for savings through conservation. By installing free faucet aerators from EBMUD, water consumption from washing hands, brushing teeth, etc. can be reduced by 6,521 CCF per year, at an annual cost savings of $22,171.

	# faucets per unit	% faucets using >1.0 gpm	# of students using faucets > 1.0 gpm	Excess water use per year CCF	$ Utility savings/year
Unit 1	120	37	350	1880	6,392
Unit 2	136	100	969	2548	8,663
Unit 3	160	100	920	2093	7,116
Totals				**6,521**	**22,171**

(Based upon the following assumptions: Water and Wastewater costs $3.40/CCF, Faucet User Rate: 8.1 minutes per day, Year: 300 days, Free aerator hardware from EBMUD with minimal installation time

Qualitative Evaluation:

1. Timeline for project

While these savings can be realized as soon as an installation or repair is made, current university staff will not be able to fulfill the additional duties of performing upgrades and maintenance. With an estimated installation time of 4 hours per fixture, demand on the main campus would require someone dedicated full-time to water conservation projects to work 40 hours/week for 3 years before all of the new toilet and urinal installations would be complete. Repair and maintenance work is projected to require much less work, and would extend time for all main campus water conservation work by approximately 3 weeks. By adding new staff, the installations can be more quickly pursued, however demand for these people's labor will likely significantly decline after the initial installations are finished.

2. Other Conservation Opportunities

As suggested previously, the analysis provided within this report is limited in scope. Many improvements can be made at UCB by focusing on main campus restrooms, however other beneficial water conservation projects abound. The following is a short list of additional technologies and conservation strategies that can help to reduce the university's water consumption and related GHG emissions.

General Use Buildings
- Install push-rod faucets
- Install or retrofit aerators on faucets
- Allow for more local control over HVAC
- Install or retrofit showerheads and faucets in RSF (?)

Laboratories
- Install or retrofit equipment to non-once through cooling
- Eliminate disincentives for laboratories to hook up to campus cooling tower

Landscape
- Install moisture sensors for irrigation equipment
- Replace current plant species with drought-tolerant species
- Allow more irrigation control for onsite landscapers

Residential Halls
- Install push-rod faucets
- Install water efficient clothes washers

Dining Facilities
- Install or retrofit pre-rinse sprayers to more efficient models (Crossroads dining hall facility conserves approximately 30,000 gallons/day compared to traditional water use products. Replacement of 35 pre-rinse spray nozzles is estimated to have saved 10,500 gallon per day ($9,300 utility costs/year)). (Daniels 2005)
- Install water efficient dish washers

Additional Areas of Interest
- Grey water capture, storage and irrigation (Marrying irrigation and grey water use could offset the average 180,000 gallons/day of water consumed. A water recycling center proposed for installation under the bleachers of Edwards Stadium will produce 25,000 gallons of usable grey water per day, at an estimated $7500 annual savings.) (Daniels 2005)
- Purchase recycled water from EBMUD
- Increased sub-metering for encouraging economic and behavioral responses to consumption information

3. Partnership Opportunities with EBMUD[16]
- High-use pre-rinse spray nozzles free replacement

[16] EBMUD water conservation programs' details accessed at http://www.ebmud.com/conserving_&_recycling/.

- Irrigation audit related rebates—Customers who participate in a landscape irrigation audit may qualify for rebates of 50 to 100 percent of the materials cost of installing water-efficient irrigation equipment.

50% EBMUD Rebate	**75% EBMUD Rebate**	**100% EBMUD Rebate**
Irrigation controllers	Drip Irrigation Equipment	Moisture Sensors
Matched Precipitation Rate Sprinkler Heads	Pressure Regulation Devices	Rain Shut-off Devices
Sub-meters		Check Valves
		Nozzles

- High efficiency clothes washer rebate (purchased or signed lease agreement Jan-June 2007); $150 per qualifying washer for multi-family properties and other businesses
- General commercial rebates available for up to one-half the installed cost of equipment that improves water efficiency such as retrofitting cooling towers, and replacing water-cooled with air-cooled equipment. Any hardware change that will result in predictable water savings may be eligible.
- Recycled water purchasing

Appendix X: CalCAP Scenarios

Scenario Matrix

	Percent of Identified Investment	Capital Cost	Annual Costs (Savings)	Simple Payback	Annual Emissions Reduction	Berkeley Target in 2014			AB 32 in 2020		
						% below 2000	Emissions Level	% below 1990	% below 2000	Emissions Level	% below 1990
# 1: Do Nothing											
Capital & Behavioral Projects	0%	$ -	$ -		-						
RECs	0%	$ -	$ -		-						
Offsets	0%	$ -	$ -		-						
Total		$ -	$ -	n/a	-	15%	226,402	(35%)	9%	240,255	(44%)
#2: AB 32 with Projects and Offsets											
Capital & Behavioral Projects	100%	$ 13,995,731	$ (3,381,310)		11,648						
RECs	0%	$ -	$ -		-						
Offsets	40%	$ -	$ 816,397		60,713						
Total		$ 13,995,731	$ (2,564,913)	5.5	72,361	42%	154,041	8%	37%	167,894	(0%)
# 3: AB 32 Using Just Offsets (Least Capital Cost)											
Capital & Behavioral Projects	0%	$ -	$ -		-						
RECs	0%	$ -	$ -		-						
Offsets	48%	$ -	$ 979,676		72,856						
Total		$ -	$ 979,676	n/a	72,856	42%	153,546	8%	37%	167,399	0%
# 4: Berkeley Target with Projects and RECs											
Capital & Behavioral Projects	100%	$ 13,995,731	$ (3,381,310)		11,648						
RECs	75%	$ -	$ 3,927,181		47,228						
Offsets	0%	$ -	$ -		-						
Total		$ 13,995,731	$ 545,871	n/a	58,876	37%	167,526	(0%)	32%	181,379	(8%)
# 5: Projects Only											
Capital & Behavioral Projects	100%	$ 13,995,731	$ (3,381,310)		11,648						
RECs	0%	$ -	$ -		-						
Offsets	0%	$ -	$ -		-						
Total		$ 13,995,731	$ (3,381,310)	4.1	11,648	19%	214,754	(28%)	14%	228,607	(37%)
# 6: Some Projects (balancing annual savings)											
Capital & Behavioral Projects	100%	$ 13,995,731	$ (3,381,310)		11,648						
RECs	65%	$ -	$ 3,403,557		40,931						
Offsets	0%	$ -	$ -		-						
Total		$ 13,995,731	$ 22,247	n/a	52,579	34%	173,823	(4%)	29%	187,676	(12%)
# 7: Expand Project Identification											
Capital & Behavioral Projects	200%	$ 27,991,462	$ (6,762,620)		23,295						
RECs	100%	$ -	$ 5,236,242		62,971						
Offsets	0%	$ -	$ -		-						
Total		$ 27,991,462	$ (1,526,379)	18.3	86,266	47%	140,135	16%	42%	153,988	8%
# 8: Some Projects and all RECs											
Capital & Behavioral Projects	50%	$ 6,997,866	$ (1,690,655)		5,824						
RECs	100%	$ -	$ 5,236,242		62,971						
Offsets	0%	$ -	$ -		-						
Total		$ 6,997,866	$ 3,545,587	n/a	68,795	41%	157,607	6%	35%	171,460	(2%)
# 9: Neutrality in 2014											
Capital & Behavioral Projects	100%	$ 13,995,731	$ (3,381,310)		11,648						
RECs	100%	$ -	$ 5,236,242		62,971						
Offsets	100%	$ -	$ 2,040,992		151,783						
Total		$ 13,995,731	$ 3,895,924	n/a	226,402	100%	-	100%	95%	13,853	92%

(Please visit website to access the spreadsheet)

Appendix Y: University Leadership

General comments:

- In March 2007, UC Berkeley, along with other UCs, have signed the American College and University President Climate Commitment (ACUPCC), which calls universities to reduce greenhouse gas emissions at their institutions, ultimately leading to climate neutral campuses.
- UC Berkeley's peer schools on the East Coast have established targets, but it is not clear from public documents what baseline they have used to set their targets.
- Most of the UCs joined the California Climate Action Registry in 2006 and have not published preliminary indications of what emissions sources or targets they are looking into.

[All signatories of ACUPCC have now made commitments.]

