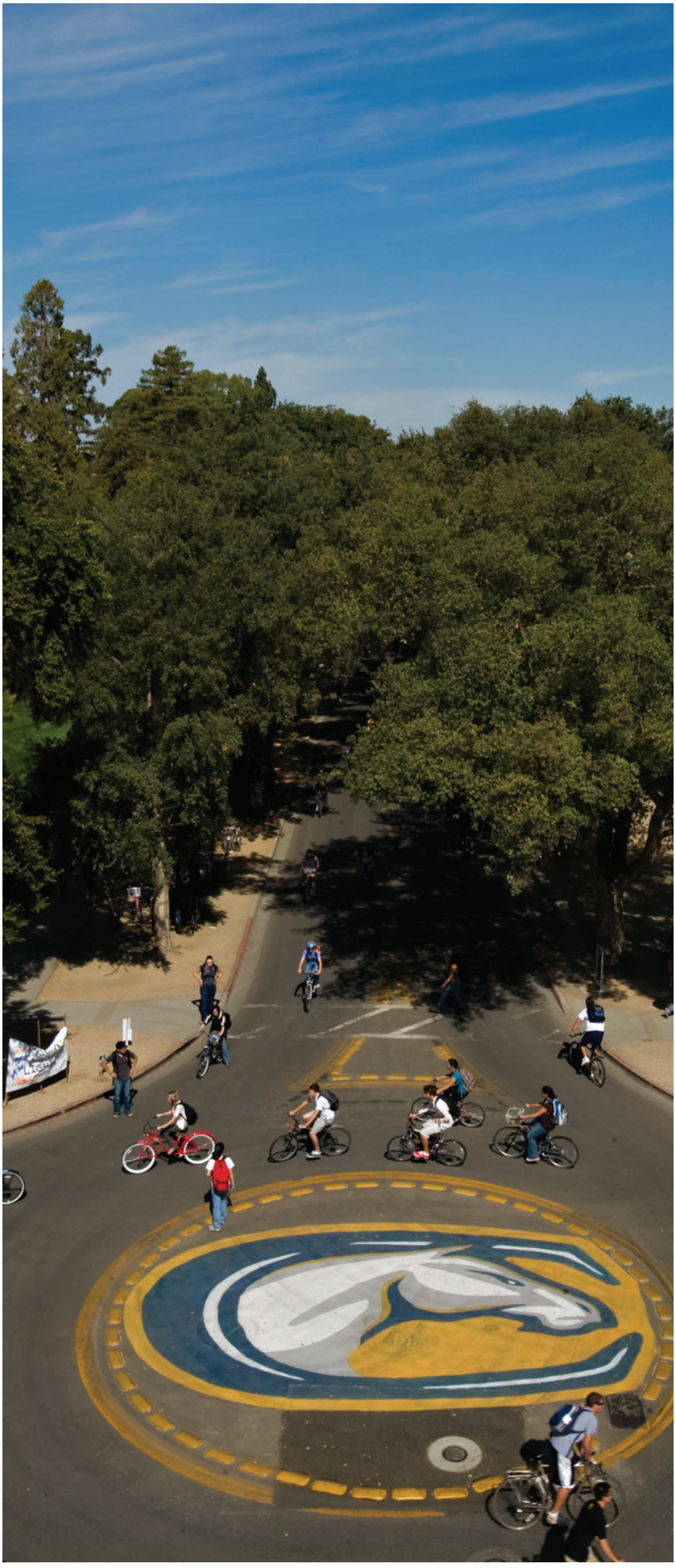

UC DAVIS 2009–2010 CLIMATE ACTION PLAN

JUNE 1, 2010

UCDAVIS
ENVIRONMENTAL STEWARDSHIP AND SUSTAINABILITY

UC DAVIS 2009-2010 CLIMATE ACTION PLAN

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ACKNOWLEDGMENTS

PRINCIPAL AUTHOR

Camille Kirk, Sustainability Planner, Environmental Stewardship and Sustainability

ASSISTING AUTHORS

Bill Starr, Senior Project Manager, Design and Construction Management

Erdem Savasir, Student Assistant, 2010 MBA Candidate, Graduate School of Management

David Soares, Student Assistant, 2010 BSc candidate, Chemical Engineering

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REVIEWERS

John Meyer, Vice Chancellor
Administrative and Resource Management

Kelly Ratliff, Associate Vice Chancellor
Budget and Institutional Analysis

Sid England, Assistant Vice Chancellor
Environmental Stewardship and Sustainability