Institution & target adoption	Commitment	What are they counting in their emissions inventory	Source
UC Berkeley (Chancellor Announcement April 2007)	Compliance with Governor's Executive Order: ▪ 2000 levels by 2010 ▪ 1990 levels by 2020 ▪ 80% below 1990 by 2050	CCAR required: Purchased electricity, natural gas, purchased steam, campus fleet Fugitive emissions CCAR optional: waste disposal, staff/faculty auto commute, student auto commute, air travel, water consumption	CalCAP
Stanford University	Not committed to any specific target	CCAR required: Purchased electricity, natural gas, purchased steam, campus fleet Fugitive emissions CCAR optional: staff/faculty auto commute, student auto commute	Personal Interview with inventory manager on Feb 20, 2006.
Harvard University	Not committed to any specific target	Purchased electricity, Purchased steam, Natural gas, Fleet, Refrigerants, Commute, Air travel, Solid waste	"Green House Gas Inventory" Harvard Green Campus Initiative
Cornell University (Apr. 2001)	7% below 1990 levels by 2008	Information not publicly available	-
Middlebury College (May 2004)	8% below 1990 levels by 2012 (on a per student basis)	Electricity Consumption Fleet Solid Waste Commute	M. Douglas Dagan "A Summary of Energy Consumption and Greenhouse Gas Emissions at Middlebury College"

Tufts University (Apr. 1999 and 2004)	7% below 1990 levels by 2012 and 4% below 1998-2001 baseline by 2006	Electricity, Heating, Transportation (commute), Agriculture Comment: Tufts does not explicitly state what sources they are using in their trend analysis, but it seems that they are considering all sources (electricity, heating, transportation, and agriculture) in quantifying their progress toward their targets.	"Tufts University Greenhouse Gas Inventory: 2006 Update" Tufts Climate Initiative
Yale University (Oct. 2005)	10% below 1990 levels by 2020	Power generation, Electricity, steam, and chilled water, Buildings, Fleet, Refrigerants, Commute, Waste. Comment: Yale collected 2002 data and then made the assumption that a 10% below 1990 target would mean a 40% reduction in 2002 data for power plants and procurement.	"Inventory and Analysis of Yale University's Greenhouse Gas Emissions" The Yale Climate Initiative Team
University of British Columbia (2006)	25% below 2000 levels by 2010 (only for emissions from buildings)	Electricity, commute	Jonathon. Frantz "Greenhouse Gas Emissions Baseline: Students, Faculty and Staff Commuting to the University of British Columbia"
Bowdoin College (Jan. 2006)	11% below 2002 levels by 2010[1]	Emissions inventory in progress. Their environmental impact audit included: energy, transportation, solid waste, hazardous waste, water, construction, landscaping, purchasing	"Final Draft Report: Environmental Impact Audit" Woodard & Curran
University of North Carolina at Chapel Hill (June 2006)	10% below 2005 levels by 2015; 20% by 2030; 30% by 2040; 45% by 2045; 60% by 2050	Resource consumption study (not emissions inventory): steam, electricity, gas, water, sewer	"Resource Consumption Data for UNC Building Classes" Sustainability at UNC
Oberlin College (Apr. 2004)	Climate Neutrality by 2020	Electricity, Natural gas, Refrigerants, Campus fleet, Commute, Air travel, Landfill, Waste water treatment, Agriculture and food	"Oberlin College: Climate Neutral by 2020" Rocky Mountain Institute
Carleton College (May 2006)	Climate neutrality, no timetable	Purchased electricity, Produced steam, Natural gas, Campus fleet, Refrigeration, Commute, Air travel, Agriculture, Solid waste	Jason Lord "Green House Gas Emissions at Carleton College: A Complete Inventory for 2004-2005 with Extrapolations Back to 1990"

University of California

Institution & target adoption	Commitment	What are they counting in their emissions inventory	Source
UC Davis	Not applicable	Emissions inventory in progress. Joined CCAR in 2006.	CCAR Newsletter
UC Los Angeles	Not applicable	Emissions inventory in progress. Joined CCAR in 2006.	CCAR Newsletter
UC Merced (Nov 2006)	Draft in progress: either Governor's Executive Order or Kyoto targets	Emissions inventory in progress. Joined CCAR in 2006.	Campus News http://www.ucmerced.edu/news_articles/11292006_uc_merced_signs_on.asp
UC Riverside	Not applicable	Emissions inventory in progress.	CCAR Newsletter
UC Santa Barbara (May 2006)	2000 levels by 2010 1990 levels by 2020	Completed inventory and feasibility study in 2006. Target based on required sources. Inventory includes - CCAR required: Purchased electricity, natural gas, campus fleet, Fugitive emissions CCAR optional: waste disposal, staff/faculty auto commute, student auto commute, air travel	Bren School of Environmental Science and Management, UCSB
UC San Diego	Not applicable	Emissions inventory in progress.	CCAR Newsletter
UC Santa Cruz	Not applicable	Emissions inventory in progress. Joined CCAR in 2006.	CCAR Newsletter

Source: Association for the Advancement of Sustainability in Higher Education (AASHE) and quoted websites.

Appendix Z: American College and University Presidents' Climate Commitment (ACUPCC)

* UC Berkeley is a signatory

The Association for the Advancement of Sustainability in Higher Education (AASHE) presents the American College and University Presidents' Climate Commitment

An influential group of college and university presidents will launch the American College and University Presidents' Climate Commitment (ACUPCC), a high-visibility effort to address global warming by getting a joint commitment to reduce greenhouse gas emissions at their institutions, ultimately leading to climate neutral campuses. The effort is modeled after the U.S. Mayors Climate Protection Agreement led by Seattle Mayor Greg Nickels. The initiative will be coordinated and promoted by the Association for Advancement of Sustainability in Higher Education (AASHE) and ecoAmerica.

"After program and planning sessions among a group of college and university presidents and their representatives at the AASHE conference in October 2006 at Arizona State University, 12 presidents agreed to become Founding Members of the Leadership Circle and launch the American College & University Presidents Climate Commitment. In early December 2006, these presidents sent a letter to nearly 400 of their peers inviting them to join the initiative. By March 31, 2007, 152 presidents and chancellors representing the spectrum of higher education had become charter signatories of the ACUPCC. 95 of them joined the Leadership Circle, agreeing to promote the initiative among their peers, serve as representatives to the press, and participate if possible in the public launch of the Presidents Climate Commitment in June. In late March, the expanded Leadership Circle sent a packet of information to their peers at over 3,500 institutions, asking them to sign the Commitment."

Terms of Membership

1. Initiate a plan to achieve climate neutrality as soon as possible:
   a. Create institutional structures
   b. GHG emissions inventory (incl. air travel & commuting)
   c. Develop plan to become climate neutral
      i. Target date + interim targets
      ii. Curricular integration
2. Initiate two or more of the following in the shorter term:
   a. LEED Silver policy for new construction
   b. Energy STAR policy for new appliances
   c. Policy to offset GHG emissions for campus-financed air travel
   d. Encourage public transportation by campus community
   e. Purchase at least 15% of electricity from renewable sources within 1 year
3. Publicly report periodically through AASHE
4. Encourage other institutions to take similar steps

Source: The above excerpt is taken directly from AASHE's ACUPCC website < http://www.presidentsclimatecommitment.org/ > (AASHE, 2007).

CHANGING THE CAMPUS CLIMATE:

A Guide for University Student Groups
Planning to Mitigate Campus Greenhouse Gas Emissions

Fahmida Ahmed | Jeff Brown | David Felix | Todd Haurin | Betty Seto

May 2006

A Bren School of Environmental Science and Management Master's Project

Sponsored by
National Association of Environmental Law Societies

NAELS
National
Association of
Environmental
Law Societies

Project Goal

The Campus Climate Neutral campaign is an ambitious and unprecedented grassroots effort to mobilize graduate students to lead the way to aggressive, long-term climate solutions. The premise of our project is that universities, as emitters of greenhouse gases (GHGs), and more importantly as educational institutions, have an important role to play in society's response to climate change. They have the opportunity to transform markets through their purchasing power, to develop new technologies through their research, and, through their education, to produce the citizens and leaders that will be integral to our society's mitigation of and response to climate change.

With this broader perspective in mind, we examine how University of California, Santa Barbara (UCSB) could respond to climate change and undertake emissions reduction measures. The overarching goal was to define a feasible path for UCSB to achieve climate neutrality (i.e., net-zero emissions of GHGs), and we set out with the following specific objectives:

- Obtain support for the adoption of GHG emissions reduction targets and integrate these targets into UCSB institutional planning;
- Develop an appropriate GHG emissions reductions plan for UCSB based on a thorough emissions inventory, a cost analysis of mitigation strategies, and knowledge about current energy and resource reduction initiatives and projected campus growth;
- Identify institutional barriers to the implementation of our final recommendations;
- Collaborate with the UC Office of the President and other UC schools to work towards UC-wide GHG emissions reduction targets;
- Contribute to the literature on campus GHG emissions reduction initiatives; and
- Engage the campus and local community in collaborative efforts to raise awareness to climate change and reduce GHG emissions.

Our Project Approach

To accomplish these objectives, we designed a broad approach that would not only help us understand how UCSB works, but also help us reach those objectives in a systematic fashion. The figure below is a depiction of our approach. From the start, we wanted to engage with the campus decision makers, including the Administration and Facilities Management. We saw their buy-in as a critical step to our mission to ensure our project recommendations will actually be used to implement change. In addition, we formulated a two track approach encompassing both policy analysis and implementation analysis – where policy analysis would help us identify the climate change mitigation options, and implementation analysis would help us identify how the policies would be enacted at UCSB. For the duration of our project, policy and implementation analysis happened in a simultaneous fashion.

First: Engage with campus decision makers

Policy Analysis

- **Third.** Inventory GHG emissions
- **Fourth:** Introduce and Analyze GHG emission targets
- **Fifth:** Develop Criteria and Use it to analyze Mitigation Policies

Implementation Analysis

- **Second:** Understand decision making at UCSB
- **Sixth**: Identify institutional barriers and strategies to address them

Our project sponsor, the National Association of Environmental Law Societies (NAELS), seeks to use our project as a model for other campuses to follow to reduce GHG emissions. Based on our experiences working with UCSB campus officials, we offer our research strategy, findings and best practices in this guide, in an effort to motivate student groups who wish to effect change on their campus.

We present our journey to you organized around the six key steps of our approach depicted above. For each approach, we describe what we did and why, how we did it, and lessons we learned from it so you can follow our journey and relate it to your goals. We conclude this chapter with an estimated timeline for our work and thoughts on the greater CCN network.

First. Engage with Campus Decision Makers

"Any effort to bring about wide-scale participation must be responsive to the existence of three predominant subcultures that exist within universities – faculty, administration and student organizational cultures. Evidence suggests that the greatest leverage in achieving institutional change occurs when all three subcultures or groups have a shared vision and a sense of organizational alignment in their respective actions." (Sharp, 2002)

What We Did and Why

We engaged with decision makers early to introduce our goal of UCSB reducing its GHG emissions. Communicating our goal, technical approach, and analysis plan were important because they helped establish a rapport and credibility with campus decision makers. The early engagement gave these campus decision makers the opportunity to voice their opinions about our approach, and how ready they thought the campus was to receive our recommendations a year down the road. These meetings were also vehicles for data collection on energy consumption and sustainability on campus. Most importantly, an early engagement helped us identify the important stakeholders and campus organizations, as well as management processes. Engaging other campus groups and individuals, in our opinion, would ensure an audience for our finding and increase the probability that our recommendations would be implemented.

How We Engaged with Campus Decision Makers

We interacted with UCSB students, staff, top administrators and faculty – the four most important constituents on campus. Please also refer to Appendix E on "Engaging with UCSB" which detail the specific organizations we interacted with and the strategy we followed to mobilize them.

Working with Students

At the beginning, we leveraged the California Students for Sustainability Coalition (CSSC) at UCSB. This mostly undergraduate organization already worked closely with members of the UCSB administration on various environmental initiatives such as the Green Building Initiative, Green Purchasing and the Long-Range Sustainability Plan. Due to their existing prior work, they were instrumental in the early weeks of our project by bringing us up to speed on existing campus greening initiatives and providing us with key contacts on campus. For instance, they also connected us with the Campus Sustainability Coordinator, who became an invaluable resource for gaining inroads into the campus administration.

Lessons Learned:

- **Outreach to and leverage other people and organizations who share your desire to "green" your campus.** Our team was pleasantly surprised to find how many students have already dedicated their time to these issues. By networking and bringing the relevant minds together, you will not only build consensus, but also create a climate initiative that everyone is enthusiastic about.

- **Give credit to the work that dedicated students have already undertaken.** Other students can provide you with valuable contacts and help you understand the subtleties of working with campus administrators. By working together, different student groups can aggregate their resources, present a united front to the administration and more effectively use limited financial and human resources.

Working with Staff

UCSB staff members, such as the Campus Energy Manager, Fleet Manager, and the Sustainability Coordinator, helped us to collect the data we needed for an emissions inventory and aided our understanding of the constraints they face in further emissions reductions. Since UCSB has already made significant progress in improving energy efficiency and reducing energy demand, staff members offered helpful suggestions for innovative strategies to further emissions reduction.

We initially thought that we may be able to offer appropriate technological recommendations such as lighting retrofits and occupancy sensors to help reduce greenhouse gas emissions. Interviews with campus engineers quickly taught us that they were already familiar with such solutions, and that the constraints they faced required solutions that extended beyond mere technological fixes.

In evaluating the feasibility of various emissions reduction mechanisms, we met with staff members ranging from the solid waste coordinator to the building level engineers to human resources and budget officers who all offered unique insights into campus operations. They were able to tell us which ideas may have traction within the administration (e.g., building more housing), and which ones would be very politically unpopular (e.g., raising parking rates).

Lessons Learned:

- **Interview staff members at all levels to understand where the best intervention point is for you to target your recommendations.** At UCSB, meetings with the Campus Energy Manager and Chancellor of the University pointed to the influential role of the Assistant Vice Chancellor for Facilities and Management in overseeing new campus construction, existing infrastructure and utility budgets.

- **Having a full-time staff member devoted to sustainability (i.e. in the form of a Campus Sustainability Coordinator) is invaluable.** Campus sustainability requires coordination among many different departments and offices. Our sustainability coordinator was able to ensure that all appropriate stakeholders were engaged, and that efforts on campus were properly leveraging the knowledge and resources available.

- **Meet with staff members to explicitly discuss their concerns about GHG emissions reduction efforts.** Most people are under the impression that emissions reductions will be costly and burdensome, and this is your opportunity to collectively brainstorm ideas that address these concerns. Furthermore, staff members can also communicate to you the obstacles they face in reducing emissions on campus. You must evaluate how significant these obstacles are and develop recommendations that are realistic and that Staff can feel comfortable carrying out.

Working with Top Administrators

In addition to gaining the support and commitment from staff members for project-level emissions reductions, we sought to incorporate climate mitigation into the long-term campus strategy. University-wide strategic decisions require leadership from the Chancellor's office, the top position in the University administration.

To accomplish this goal we met with the Chancellor and the Executive Vice Chancellor (EVC) every term. In each meeting, we communicated our vision for UCSB to become a leader in GHG emissions reduction. We also kept them up to date on our analysis and findings so our final recommendations would not come as surprise. This consistent communication helped us establish a rapport and enabled the Chancellor and EVC to advise us on who to work with within the organization for next steps.

We approached with the intent of repeated engagement to make sure they were convinced that climate change mitigation was important for the University. For instance, during our first meeting with the Chancellor and EVC, we introduced our project to both sell it and to hear any initial feedback they might have. By our second meeting with the Chancellor, we already felt a distinct shift in attitude towards a more favorable view of GHG emissions reductions.

Lessons Learned:

- **Approach decision-makers strategically and leverage data that can help to give your message credibility.** Many top campus administrators will be unaware of the relative size and the historical trends of GHG emissions sources on campus. UCSB demonstrated that it could increase enrollment without increasing overall energy consumption; presenting administrators with this information can help convince them that further emissions reductions may be possible and profitable.

- **Seek institutionalization rather than one time events.** A small solar project may be great this year, but a long-term campus commitment to addressing climate change can make a larger impact in the years to come. Focus on systemic change that will endure long after you have graduated.

- **Recognize that gaining buy-in will require time and that Universities change very slowly**. Decisions to acknowledge climate change may require policies and offices that are typically developed over a span of time. Furthermore, people need time to process new ideas and ways of operating.

- **Most often the administration is on your side**: We were pleasantly surprised by how receptive the Administration was to our ideas once we explained how GHG emission reduction was important to the campus community and in alignment with many of UCSB's current goals. We found that they are happy to help if the students acknowledge the constraints and rules the administration faces. If you keep this in mind, your communications will exude a positive attitude which can be contagious!

Working with Faculty

In addition to the Chancellor's office, we quickly learned that the Faculty Academic Senate had a significant amount of influence at UCSB. The Senate is the key organizing body for faculty members to vote on campus-wide issues ranging from general education requirements to allowing on-campus military recruitment to whether the UC system should continue to manage weapons-related research laboratories.

Although we recognized the potential power of faculty to leverage change on campus, we initially experienced some difficulty in identifying faculty outside the Bren School who would be willing to help push UCSB to commit to emissions reductions.

Lesson learned:

- **Engage with faculty any way you can – including independent study**. Faculty can be the hardest campus stakeholder to engage, especially if climate change is not related to their research area. In general, they hold a tremendous amount of governing power on campus, while mostly choosing to remain aloof from day-to-day campus operations. By soliciting faculty to oversee your project, you can ensure that at least one professor is engaged.

- **Cultivate faculty champions** – In most universities, faculty are an important component of its governance system, so it is really important to ensure faculty support for your mission. Try to have a faculty advisor for your initiative. Also make sure this person believes in and will champion your cause and help you strengthen your case, especially when you face bureaucracy or resistance.