Matt Dulcich, Assistant Director, Environmental Planning
Environmental Stewardship and Sustainability

Allen Doyle, Sustainability Manager
Environmental Stewardship and Sustainability

Lin King, Program Manager
Environmental Stewardship and Sustainability

Karl Mohr, Assistant Vice Chancellor
Capital Resource Management

Paul Schwartz, Associate Director
Capital Resource Management

Jeff Lefkoff, Associate Director
Capital Resource Management

Allen Tollefson, Director
Facilities Management

David Phillips, Director
Facilities Management

Chris Cioni, Associate Director
Facilities Management

Clayton Halliday, Assistant Vice Chancellor
Design and Construction Management

Ardie Dehghani, Director of Engineering
Design and Construction Management

Gary Dahl, Senior Project Manager
Design and Construction Management

Bob Segar, Assistant Vice Chancellor
Campus Planning and Community Resources

Sal Genito, Director
Grounds

Cliff Contreras, Director
Transportation and Parking Services

Richard Battersby, Director
Fleet Services

Geoff Straw, Director
Unitrans

Jill Parker, Associate Vice Chancellor
Safety Services

Sue Fields, Environmental Manager
Environmental Health and Safety

Aimee Pfohl, Specialist
Environmental Health and Safety

Mike Sheehan, Associate Director
Student Housing

Patrice Stafford, Sustainability Coordinator
Student Housing

Jan Gong, Associate Vice Chancellor
Student Affairs

Janice King, Director
Purchasing

Dave Shelby, Assistant Vice Provost
Information and Educational Technology

Tom Hinds, Marketing Director
University Communications

Marj Dickinson, Assistant Vice Chancellor
University Relations

Gary Sandy, Director
University Relations

Bob Taylor, Assistant Director
Administrative and Professional Services, Health System

Jared Quinton, Administrative Fellow
Health System

Charles Witcher, Manager
Plant Operation and Maintenance, Health System

Michael Lewis, Principal Engineer
Plant Operations and Maintenance, Health System

Patrick Putney, Senior Development Engineer
Plant Operations and Maintenance, Health System

John Danby, EH&S Specialist
Health System

Tom Rush, Manager
Facilities Design and Construction, Health System

Mike Boyd, Executive Associate Director
Facilities Design and Construction, Health System

Duane Hicks, Manager
Parking and Transportation Services, Health System

Tamara Cole, Fleet Supervisor
Health System

ACRONYMS AND GLOSSARY

The following terms are used throughout the document or may be unfamiliar to readers. For ease of formatting, chemical formulas are not expressed with subscript in this document – for example, carbon dioxide is expressed as CO2, instead of CO_2.

Biogenic emissions: greenhouse gas emissions resulting from natural, non-anthropogenic biological processes, such as decomposition or burning of vegetative matter.

CAP, Climate Action Plan: a strategic outline of how an institution will measure greenhouse gas emissions and attempt different methods to reduce those emissions.

CARB, ARB: California Air Resources Board

CCAR, the California Climate Action Registry: one of the two registries that University of California campuses may join as members and report annual greenhouse gas emissions.

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 (text from the University of California Policy on Sustainable Practices).

CO2e, MTCO2e: Carbon dioxide equivalent, which is a way of reporting greenhouse gas emissions taking into account the different global warming potentials of the different classes of greenhouse gases. MTCO2e is the expression for metric tonnes of carbon dioxide equivalent. A metric tonne equals 2,204.62262 pounds, or 1.10231131 short tons (United States).

De minimis: emissions that: (1) cumulatively amount to less than 5 percent of total emissions, and (2) are unverifiable due to data sources.

eGRID factor: the Emissions and Generated Resource Integrated Database (eGRID) is maintained by three Federal government agencies, and is the source for emission factors used for portions of the electricity purchased by UC Davis (more information here: www.epa.gov/rdee/energy-resources/egrid/faq.html).

GHG, Greenhouse gas: any one of six gases or categories of gases known at present time to cause climate change, the gases include carbon dioxide (CO2); nitrous oxide (N2O), methane (CH4), hydrofluorocarbons (HFCs); perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) (unfccc.int/kyoto_protocol/items/3145.php).