Second. Understand Decision Making at UCSB

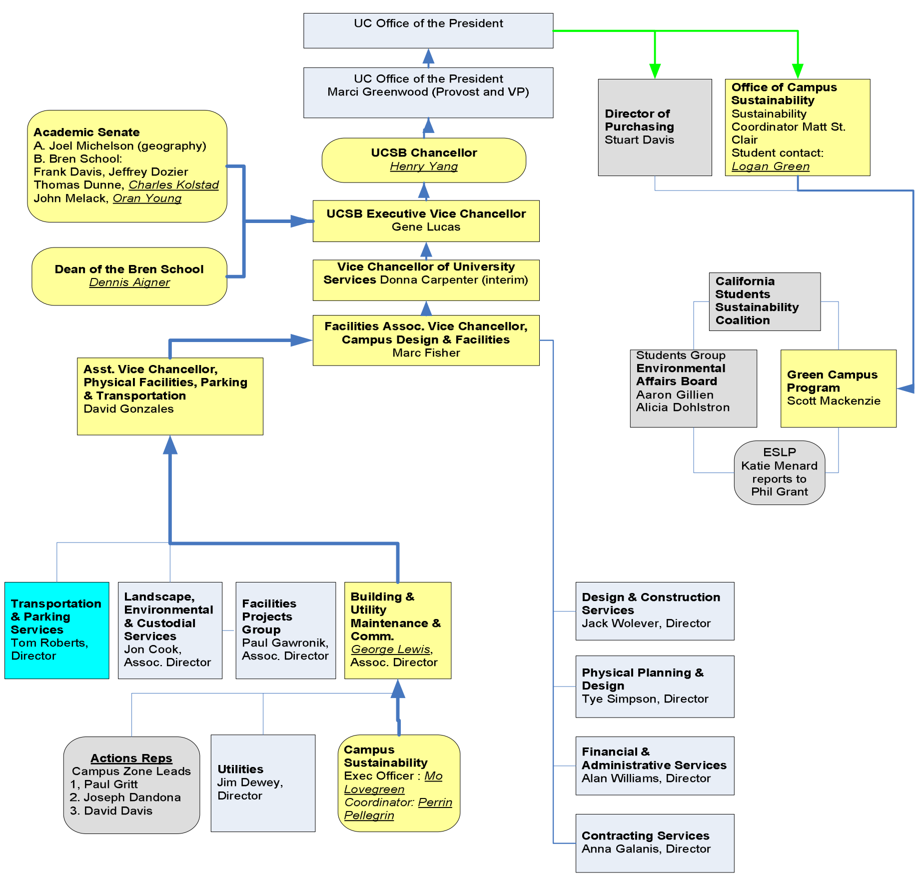
What We Did and Why

As we engaged with campus decision makers, we dedicated a substantial portion of our time researching UCSB's decision making process to focus our efforts on important leverage points within University system.. We compared UCSB's organizational structure as advertised and the actual power and decision making processes, to see how those two differ and who are the key "movers and shakers" within an existing organization.

How We Understood Decision Making at UCSB

We designed a decision tree (example next page), to create a map of how to proceed with our research, who to ask for ideas, and how to reach the high level decision makers. This map helped us apply a "method to the madness" among the myriads of organizations and their processes relevant to our project at the beginning. By following a decision tree, we were able to better scope our investigation and final recommendations.

UCSB Administration Decision Tree for CCN Project



The solid blue arrows represent the path we followed to get an audience with Chancellor Yang. Though the meeting with the Chancellor did not have to be to so formal, we had a strategy of gaining consensus for our ideas before we interacted with him.

Lessons Learned:

- **Watch out for the difference between title and responsibility**: Often, the person who really has the information or the responsibility does not have the title you would necessarily expect. It is important that you find out who has the information and the ideas for sustainability, because they may not always be the managers or the directors of the department who focus on strategic functions as opposed to the daily functions.

- **Work bottom up and top down:** Implementing new ideas requires support from bottom up as well as top down. Without the support and enthusiasm of staff for working on energy efficiency, management may be reluctant to implement new initiatives or projects.. Then again, staff will have difficulty prioritizing work on items that do not have management buy-in. It is important to maintain communication on both ends and convey the ideas and concerns of both parties to bring everyone to the same page. This way, the initiative gains legitimacy and momentum.

Third. Inventory GHG Emissions

What We Did and Why

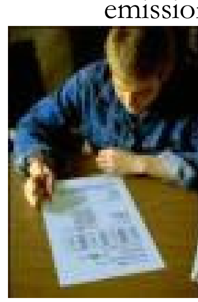
With contacts and buy-ins in place, we started identifying and documenting GHG emissions at UCSB to have a basis for analyzing data and forming recommendations. The inventory was necessary to develop a baseline against which future emissions reductions can be measured. More importantly, an accurate initial inventory was necessary to identify opportunities for significant emissions reductions.

How We Inventoried GHG Emissions

During this inventory process, we surveyed publications that address GHG inventory methods and reduction strategies developed by other leading universities and organizations. The key players in climate change policy and GHG mitigation that we identified were the World Resources Institute, Pew Center on Global Climate Change, World Business Council on Sustainable Development, Rocky Mountain Institute, Climate Neutral Network, Clean Air Cool Planet, National Association of Environmental Law Societies, the Community Environmental Council and Energy Action.

Additionally, several other U.S. universities inventoried their GHG emissions and created plans to reduce these over time, including Oberlin College, Tufts University, Harvard University, and University of California San Diego.

We collected data from various departments in UCSB Facilities Management including facilities management - utilities, housing, transportation, and waste management to capture all the emission sources.



Data collection and inventory continued for several months because, in many cases, the data were not readily available or captured in a usable form (See Chapter 6 on GHG Information Obstacles). However, once we finished the inventory, we did another literature review to ensure that our final results were within a comparable framework with other organizations and universities.

Emissions Inventory as a University Commitment

After a review of different emissions inventory tools, we determined that the California Climate Action Registry (Registry) seemed most logical for UCSB to ensure consistency with other state inventories and to help protect against future state legislation. When we approached UCSB Facilities about membership with the Registry, they were already familiar with the non-profit organization and its legislative mandate to allow institutions and corporations to voluntarily and publicly report annual GHG emissions. When presented with our research and cost estimations, they were very excited to sign on. We acted as a liaison between the Registry and UCSB, to help maintain momentum for UCSB commit to an official GHG inventory.

To most efficiently use our resources (mainly time and personal effort), we focused on catalyzing the relationship between UCSB and the Registry, and then stepping back to allow Facilities staff to work directly with the Registry to complete registration and develop the emissions inventory.

Lessons Learned:

- **Focus on easily achievable initial successes**. Since Facilities Staff were already interested in registering with CCAR, it was relatively easy for us to help them see the process through. By serving to catalyze UCSB's relationship with CCAR, two months into our project, we successfully ensured that an annual emissions inventory would be completed by the University even after we have graduated.

- **Encourage full-time staff to assume responsibility for long-term emissions monitoring and data collection**. It is easy for students to perform an emissions inventory, but University staff need to understand their own emissions sources in order to address them. Furthermore, data collection can be challenging and Universities can take steps to streamline the process if they understand that it will help them in the long-term.

- **Suggest an appropriate forum for your University to collect and report its emissions.** Schools may find their regional GHG registries to be most appropriate for campus inventories, as future state and federal legislation will likely seek to harmonize with these initiatives.

Emissions Inventory - A more Comprehensive Approach

Although CCAR provided a convenient platform for our campus to begin recognizing its greenhouse gas emissions, the required emissions sources mandated by the program is more limited than those typically reported by other universities across the country. Therefore, we decided to use the Clean Air – Cool Planet (CACP) Campus GHG calculator to expand the scope of emissions sources so that the results of our inventory could be more complete. Additionally the CACP calculator generated charts and tables very conveniently.

By performing our own inventory of campus emissions, we were able to compare the relative size of emissions sources excluded from the CCAR inventory. This ensures that our inventory is comparable in scope to other campuses that included sources such as commuting and solid waste. Furthermore, this exercise made sure that the numbers were accurate for both the inventories.

Lessons Learned:

➲ **Complete your own campus emissions inventory**. Performing an inventory of campus emissions can help to familiarize your team with the physical sources of emissions. Your emissions inventory can also facilitate relationship building with facilities staff and help support their efforts to complete an accurate inventory. Plus, it is always helpful to compare your own inventory with that of the school's to identify errors, differences in calculation and important gaps in data collection that would not be noticed otherwise.

➲ **Expand the scope of emissions sources to include those typically found on other campus inventories**. By looking at additional emissions sources (e.g. commuters, University-related air travel), your inventory may include more sources that the University has the power to influence. This opens up emissions reduction opportunities in more areas of the university, especially where traction may already exist to reduce greenhouse gas emissions for other reasons (i.e. reduced impact from driving).

Inventory Data Management

Below is a list of the specific tasks we performed to collect and organize GHG emissions inventory data.

- Identified our preliminary list of important GHGs. We began by investigating the six Kyoto Protocol gases: carbon dioxide (CO_2), methane (CH_4), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs) and nitrous oxide (N_2O). We considered all six of these gases in the CA-CP calculator, but then we normalized to CO_2 equivalent ($MTCO_2e$).
- Identified the primary GHG emissions categories for UCSB. They are:
  - **Direct emissions** from campus activities, such as emissions from boilers or furnaces, travel in vehicles owned by UCSB, and other campus related maintenance activities.
  - **Indirect emissions** from purchased electricity, steam, or heat.
  - **Other indirect emissions** from student, staff and faculty commuting, air travel, fugitive emissions of refrigerants, and campus waste.
- Located existing energy and emissions data sources in Facilities Management and determined if any important GHG emissions sources are missing from these datasets. While most divisions and groups within UCSB do not track GHG emissions specifically, many collect the key data (e.g. fuel and electricity use) necessary for a comprehensive campus GHG inventory. Other data sources were more difficult – we found that the university did not thoroughly track commuting and air travel data.
- Established a baseline for UCSB (Year 2004). Appropriate conversion factors were available in the CA-CP Calculator

Fourth. Introduce and Analyze GHG Emissions Targets

What We Did and Why

With the inventory completed, we calculated relevant GHG emissions metrics (e.g., total GHG emissions per student, total GHG emissions per building square footage) and temporal trends in these metrics. By combining these GHG emissions metrics with projected campus growth (specified in number of students) we established a business as usual projection of GHG emissions through 2020. This was important because our University will continue to grow in enrollment, faculty, new building and campus size to meet the growing demand for education in California and our analysis of the feasibility of meeting overall reduction targets needed to take this projected growth into account.

Then, we decided to map possible targets to assess what type of reductions would be feasible for UCSB. Recall that the goal of our project has been to define a feasible path for UCSB to achieve Climate Neutrality, and we felt that assessing the feasibility of other less stringent targets, such as the California or Kyoto targets, were important as stepping stones on the way towards Neutrality. In addition, we suspected that without targets, there was less likelihood that our recommendations would actually be implemented. Many universities with GHG emissions reductions goals (see Appendix A) have chosen to follow Kyoto Protocol targets or their state's goals.

How We Analyzed GHG Emissions Targets

We calculated campus GHG emissions growth based on the emissions per capita for students in 2004 (baseline) multiplied by the projected increase in enrollment. By projecting emissions trends into the future, we pinpointed the gap between business as usual emissions and any established target (California, Kyoto Protocol, or Climate Neutrality, by 2020) to quantify how much emissions reductions would be likely to be necessary to meet a specific target.

The concept of Climate Neutrality, pioneered by the Rocky Mountain Institute and the Climate Neutral Network, combines aggressive GHG cuts with emissions offsets to achieve a zero net impact on the Earth's climate. According to Timothy Wirth, President of the UN Foundation, the world must "stabilize the concentration of carbon at double the historic record. In order to do that, the world needs to cut emissions by at least two-thirds, or about 70% percent, by the year 2050" (Wirth, 2005). This long-term goal - 70% reductions and 30% offsets provided a good model for achieving Climate Neutrality.

Lessons Learned:

- **Enlist the input of staff and administrators in setting a University goal**. Differing perspectives may exist among campus decision-makers about what is considered a realistic emissions reduction goal. Multiple meetings may be necessary to introduce the idea, as University administration may be initially resistant. As you address their concerns and include them in the initiative, they may be more amenable to a goal down the line.

- **Show widespread support for a University goal**. Engage with students, faculty and staff to demonstrate that climate change is an issue that most people at your school care deeply about. Alternatively, engage yourself in existing campus efforts that are addressing greater sustainability issues. In December 2005, we joined with seventy plus Academic Business Officers Group members (known as change agents) to learn more about the Natural Step workshops presented by Brightworks, Inc.

Fifth. Develop Criteria and Use it to Analyze Mitigation Strategies

What We Did and Why

We researched various emissions reduction technologies and projects in order to identify the most cost-effective emissions reduction package for the University. Since Facilities Management and Housing divisions had already made significant strides in the areas of energy efficiency, we worked closely with them to include their energy efficiency projects in our analysis.

How We Developed Criteria and Analyzed Mitigation Strategies

In order to identify emissions mitigations policies, we looked into the following opportunities.

Opportunities for reduction of UCSB's direct GHG emissions. "Direct reductions are the most important, because they are under the control of the institution, and they can be expected to provide additional benefits in the form of cost savings, local pollution reductions, jobs, educational activities, etc." (Rocky Mountain Institute, 2002, p.30) To reduce emissions from fleet vehicles, we investigated options such as use of biodiesel.

Opportunities for energy efficiency improvements. Other institutions that have conducted a detailed inventory of their campus energy use have found that significant and cost-effective opportunities lie in efficiency improvements in the following areas: lighting, HVAC (heating, ventilation and air conditioning), cooling, space heating, water heating, and plug loads such as refrigeration and office equipment. We obtained a list of these projects from Facilities Management for our calculations.

Opportunities for transportation program enhancement. UCSB made significant progress in this area by subsidizing public transportation for students, vanpool, restricting parking permits for students living within 2 miles of campus and by developing bike paths. Because 80% of faculty and staff commutes in single-occupancy vehicles, we looked into additional programs (i.e. rate incrementalization) that could help reduce emissions related to student and employee commuting,

Opportunities for behavioral changes. We explored how to best encourage behavioral changes to reduce energy usage, such as turning off lights, computers and appliances when not in use. Other universities have demonstrated success with simple stickers and education campaigns to raise awareness around campus to energy conservation.

Opportunities to purchase emissions offsets. Direct emissions reduction and efficiency improvements alone may not be enough to achieve any specific target, especially climate neutrality. Even after our best reduction efforts, purchasing CO_2 offsets would be necessary to achieving net zero GHG emissions. Therefore, we paid special attention to including offsets in our analysis of targets. However, your University's values have to be reflected in the choice of offset projects to support. We found that our University staff perceived offsets as "buying your way out of emissions reduction", so we did not actively pursue membership with offset providers such as the Chicago Climate Exchange or AgCert.com.

We also developed criteria to evaluate mitigation projects; these include $/MTCO$_2$e, capital cost, and payback period. These criteria were developed based on interviews with campus decision makers and a literature search. We followed their decision logic, which typically involved implementation of policies with the lowest cost and shortest payback period. We ranked our policies so that the policies with zero capital cost appeared first, followed by the most cost effective reduction policies up to the point of the cost of offsets, at which point the remaining emissions are offset to reach targets.

Finally, once we identified and researched the individual policy options, we analyzed the total cost of the different policy packages to examine the financial feasibility of meeting different targets. We sought to present our findings as policies that can lower energy costs in the short and long run.

During this time, we found that the obstacles related to reducing emissions on campus did not stem from a lack of campus knowledge about technological solutions. What they lacked was a coordinated approach to comparing solutions across emissions sources and for overcoming institutional barriers and funding difficulties. Therefore, we focused our research on a comparative analysis encompassing both cost and environmental considerations across a spectrum of campus emissions sources.

Note: Initially, we included seven criteria including: capital cost, operating cost, payback, $/GHG reduction, risk of ineffectiveness, campus attitude, and external attitude. We quickly realized that there were too many criteria. Follow-up meetings with the Assistant Vice Chancellor for Facilities and Management helped us to narrow it down to the ones he felt were most important.

Lessons Learned:

- **Work with those who understand the emission sources best and who will be required to implement emission reduction projects**. They can provide information and advice on what the criteria they would use to evaluate prospective projects.

- **Emphasize the compatibility of climate goals with existing campus goals**. Doing so can help sell climate initiatives as another way to justify and raise awareness for the energy efficiency and resource conservation work of the Facilities Management staff.

Sixth. Identify Institutional Barriers and Strategies to Address Them

What We Did and Why

Our analysis revealed reducing GHG emissions could be profitable for the University, but would the university readily take advantage of such a profitable opportunity? We found that even a compelling analysis did not ensure implementation because of various obstacles and exogenous constraints – institutional barriers. Our advisor, Dr. Oran Young, often referred to some of these barriers as "institutional arthritis that rigidifies bureaucracy."

Understanding these implementation obstacles were critical for us throughout the project, not just for formulating policy in the near-term, but also for long-term sustainability. One such example was lack of funding. Therefore, we focused on designing a student-fee based fund and campaigned for it in Spring 2006.

How We Did It

We were able to identify the obstacles by interacting with staff. Our interviews with them revealed why more of the energy efficiency projects cannot happen on campus due to funding, information or management issues. We then did literature review to substantiate our finding and discover strategies to overcome the obstacles.

The University organization is complex and fraught with irrationality (Sharp, 2002) – which we found to be true in some cases for UCSB as well. The current funding systems are set up in a way that discourages many projects that make financial and environmental sense (see Chapter 6). For example, subsidies for public transportation are funded by parking permit sales. Therefore, the success of alternative transportation automatically increases expenditures while decreasing revenue.

We examined these institutional barriers to GHG management explicitly in the effort to effect long-term institutional reform that can support environmental initiatives, rather than detract from these efforts.

For our project, the best recommendations are those which enable significant GHG emissions reductions with minimal implementation problems. In the end, we formulated our recommendations around ideas that will overcome or bypass bureaucracy, which enabled us to present our recommendations to UCSB as a pragmatic and complete solution.

Lessons learned:

- **Address systemic or procedural solutions to GHG management**. University systems are not currently set up to consider GHG emissions, and should be encouraged to include it as a project criterion along with cost considerations. Ultimately, effective environmental solutions must go beyond technical fixes (Hammond, 1998) and address systemic flaws.