GWP, Global warming potential: the ratio of the warming caused by a substance to the warming caused by a similar mass of carbon dioxide. The GWP of CO2 is defined as 1.0 (www.epa.gov/ozone/defns.html#gwp). The Intergovernmental Panel on Climate Change has recalculated GWP, based on new data, in several assessment reports. UC Davis has used the required second assessment report values in GHG inventories, and has used the third assessment report values in the CAP for modeled data (www.epa.gov/climate/climatechange/emissions/downloads/ghg_gwp.pdf).

HVAC: Heating, ventilation and air conditioning

kBtu: One-thousand (1,000) British thermal units (Btu). A Btu is equal to about 1.06 kilojoules, and is a unit commonly used when discussing power generation and HVAC systems.

kWh. kilowatt-hour: A kilowatt is 1,000 watts, and a watt is a unit of power. To describe electricity used by the campus, it must be described as energy, which is power (in watts) multiplied by time (in hours). A kilowatt-hour equals 3.6 megajoules.

REC: Renewable energy credit

SEPP, Strategic Energy Partnership Program. The SEPP is a program that the UC and investor-owned utilities have entered into whereby the utilities provide a certain amount of matching funds for energy

efficiency and energy conservation initiatives that eligible UC campuses undertake. Actual savings in kWh and therms must be demonstrated to receive the matching funds. The Davis campus participates, but the Sacramento campus is not eligible because SMUD does not participate in the program.

Sequesterization: The process of capturing CO2 and storing it. At UC Davis, biosequestration is the most likely near-term form of carbon sequestration, using vegetation to pull CO2 from the atmosphere into the soil.

Server virtualization: Refers to the separation of the server operating system from the hardware, which can allow multiple servers on a single piece of physical equipment or allow a running server to move to different physical equipment. Virtualization reduces the number of physical servers, and therefore the amount of space to house them and the electricity to run them and cool the server rooms.

TCR, The Climate Registry: see CCAR

Therm: An energy unit equal to 100,000 Btus or about 29.3 kWh. A therm is nearly the energy equivalent of burning 100 cubic feet of natural gas.

EXECUTIVE SUMMARY

WHAT IS THE CLIMATE ACTION PLAN?

The UC Davis 2009-2010 Climate Action Plan (CAP) is a roadmap for the journey towards a more sustainable future for UC Davis.

The CAP includes:

- Documentation of how campus greenhouse gas (GHG) emissions are calculated
- Report of current GHG emissions
- Estimates of past and future GHG emissions
- Statement of GHG emission reduction goals
- Characterization of options to reduce emissions
- Blueprint for future action

WHY DOES UC DAVIS NEED A CAP?

The most important function of the CAP is to support and provide vision and direction to the UC Davis sustainability initiative.

The CAP also describes and addresses policy and regulatory requirements. These include the UC Policy on Sustainable Practices; the California Global Warming Solutions Act of 2006 (also referred to as AB 32); American College and University Presidents Climate Commitment; the California Environmental Quality Act (CEQA); and United States Environmental Protection Agency reporting requirements.

Of these, three key targets from the UC Policy on Sustainable Practices define the CAP boundaries:

- Reduce GHG emissions to 2000 levels by 2014
- Reduce GHG emissions to 1990 levels by 2020
- Achieve climate neutrality as soon as feasible.
  Climate neutrality means that the University will have a net zero impact on the Earth's climate, and will be achieve by minimizing GHG emissions as much as possible and using carbon offsets or other measures to mitigate the remaining GHG emissions.

WHAT IS THE CHALLENGE?

In 2008, UC Davis emitted nearly 239,000 metric tonnes of CO2 equivalent (MTCO2e) for operations, and another 59,000 MTCO2e in commuting and air travel, or about 294,000 MTCO2e total. Most of the operations-related GHG emissions result from maintaining and operating buildings.

The challenge is: how will we develop further, while reducing our emissions? What will growth mean, what will development look like, and how can we make it sustainable?

SCALE OF THE CHALLENGE

UC Davis encompasses:

- 5,300 acres (largest UC campus)
- 1,000+ buildings
- 30,000+ students and 32,000+ employees
- Davis campus: 69.6% of total UC Davis GHG emissions
- Sacramento campus (Medical Center): 28.8% of total UC Davis GHG emissions
- Outlying facilities: 1.6% of total UC Davis GHG emissions
- Own and operate many sources of emissions, such as utility systems, including a cogeneration plant at the Sacramento campus, public services, and local public transportation system
- Research science intensive – many laboratories, clinic facilities, and a hospital
- Unique power supplies, including a contract with the quasi-federal Western Area Power Administration
- Inland climate
- Remarkable growth in both population and built square footage since 1990, nearly doubling built square footage, and two-thirds more students, faculty and staff

REDUCTION TARGETS

For UC Davis, inventoried GHG emissions sources include:

- combustion of fossil fuels in boilers, generators, vehicles and other combustion-powered equipment;
- combustion of biodiesel fuel and landfill gas;
- wastewater treatment plant processing emissions;
- fugitive emissions such as refrigerants lost from chillers and air conditioning systems;
- purchased electricity from utility companies; and
- commuting, work-related ground and air travel, athletics and study-abroad travel.

Staff worked with graduate and undergraduate students to create as complete a picture of GHG emissions back to 1990 as feasible. This work used a mix of hard data and projected or trended data for as many emission sources as possible.

2000 levels: 245,837 MTCO2e from operations and 48,811 from commuting and business travel
1990 levels: 142,196 MTCO2e from operations and 44,442 from commuting and business travel

UC Davis is already meeting the 2014 target for operations-related emissions, and has articulated a 2014 challenge goal of 210,000 MTCO2e, which is roughly equivalent to 1999 levels of GHG emissions.

Of note, natural gas consumption and purchased electricity constitute 85 percent to 88 percent of the non-travel related GHG emissions for UC Davis.

HOW WILL WE REACH OUR TARGETS?

There are four primary ways to reduce GHG emissions:
1. Energy conservation and efficiency
2. Use renewable energy sources
3. Sequester carbon
4. Purchase credits, offsets or allowances

Energy use is overwhelmingly the major source of GHG emissions from UC Davis' operations. UC Davis has already been very active in undertaking energy conservation projects over the past two decades (a list is provided in Appendix 3). For the past four years, UC Davis has had a partnership with PG&E, the Strategic Energy Partnership Program (SEPP), to jointly fund energy conservation projects.

For the CAP, a model for the Davis campus was built (a similar model is under construction for the Sacramento campus) which created five scenarios for emissions reduction. The model focuses on building square footage, since most energy is expended in and on buildings. Modelled opportunities included another round of SEPP projects, a user education campaign, slowing the rate of square footage growth, requiring all new capital projects to be GHG neutral after 2012, and decommissioning 100,000 square feet of energy-inefficient space per year for 10 years.

The model results demonstrated that the bulk of our near-term effort should be focused on energy efficiency, energy conservation, and making sure that growth and development are strategic and add to the solution of GHG emissions reductions. Secondary effort should be expended on renewable energy sources.

WHAT ARE THE NEXT STEPS?

To achieve the goals of the CAP, during 2010-2011, UC Davis will:

- Appoint a CAP implementation committee, with membership from faculty, students and staff
- The committee will further analyze options proposed in the CAP, and others derived by the committee
- Expand a user education campaign to capitalize on the power of engaging the whole campus community in the project of making UC Davis a sustainability leader
- Track state and federal policy closely
- Support University efforts to develop a systemwide renewable energy supply strategy

CHAPTER 1: **INTRODUCTION**

1.1 OVERVIEW

The UC Davis 2009-2010 Climate Action Plan (CAP) is a strategic outline of how the institution will measure greenhouse gas emissions (GHG), and pursue strategies to reduce those emissions. The 2009-2010 CAP addresses the Climate Protection section of the University of California Policy on Sustainable Practices, which specifies GHG reduction targets in 2014 and 2020, and an ultimate goal of climate neutrality. (See: http://www.universityofcalifornia.edu/sustainability/documents/policy_sustain_prac.pdf)

A Climate Action Plan is only one component of overall sustainability planning, and there are many areas of overlap between this plan and other plans and programs underway regarding aspects of the sustainability policy and achieving a sustainable future for UC Davis.

1.1.1 Structure

The approach UC Davis is taking with the 2009-2010 CAP is to document current and historic emissions, identify a 2014 target beyond the policy, summarize efforts to date to reduce GHG, and describe planned efforts to reduce GHG to meet the targets. The 2009-2010 CAP is a strategic plan, offering a roadmap with multiple paths for working toward climate neutrality. A companion feasibility study, to be prepared during 2010-11, will assess costs and scheduling for specific actions that enable the campus to reach its first target in 2014 and demonstrate progress towards the second target in 2020 and the ultimate goal of climate neutrality.

A two-year update cycle is anticipated for the Climate Action Plan. In odd years (2009-2010, 2011-2012, etc.), the plan will be revised and updated, and in even years (2010-2011, 2012-2013, etc.), detailed and specific analyses needed to support and advance actions proposed in the Climate Action Plan will be performed.