- **Identifying institutional barriers is instrumental in supporting the work of facilities staff on campus**. Be sure to interview staff and ask for their feedback on existing organizational structure. Understanding what prevents the implementation of more energy efficiency projects will help you understand the staff constraints, while outlining a more realistic picture of what really needs to happen to improve campus sustainability.

- **Pursue innovative paths and be persistent.** When we first learned about the funding constraints we were somewhat disappointed. After studying literature and talking to other student groups, we soon realized that there were innovative ways to get funding, a student based fee being one of them. Fortuitously, an undergraduate environmental group had decided to propose a new student green fee, and this is where our campus engagement paid off. By involving ourselves in the development of this undergraduate initiative, we were influential in developing a revolving fund for energy efficiency and other sustainability projects on campus. One brainstorming session in September 2005 blossomed into a 6 month campaign for The Green Initiative Fund (TGIF).

In April 27, 2006, 75% of the undergraduate and 82% of the graduate voters voted YES on TGIF, making TGIF the first student fee based fund dedicated for energy efficiency and sustainable projects on campus.

General Best Practices

Get academic credit for your work: Doing so will improve the quality of your work by providing a formal academic advisor to your project, legitimizing the time you spend on the project and helping to keep people committed to project deliverables. Furthermore, it is an invaluable opportunity to involve faculty in campus sustainability issues.

Run with ideas and paths of least resistance: Capitalize on ideas that attract the most support and utilize these as a means of generating the foundation for gradually more challenging ideas (Sharp, 2002). Take action where you can be successful (Hammond, 1998). Focusing on areas where the University can save money will often be the easiest path to environmental stewardship. What campus administrator can be opposed to cost savings?

Be professional and respect staff time: There are likely to be other students on campus also contacting staff with data requests. Coordinate your questions with other students, and seek to identify the most effective communication methods. Some staff members prefer email, and others in the field may respond better to phone calls.

Stay aware of the climate-related initiatives on other campuses: Knowing what other campuses are doing can help you to design and sell your project to your campus administrators. Currently, 59 universities in the United States have pledged to reduce their GHG emissions. The Harvard Green Fund has provided inspiration for other campuses to develop revolving loan funds to support capital-intensive efficiency projects.

Always ask for their opinion: When in doubt, ask the University what it would take for them to reduce their GHG emissions. Try to identify solutions that would meet their criteria. Use their knowledge to propose realistic solutions that may already have momentum, but just need a little extra push.

Make sure key players are aware of opportunities for leadership: It is very important to motivate the people you work with so that they understand there is opportunity for mutual benefit. Asking staff, student or faculty to do something, and even asking very nicely, does not yield support and cooperation. To really gain support, you need to communicate the benefit of their participation to them, to you, and the overarching goal. This approach energizes people and helps them overcome hesitance or reluctance.

Celebrate your successes – Institutional change is a slow process. Take your small victories and give credit to the hard work of those who made it possible.

And ..**Don't give up!**

Project Timeline

We followed this tentative timeline for this year long project. Note that most activities did not have a definite start or end point, but rather they moved in parallel as the project progressed.

Goals	Tasks	Timeline
Diagnose and document GHG emissions at UCSB	Establish campus contacts	March-April 2005
	Basic Emissions Reduction Literature Research	April 2005
	Research UCSB's environmental policy and decision making hierarchy	April 2005
	Create GHG Inventory	May, 2006
Identify and Evaluate Emissions Reduction Policies	Policy Data	July - August 2005
	Identify policy mechanisms and costs calculations	September – October 2005
	Evaluated with decision makers	November-December 2005
Take steps to implement approaches	California Climate Action Registry	June 2005
	Involving stakeholders	Throughout (especially in the beginning and in the end)
	Trends and targets analysis	February 2006
	Final Recommendation to Campus Decision Makers	March 2006
	Establishing the greater CCN network	Throughout
	The Green Initiative Fund	Sept 2005-May 2006

Conclusion

We sought to establish the Bren School initiated campus climate neutral goal as a part of the campus' larger sustainability goals. Our specific recommendations for emissions reductions strategies were channeled through the committee on sustainability because that would ensure implementation and continuity of this important initiative. Our analysis yielded a financially compelling finding (profit in committing to an emissions reduction target), but financial incentives were not enough. To ensure implementation we needed to work hand in hand with campus decision makers and continue to portray the shared vision for why GHG reduction is so important and attainable. To help maintain the momentum out group has built, Campus Climate Neutral 2 (Bren School Class of 2007) will continue our work.

Establishing the Greater CCN Network - a NAELS Directive:

Ultimately, we worked within a broader national movement to encourage behavioral change in society and mobilize communities to be accountable for the climate impact of their actions. We helped pressure and move UCSB to commit to GHG emissions reductions and used analysis to justify our recommendations. In fact, our group became a part of a social movement at UCSB that defines how local actions can be connected and transformed into a broader movement. Here is how we became a part of this broader movement:

Campus level - We participated in several major conferences on climate change policy and student led initiatives to exchange information and ideas on institutional change, energy efficiency, emissions reduction, and emissions offsets. We networked through conferences such as the California Climate Action Registry, student groups such as California Students for Sustainability Coalition. By sharing our lessons and experiences, we joined forces with others who are working with campuses, business and organizations to reduce their emissions of anthropogenic greenhouse gases.

City and State level - The City of Santa Barbara adopted a regional goal of complying with the Kyoto Protocol. By demonstrating the feasibility of reaching the California State targets, we encouraged the City of Santa Barbara and City of Goleta that it is possible to fulfill their organizational missions while preventing dangerous levels of climate change. We also participated with UC system-wide initiatives to endorse sustainable transportation policies and to push for all UC schools to adopt GHG reduction goals.

National level - We stood in solidarity with others in the climate change movement, contributing our voices towards effecting change, and ultimately contributing to the literature of experiences in mobilizing organizations to reduce greenhouse gas emissions.

Acknowledgements

A project of this nature is highly dependent on the willingness of the dedicated staff who work at UC Santa Barbara. We received extensive help from many members of the campus and surrounding community. In particular, we would like to thank the following for providing numerous interviews, data, support for our research and an in-depth look at campus operations:

John Behlman, *Computer and Network Technologist II, Transportation Services*; Jim Corkill, *Director, Accounting Services & Controls;* Joseph Dandona, *Senior Zone Lead;* David Davis, *Senior Zone Lead*; Anna Davison, *Santa Barbara News Press;* Jim Dewey, *Director, Campus Utilities*; Marc Fisher, *Associate Vice Chancellor, Campus Design & Facilities*; Claire Goodman, *The Daily Nexus*; Paul Gritt, *Senior Zone Lead*; Tam Hunt, *Energy Program Director, Community Environmental Council*; Todd Lee, *Assistant Chancellor of Budget & Planning*;; George Lewis, *Associate Director, Building & Utility Maintenance,;* Mo Lovegreen, *Executive Officer, Campus Sustainability*; ; Scott MacKenzie, *Sustainable Procurement Coordinator, Purchasing*; David McHale, P.E., *Senior Electrical Engineer*; Asger Pedersen, *Disbursement & Accounts Payable Manager, Accounting Services & Controls*; Perrin Pellegrin, *Coordinator, Campus Sustainability*; Mark Peppers, P.E., *Senior Mechanical Engineer*, *Design & Construction Services*; Tom Roberts, *Transportation and Parking Services*; Mark Rousseau, *Energy & Environmental Manager, Housing & Residential Services*; Arjun Sarkar, *Fleet Technician/Alternatives Fuels,* Ray Tracy, *Production Services Manager, Instructional Resources,* James Wagner, *Manager, Transportation Alternatives Program*; Nick Welsh, *Santa Barbara Independent*; and Henry Yang, *Chancellor.*

We also thank the following Bren Staff and Faculty for their guidance: Dennis Aigner, BJ Danetra, Maria Gordon, Charles Kolstad, John Melack, Connie Meza, Jill Richardson, Bob Wilkinson and Durwood Zaelke. UCSB Student Leaders: Eric Cummings, Logan Green and Soumil Mehta. We are also grateful for the expert advice from: Rick Heede, Matt St. Clair and Rachel Tornek.

Finally, we would like to express our sincere thanks to project sponsor, Dan Worth (NAELS), and our advisor, Oran Young, for their unending assistance and encouragement

GLOSSARY OF TERMS

CA-CP
"Clean Air-Cool Planet creates partnerships in the Northeast to implement solutions to climate change and build constituencies for effective climate policies and actions" (CA-CP, 2004).

CCAR
"The California Climate Action Registry (the Registry) was established by California statute as a non-profit voluntary registry for greenhouse gas (GHG) emissions. The purpose of the Registry is to help companies and organizations with operations in the state to establish GHG emissions baselines against which any future GHG emission reduction requirements may be applied" (CCAR, 2006).

EU ETS
European Union Greenhouse Gas Emission Trading Scheme is "the largest multi-country, multi-sector Greenhouse Gas emission trading scheme world-wide." (EU, 2006)

GHG
Greenhouse Gas. Specifically the 6 gases recognized by the Kyoto Protocol: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6) (IPCC, 2006).