Responsibility for implementation of this plan lies with the whole campus community, but a core workgroup will be convened to conduct the detailed and specific analysis needed for the 2010-11 analysis, and to develop resource allocation proposals and implementation schedules.

1.1.2 Timeframe

The immediate horizon of the UC Davis 2009-2010 CAP is 2014, with an intermediate horizon of 2020 and the ultimate goal of climate neutrality. The 2009-2010 CAP does not set a date for achieving climate neutrality; however, the 2009-2010 CAP does describe the basic approach to neutrality and estimates the current market cost to offset all carbon emissions to achieve zero net carbon as of December 31, 2009.

1.1.3 Institutional Control and Emissions Sources

Emissions sources considered in the greenhouse gas inventory baseline include those programs and facilities subject to institutional control over their operation (operational control) and those subject to control over expenditures (financial control) by UC Davis. Data has been assessed for as many emissions sources as possible; where data is unavailable, either a source has been omitted, but documented in the 2009-2010 CAP as missing, or a best estimate has been made, based on extrapolated data.

1.1.4 Gases

All six Kyoto Protocol greenhouse gases are inventoried, characterized, and considered; however, the predominant focus in the 2009-2010 CAP is on carbon dioxide, nitrous oxide, and methane. These three gases are the most abundantly produced by activities carried out on behalf of UC Davis, and the major contributors to the emissions inventory. The other three are very minor contributors.

1.2 POLICY AND REGULATORY BACKGROUND

The 2009-2010 CAP is situated within a policy and regulatory setting that is both rapidly changing at the state level and changing more slowly at the national and international level. This differential complicates anticipation of regulation timing and implementation. The following material summarizes key policy and regulatory influences on climate action planning for the campus.

The **UC Policy on Sustainable Practices** sets policies guidelines and implementation procedures for a wide array of sustainability-related topics. The section on Climate Protection Practices identifies several goals including the following:

- 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 California Assembly Bill 32 (AB32), **"The California Global Warming Solutions Act of 2006"** that is, by 2020 to reduce GHG emissions to 1990 levels.
- …the University will pursue the goal of reducing GHG emissions to 2000 levels by 2014
- …the University will develop an action plan for becoming climate neutral which will include: a feasibility study for meeting the 2014 and 2020 goals … a target date for achieving climate neutrality as soon as possible while maintaining the University's overall mission
- 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.

The policy also requires each UC campus to pursue individual membership with the California Climate Action Registry (CCAR) or The Climate Registry (TCR), both of which are registries for GHG emissions inventories.

In addition to the developing its own policy on sustainable practices, the University of California is a signatory to **the American College and University Presidents' Climate Commitment** (ACUPCC) (www.presidentsclimatecommitment.org). The UC sustainability policy was revised in September 2009 and is consistent with the ACUPCC. One important aspect of the ACUPCC is that it obligates UC campuses to inventory certain sources not required by the registries used to report annual GHG emissions. These sources include commuter miles and business-related airline travel paid for by or through the institution. Considering commuter miles as part of the campus footprint requires campus involvement in regional transportation planning issues.

The California Air Resources Board (ARB) is the state agency responsible for providing implementation mechanisms, regulatory guidance and enforcement of Assembly Bill 32 (AB32). AB32 includes statutory requirements requiring inventorying, reporting and verification of GHG emissions, depending upon size and source type. UC Davis is subject to these reporting requirements. In addition, it appears that ARB will be implementing some type of cap and trade system to rachet down CO2 emissions as a component of implementing AB-32. Cap and trade could have a significant fiscal impact on UC Davis. This pending regulation will require sources of GHG emissions to manage their emissions under an aggregate declining emissions cap that supports achieving the 2020 emissions target mandated by AB32. The program is planned to start in 2012 with the state's largest GHG-emitting stationary sources. In the case of UC Davis, the drivers are the cogeneration plant at the Sacramento campus and the boilers at the Davis campus. Sources would have to obtain emission allowances, although the process has yet to be finalized. It is anticipated that allowances will be obtained through an auction process, which could represent a significant annual increase to source operating cost, potentially in the millions of dollars. Market forces will push the issue, for as the emissions cap shrinks, operating costs will increase unless the source can reduce emissions.