GWP
"Global warming potential is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the gas in question to that of the same mass of carbon dioxide (whose GWP is by definition 1). A GWP is calculated over a specific time interval and the value of this must be stated whenever a GWP is quoted or else the value is meaningless" (Wikipedia GWP, 2006).

HVAC
Heating Ventilation and Air Conditioning is "A system that provides heating, ventilating, and/or cooling within or associated with a building." (EERE, 2006).

IPCC
The Intergovernmental Panel on Climate Change. "The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation" (IPCC, 2006).

kWh
kilowatt-hour is equivalent to 1000 watt-hours: "One watt-hour is equivalent to one watt of power used for one hour. This is equivalent to 3,600 joules. For example, a sixty watt light bulb uses 60 watt-hours of energy every hour. Similarly, a 100 watt light bulb uses 50 watt-hours in thirty minutes" (Wikipedia Watt-Hour, 2006).

$MTCO_2e$
Metric Ton Carbon Dioxide Equivalent is equal to 1000 kilograms or 2200 pounds of Carbon Dioxide (IPCC, 2006).

NPV
Net-Present Value. An economic term that is "the difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyze the profitability of an investment or project" (Investopedia, 2006).

UCOP
University of California Office of the President is "the systemwide headquarters of the University of California" (UCOP, 2006).

UNFCCC
"The United Nations Framework Convention on Climate Change (UNFCCC or FCCC) is an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED), informally known as the Earth Summit, held in Rio de Janeiro in 1992. The treaty aimed at reducing emissions of greenhouse gas in order to combat global warming" (Wikipedia UNFCCC, 2006).

BIBLIOGRAPHY

(2005). *The UC Berkeley 2020 Long Range Development Plan*. Prepared by Berkeley (Planning Office). Retrieved May 9, 2007, from http://www.cp.berkeley.edu/LRDP_2020final.htm.

(1992). *United Nations Framework Convention on Climate Change*. [Treaty]. New York: United Nations. Retrieved May 11, 2006, from http://unfccc.int/resource/docs/convkp/conveng.pdf.

(1997). *United Nations Framework Convention on Climate Change*. Kyoto Protocol. [Treaty]. Bonn: UNFCCC Secretariat. Retrieved May 11, 2006, from http://unfccc.int/resource/docs/convkp/kpeng.pdf.

(2002). California Assembly Bill No. 1493.

(2004). *Tufts Climate Initiative 5 Year Report: Reflecting on the Past, Looking to the Future*. Tufts University. Medford, MA.

(2005). *Joint science academies' statement: Global response to climate change*. United States of America: National Academy of Sciences, et al.

(2005). *Sense of the Senate on Climate Change*, U.S. Senate, 109th Congress, 1st Session.

(2005). *U.S. Mayor's Climate Protection Agreement*. Retrieved May 11, 2006, from http://www.seattle.gov/mayor/climate/PDF/USCM_6-page_Climate_Mailing_ALL.pdf.

(2005, May 2). *Overview of UCSB's Sustainability Efforts*. University of California, Santa Barbara. PowerPoint Presentation.

(2006). Intergovernmental Panel on Climate Change. Retrieved May 10, 2006, from http://www.ipcc.ch/.

(2007). January 2006 Bill Inserts – Pacific Gas and Electric Company. Retrieved June 10, 2007, from http://www.pge.com/customer_service/bill_inserts/2006/jan.html.

AASHE. (2007). *American College and University Presidents' Climate Commitment*. Retrieved May 10, 2007, from http://www.presidentsclimatecommitment.org/html/commitment.php.

Ahmed, Fahmida, et al (2006) *Changing the Campus Climate: Strategies for Reducing GHG Emissions at UC Santa Barbara*. A Bren School of Environmental Science and Management Master's Project. Sponsored by National Association of Environmental Law Societies.

California Air Resources Board. (September 2006). *AB 32 Fact Sheet - California Global Warming Solutions Act of 2006*. Retrieved June 20, 2007, from http://www.arb.ca.gov/cc/factsheets/ab32factsheet.pdf.

California Climate Action Registry. (October 2002). *General Reporting and Certification Protocol.* Retrieved May 20, 2007, from http://www.climateregistry.org/PROTOCOLS/GRCP/.

California Climate Action Registry. (2005). *Climate Change and California*. Retrieved May 10, 2007, from http://www.climateregistry.org/ABOUTCLIMATECHANGE/California/.

California Climate Action Registry. (2006). *About Us*. Retrieved May 10, 2007, from http://www.climateregistry.org/ABOUTUS/.

California Energy Commission. (2007). *Energy Efficiency Financing*. Retrieved June 10, 2007, from http://www.energy.ca.gov/efficiency/financing/.

California Environmental Protection Agency. (2006a). *Climate Action Team Report to Governor Schwarzenegger and the Legislature*. Sacramento, CA: California Climate Action Team.

California Environmental Protection Agency. (2006b). *Executive Summary: Climate Action Team Report to Governor Schwarzenegger and the Legislature*. Sacramento, CA: California Climate Action Team.

California Public Utilities Commission. (2005). *Solar incentives*. Retrieved May 10, 2007, from http://www.cpuc.ca.gov/static/energy/solar/index.htm.

Clean Air – Cool Planet. (2006). *About CA-CP*. Retrieved May 10, 2007, from http://www.cleanair-coolplanet.org/about/ Clean Air – Cool Planet. (2006). Greenhouse Gas Inventory Calculator, Version 4.0. Portsmouth, New Hampshire.

Creighton, S.H. (1998). *Greening the Ivory Tower: Improving the Environmental Track Record of Universities, Colleges, and Other Institutions*. Cambridge, MA: The MIT Press.

Crowley, T.J. (2000). Causes of Climate Change Over the Past 1000 Years. *Science*, 289 (5477), 270-277.

Dagan, M. Douglas. *A Summary of Energy Consumption and Greenhouse Gas Emissions at Middlebury College.* (2002). Middlebury College. <http://www.middlebury.edu/NR/rdonlyres/26273E73-9E1D-4283-864C-1C6E9E5B74F9/0/Emissions_InvD_dagan.pdf>.

Database of State Incentives for Renewable Energy. (2006). *California Incentives for Renewable Energy*. Retrieved May 2, 2006, from http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=CA30F&state=CA&CurrentPageID=1&RE=1&EE=0.

Durham, Kristen. *Water Conservation Strategies*. (Unpublished student research.)

Dynes, Robert C. UC Office of the President. (2007, March 22). *UC Policy on Sustainable Practices*. Retrieved May 10, 2007, from http://www.ucop.edu/facil/sustain/documents/ucregentgreenbldg.pdf.

EPA Landfill Methane Outreach Program. (n.d.) *Basic information*. Retrieved March 8, 2007, from http://www.epa.gov/lmop/overview.htm.

European Commission. (2004). *EU Emissions Trading: An Open Scheme Promoting Innovation to Combat Climate Change*. European Communities, Belgium. Retrieved May 11, 2006, from http://europa.eu.int/comm/environment/climat/pdf/emissions_trading_en.pdf.

European Commission. (2007). *European Union Emissions Trading Scheme*. Retrieved June10, 2007, from http://europa.eu.int/comm/environment/climat/emission.htm.

Firestone, Ryan. *Inventory Calculation –Estimating Greenhouse Gas Emissions from Air Travel at the University of California, Berkeley*. (Unpublished student research.)

Frantz, Jonathon. *Greenhouse Gas Emissions Baseline: Students, Faculty and Staff Commuting to the University of British Columbia*. (2003). UBC Campus Sustainability Office. University of British Columbia. <http://www.trek.ubc.ca/research/pdf/UBC_GHG_Emissions.pdf>.

Freeman, Jo. (2004). *At Berkeley in the Sixties: Education of an Activist, 1961-1965*. Indiana University Press: Bloomington.

Friedman, T. (2006, April 21). The Greenest Generation. *The New York Times* (New York, New York).

"Green House Gas Inventory." *Harvard Green Campus Initiative*. 2007. Harvard University. 10 Feb 2007 <http://www.greencampus.harvard.edu/ggi/index.php>.

Hanley, J.P., et al. (2003, June 19). *Carbon Neutrality at Middlebury College: A Compilation of Potential Objectives and Strategies to Minimize Campus Climate Impact*. [Draft Report]. Middlebury College.

HGCI and President and Fellows of Harvard College 2002-2006. (2006). *Harvard Green Campus Initiative homepage*. Retrieved May 25, 2007, from http://www.greencampus.harvard.edu/.

Hummel, S. (n.d.) *Charting a path to greenhouse gas reductions*. Duke University. Durham, N.C.

Intergovernmental Panel on Climate Change. (2007). *Climate Change 2007: The Physical Science Basis, Summary for Policymakers*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

International Energy Association. (2005). *General Converter for Energy*. Retrieved May 5, 2007, from http://www.iea.org/Textbase/stats/unit.asp.