More recently, implementation of the **California Environmental Quality Act** (CEQA) has included considering and mitigating for the effects of greenhouse gas emissions. The Office of Planning and Research issued draft CEQA guidelines amendments in April 2009 and adoption is expected in 2010. Although final guidelines have not been promulgated, all recent CEQA documents prepared by the University of California include analysis of the potential environmental effects of projects and growth plans due to changes in GHG emissions. The mitigation measures adopted in environmental impact reports then become binding under CEQA, unlike a plan such as the CAP.

At this time, the **United States Environmental Protection Agency** (USEPA) is evaluating the following rules and programs, which would affect UC Davis in the following ways:

- Final Rule- USEPA Mandatory Reporting of Greenhouse Gases: Facilities that emit 25,000 metric tons of carbon dioxide or its equivalent (MTCO2e) will be required to report their annual emissions to the USEPA, and both the Davis and Sacramento campuses have facilities that emit over 25,000 MTCO2e.
- Proposed Federal Cap and Trade Program: Both the United States House of Representatives and Senate have introduced bills to develop a Federal "Cap and Trade" approach to GHG management. It is not clear at this time how this program would affect UC Davis.
- Proposed USEPA Greenhouse Gas Tailoring Rule: USEPA has proposed a rule to tailor the major source applicability thresholds for GHG emissions under the Prevention of Significant Deterioration (PSD) and Title V programs of the Clean Air Act. Both the Davis and the Sacramento campuses would be affected since both are Title V permitted facilities.

1.3 CONTEXT AND SETTING

UC Davis' breadth of activities strongly influences both the amount of emissions the institution is responsible for and the types of actions available to the campuses of UC Davis. This section outlines this context and describes key influences on emissions.

1.3.1 Geography

UC Davis is a complex institution, with one campus in Davis, one campus in Sacramento and many off-site facilities. UC Davis has the largest number of professional schools of all the 10 UC campuses, including the only public veterinary school in the state. The institution is research intensive and ranks in the top 20 universities nationally in research expenditures.

The CAP covers the Davis campus, the Sacramento campus, and outlying facilities, and these are defined and characterized as follows:

The **Davis campus** includes the entirety of the campus lands adjacent to the city of Davis, the Russell Ranch lands approximately 1.5 miles west, the Wolfskill research property near Winters, and leased space within the city of Davis. Owned campus lands encompass 5,300 acres, with nearly 1,000 buildings totaling about 10,565,000 gross square feet. The campus Long Range Development Plan (LRDP) was adopted by The Regents in November 2003 and has a planning horizon of 2015-16.

The **Sacramento campus** includes the entirety of the campus lands in Sacramento, which house the medical center facilities, nearly all School of Medicine facilities, and some of the clinical network facilities, as well as the leased spaces which house additional clinics and research facilities. Owned campus lands encompass 142 acres, with 30 buildings totaling more than 3,440,000 gross square feet. The Sacramento campus has a 613-bed hospital, with associated care facilities, and is currently preparing a new LRDP.

Outlying facilities include the Bodega Bay Marine Laboratory, Tahoe Environmental Research Center facilities in California and Nevada, the Veterinary Medicine Teaching Facility in Tulare, and a myriad of small off-site facilities, including agricultural well pumps, small research lands and facilities, and a small facility at Lawrence Livermore National Laboratory.

Figure 1.1. Locator Map of Davis and Sacramento Campuses

1.3.2 Infrastructure and Operations

The following are some of the key influences on greenhouse gas emissions related to infrastructure and operations.

Davis campus

Infrastructure: The Davis campus owns and operates nearly all its infrastructure, including a landfill, a wastewater treatment plant providing tertiary level treatment, an electrical substation, a central heating and cooling plant to produce steam and chilled water, wells and pumping facilities to provide domestic and irrigation water, among other infrastructure. The campus owns and operates a bus system, Unitrans, and in partnership with city funds, provides service to the campus and the adjacent city of Davis. Having so much infrastructure under operational control poses both constraints and opportunities in reaching carbon neutrality.

Energy sources: The Davis campus purchases virtually all of its electricity with essentially no locally produced power. It had a cogeneration facility from 1979 to 2005; due to the cost of natural gas, the cogeneration plant was dismantled and sold. The price disadvantage of natural gas was made sharper with a contract for inexpensive electricity with the **Western Area Power Administration** (WAPA), Sierra Nevada branch; WAPA manages a number of large-scale hydropower resources, and base load delivered to the campus includes a percentage of this large-scale hydropower. Although not considered a renewable resource in the California state definition of renewable power sources, the campus does consider the hydropower to be carbon neutral because it does not involve significant consumption of fossil fuels for generation of energy, and removes the portion of kilowatt-hours attributable to hydropower from the kilowatt-hours calculated for emissions. The hydropower portion varies year to year, based on the annual hydrological regime – wet years net more hydropower, dry years less. The rest of the power WAPA delivers is obtained from a variety of sources, including coal and nuclear sources. Because the mix of those sources changes in the real-time market, the campus and WAPA do not attempt to isolate the nuclear component in calculating emissions. The Davis campus also buys power through additional power contracts with Pacific Gas & Electric (PG&E), Arizona Power Supply, Sempra, and other suppliers throughout the years. Often these supplies help the campus manage peaking needs. PG&E is also the utility for a great deal of leased, off-campus space. Natural gas is largely supplied through a contract with Department of General Services, with additional supplies from other contracts and PG&E.

Building age: The Davis campus opened its doors to the first students in 1908 and grew rapidly during the early 1960s, after it became a general campus in 1959. A number of the campus's buildings were constructed when energy efficiency was not a major priority, and before central air conditioning was available, which has required retrofitting; many buildings ventilate at constant rates day and night; and many do not have direct digital control of their mechanical systems. Consequently, many of the buildings do not deliver energy efficient performance. The campus is undertaking a major program, the Strategic Energy Partnership Program (SEPP), to correct some of these deficiencies, but these buildings will still consume copious energy even with recommissioning, lighting retrofits, new HVAC systems and other measures. Many buildings are not identified for treatment under the SEPP, due to current program limitations.

Research growth: Another key influence on the Davis campus is the growth in laboratory research, in particular the growth in the life sciences, over the past two decades. Research laboratories and animal care facilities are very energy intensive, as are healthcare and food preparation facilities. Together, these three space types appear to use about 75 percent of the energy expended in operating the campus.

Facility growth: Another key influence on power consumption, and therefore emissions, is growth. The campus has grown tremendously in the past half-century, and future growth will be a constraint on the campus in terms of meeting carbon neutrality. At root, the campus has a lot of built square footage, and intense, innovative space management is one of the frontiers of emissions reduction that the campus will need to employ.

Sacramento campus

Energy sources: The Sacramento campus owns and operates a **cogeneration plant**, chillers, and boilers in a central plant facility. Prior to building the cogeneration plant, the Sacramento campus sourced electricity from the local publically owned utility, Sacramento Municipal Utility District (SMUD). The cogeneration plant was built in 1998 to provide a reliable, smooth power supply to the hospital and other patient care facilities. The plant was brought online right before energy deregulation in California, and during that turbulent period, the campus took advantage of the opportunity to generate and sell power to SMUD. As the California Public Utility Commission changed rules about generating and selling, the Sacramento campus stopped generating and selling power for the spot market. However, in order to operate the cogeneration plant efficiently, the campus still sends power to SMUD, but those power shipments now offset purchased electricity during periods when the plant is undergoing maintenance. The cogeneration plant provides both steam and electricity efficiently. The cogeneration plant efficiency can reach 80% on a peak day for heating and cooling.

Healthcare and medical research: As a campus with a medical center complex and research facilities, Sacramento has a lot of energy-intensive square footage. Hospital facilities are heavily regulated by the Office of Statewide Health Planning and Development, with code requirements that can conflict with energy efficiency goals. Several campus buildings, including some of the hospital buildings, are over 50 years old, and their systems are not as efficient as desirable. The campus also conducts research in fields that require energy-intensive equipment, such as brain imaging.

Facility growth: The Sacramento campus is working on a new LRDP to guide growth for the next 15 years. In the new LRDP, the campus proposes approximately doubling the campus square footage. Should that growth all happen and existing buildings continue to consume the energy they are, the cogeneration plant will need to be expanded. Energy efficiency in new building and energy conservation in existing facilities are clearly target opportunities for the Sacramento campus to limit or reduce GHG emissions given the dependence on the natural gas-fired cogeneration plant.

Outlying facilities:

Energy sources: These facilities receive their utilities mainly from investor-owned utilities such as PG&E and Southern California Edison. Some of the facilities have grown over the years, and there are many more facilities since 1990. However, these facilities consistently have contributed about 1 percent to 2 percent of UC Davis' total greenhouse gas emissions.

1.3.3 Influences on Greenhouse Gas Emissions

Some key aspects of the institution that influence emissions levels include.