Investopedia. (2006). *Net Present Value*. Retrieved May 10, 2007, from http://www.investopedia.com/terms/n/npv.asp.

Jones, Christopher M. (2007). *UC Berkeley's Climate Footprint*. Unpublished report prepared for CalCAP by Berkeley Institute of the Environment in May 2007.

Koshland, Cathy. (2006). *Re: Campus Climate Protection Steering Committee- Letter to the Chancellor*. Unpublished letter produce to establish CalCAP funds that was signed by CalCAP Steering Committee members.

LEED for New Construction. Retrieved May 10, 2007, from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220&.

Levin, R., Hamilton, A., & Pepper, J. (2005, October) *Yale commits to long-term Greenhouse Gas Reduction and Renewable Energy Strategy*. Press Release.

Lechner, Micheal (2006). Email correspondence in December 2006 with Senior Account Manager Michael Lechner from APS Energy Services.

Lord, Jason. (2005). *Carleton's Green House Gas Emissions at Carleton College: A Complete Inventory for 2004-2005 with Extrapolations Back to 1990*. Carleton College. <http://apps.carleton.edu/curricular/ents/assets/Carleton_GHG_emissions_inventory.pdf>.

Motschenbacher, Anna. *Carbon Offsets*. (Unpublished student research.)

Nazaroff WW and Levin H, Climate-change mitigation: Challenges and opportunities in California's residential building sector, in *Proceedings: Healthy Buildings 2006*, E de Oliveira Fernandes, M Gameiro da Silva, and J Rosado Pinto (editors and publishers), Lisboa, Portugal, Vol. 5, pp. 299-304, 2006.

Orr, David. (2000, April). 2020: A Proposal. *Conservation Biology*, *14* (2), 338-341.

Pacala & Socolow (2004). Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies. *Science*, 350, 968-972.

Pacca, S., and Horvath, A. (2002). Greenhouse Gas Emissions from Building and Operating Electric Power Plants in the Upper Colorado River Basin. *Environmental Science & Technology*, ACS, 36(14), pp. 3194-3200.

Pew Center on Global Climate Change. (2000, August) *An Overview of Greenhouse Gas Emissions Inventory Issues.* Washington, D.C.: Loreti, C.P., et al.

"Resource Consumption Data for UNC Building Classes." *Sustainability at UNC*. 2003. The University of North Carolina at Chapel Hill. 10 Feb 2007 <http://sustainability.unc.edu/index.asp?Type=MeasuringImpact&Doc=resourceConsumptionData>.

Robinson, Eric. (2006). *Annual Fleet Growth Calculation.* Email correspondence between Eric Robinson and Fahmida Ahmed, December 12, 2006.

Rocky Mountain Institute. (2002). *The New Business Climate: A guide to lower carbon emissions and better business performance*. Snowmass, CO: Swisher, J.

Rocky Mountain Institute. (2002). *Oberlin College - Climate Neutral by 2020.* Snowmass, CO: Heede, R. & Swisher, J. <http://www.nicholas.duke.edu/news/roberstonseminars/swisher-oberlin2020final.pdf>.

Schwarzenegger, A. (2005, June 1). Speech at United Nations World Environment Day. San Francisco, CA. Retrieved May 25, 2007, from http://gov.ca.gov/index.php?/speech/1885.

Sharp, Leigh. (2002). Green Campuses: The Road from Little Victories to Systemic Transformation. *International Journal of Sustainability and Higher Education, 3*(2), 128-145.

Siegenthaler, U., Stocker, T. F., Monnin, E., Lüthi, D., Schwander, J., Stauffer, B., et. al. (2005). Stable Carbon Cycle–Climate Relationship During the Late Pleistocene. *Science*, *310 (5752),* 1313-1317.

Think Energy Management LLC. (n.d.). *Energy/Utility Glossary*. Retrieved May 9, 2006, from http://www.think-energy.net/energy_glossary.htm.

Tufts Climate Initiative. (2002, April). *Method for conducting GHG Emissions Inventory for Colleges and Universities.* Tufts Institute of the Environment. Medford, MA..

Tufts Climate Initiative. *Tufts University Greenhouse Gas Inventory: 2006 Update.* (2006). Tufts University. <http://www.tufts.edu/tie/tci/excel%20and%20word/Tufts%20Emissions%20Inventory%20Update%202006.doc>.

UC Office of the President. (2006). *About the Regents*. Retrieved May 25, 2007, from http://www.universityofcalifornia.edu/regents/about.html.

U.S. Department of Energy. (2007). *Glossary*. Retrieved May 25, 2007, from http://www1.eere.energy.gov/site_administration/search.html.

U.S. Department of Energy. (2006). *The Energy Policy Act of 2005*. Retrieved May 6, 2006, from http://www.energy.gov/taxbreaks.htm.

U.S. Department of Energy. (2007). *Technical Guidelines: Voluntary Reporting of Greenhouse Gases.* Retrieved May 10, 2007, from http://www.pi.energy.gov/enhancingGHGregistry/documents/January2007_1605b TechnicalGuidelines.pdf.

Union of Concerned Scientists and Ecological Society of America (1999). *Confronting Climate Change in California: Ecological Impacts on the Golden State.* Cambridge, MA and Washington, D.C.: Field, C. B., Daily, G. C., Davis, F. W., Gaines, S., Matson, P. A., Melack, J., et al.

Union of Concerned Scientists (2006). *Fact Sheet - AB-32: Global Warming Solutions Act.* Authored by Assembly Speaker Fabian Nunez and Assembly Member Fran Pavley. Retrieved May 25, 2007, from http://www.law.stanford.edu/program/centers/enrlp/pdf/AB-32-fact-sheet.pdf.

University of California at Berkeley. (2006, May 5). *Cal Climate Action Partnership (CalCAP) kicks off initiative to reduce greenhouse gas emissions from UC Berkeley campus activities* [Press Release]. Berkeley Institute of the Environment. Retrieved May 23, 2006, from http://sustainability.berkeley.edu/docs/calcap/BIE_CACS_CalCAP_Announcement.pdf.

University of California at Irvine. (n.d.). *Management Services Officer (MSO)*. UCI Series Concepts -- UCI size-neutral Supplemental Guidelines, Class Specifications - F.30. Retrieved May 9, 2006, from http://www.hr.uci.edu/uc-ser/f/30/aa3-14.html.

University of California at Santa Barbara. (2005, May 2). *Overview of UCSB's Sustainability Efforts* [PowerPoint presentation]. Facilities Management, University of California at Santa Barbara.

University of California at Santa Barbara. (2007). *UCSB Sustainability*. Retrieved May 25, 2007, from http://sustainability.ucsb.edu/intro.asp.

University of California at Santa Barbara. (n.d.). *UCSB facilities management overview*. Retrieved May 10, 2006, from http://facilities.ucsb.edu/departments/.

Urban Design Associates. (2003). *The Campus Plan for University of California Santa Barbara.* Retrieved May 11, 2006, from http://bap.ucsb.edu/planning/3.planning.stuff/campus%20plan/0.Campus%20Plan%202003.pdf.

Wikipedia, The Free Encyclopedia. (2006). *Global Warming Potential*. Retrieved May 25, 2007, from http://en.wikipedia.org/wiki/Global_warming_potential.

Wikipedia, The Free Encyclopedia. (2006). *United Nations Framework Convention on Climate Change Website*. Retrieved May 25, 2007, from http://en.wikipedia.org/wiki/UNFCCC.

Wikipedia, The Free Encyclopedia. (2006). *Watt-Hour Website*. Retrieved May 25, 2007, from http://en.wikipedia.org/wiki/TWh.

Wirth, T. (2005, May 26). *Climate and energy, what the United States needs.* Open Democracy Ltd. Retrieved May 25, 2007, from http://www.opendemocracy.net/globalization-climate_change_debate/USclimate_2547.jsp.

Woodard & Curran. *Final Draft Report: Environmental Impact Audit.* (2000). Bowdoin College. <http://ereserves.bowdoin.edu/other/sustain/bowdoinenvaudit.pdf>.

World Resources Institute. (2002, February 14). *Analysis of Bush administration greenhouse gas target*. Washington, D.C. Retrieved May 25, 2007, from http://pdf.wri.org/wri_bush_climate_analysis.pdf.

World Resources Institute. (2002, December). *Working 9 to 5 on climate change: An office guide*. Washington, D.C.: Putt del Pino S. & Bhatia, P.

World Resources Institute. (2006, October). *SWITCHING TO GREEN: A RENEWABLE ENERGY GUIDE FOR OFFICE AND RETAIL COMPANIES*.

World Resources Institute and World Business Council for Sustainable Development. (2004). *The Greenhouse Gas Protocol*. Washington, D.C.: Ranganathan, J., Corbier, L., Bhatia, P., Schmitz, S., Gage, P., Oren, K.

Yale Climate Initiative Team. *Inventory and Analysis of Yale University's Greenhouse Gas Emissions*. (2005). Yale University. <http://environment.yale.edu/documents/downloads/v-z/wp_7_yale_ghg.pdf>.