Population: Figure 1.2 illustrates the growth in student and personnel population since 1990. All campuses and facilities are combined. Today's UC Davis has about 45 percent more students, faculty and staff than in 1990. Population in 1989-90 was 14,614 faculty and staff and 21,920 students; by 1999-2000, faculty and staff numbered 17,723 and students 24,033; and 2008-09 faculty and staff numbered 22,738 and students 30,403. These are headcount, annual three-quarter averages for student populations and October and April snapshot figures for faculty and staff. Headcount was chosen instead of full time equivalents (FTE) to give a full sense of the number of employees and students affiliated with the campus.

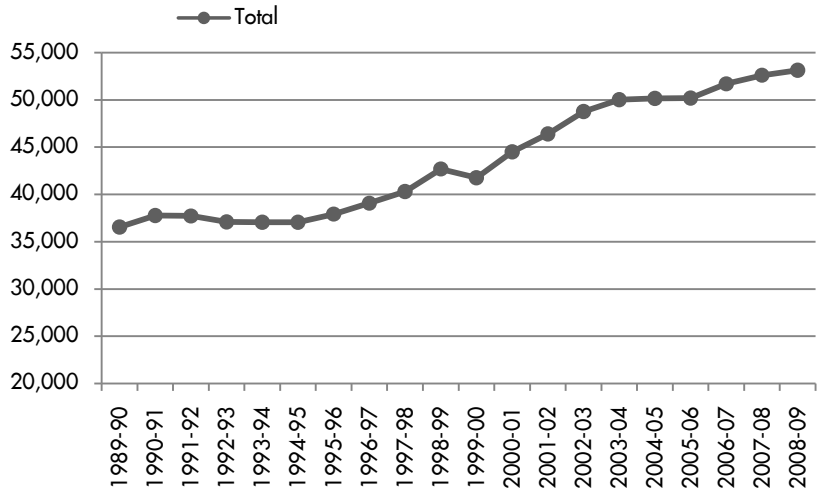


Figure 1.2: UC Davis Population, 1990-2008
Data sources: UC Davis Budget and Institutional Analysis records of student and faculty/staff headcounts

Square footage: Figure 1.3 shows total occupied gross square footage since 1990. The growth here shows the dramatic building program undertaken in the past two decades at UC Davis.

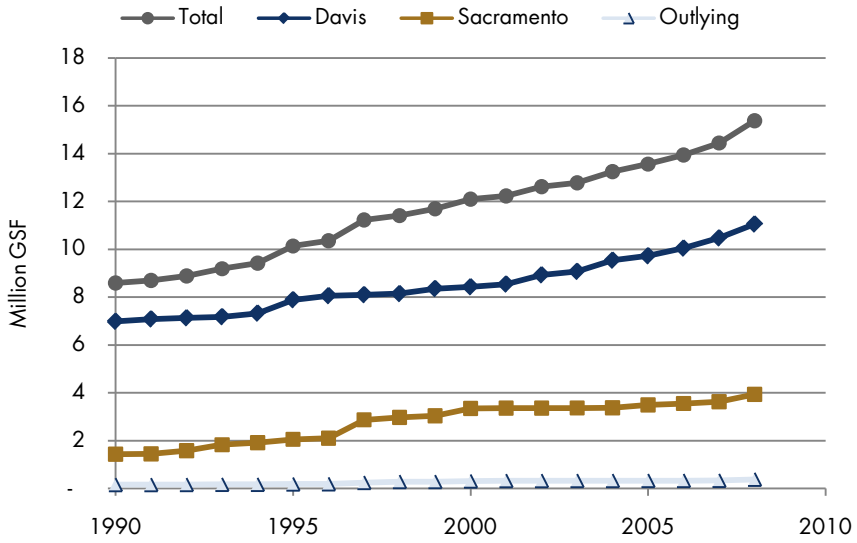


Figure 1.3: UC Davis Building Area, in Million Gross Square Feet, 1990-2008
Data from Facilities Link Hyperion data run (12/16/09); 1996 & 1997 jump may be data entry artifact.

Annual Purchased Electricity Use, in kWh:
Figure 1.4 illustrates the enormous demand for electricity. Growth over the past two decades reflects the growth in research lab activity, building square footage, and population. In 1990, the institution used 187 million kWh; by 2000, the demand rose to 221 million kWh; and in 2008, demand was 284 million kWh, an increase of nearly 100 million kWh since 1990 (see footnote 1).

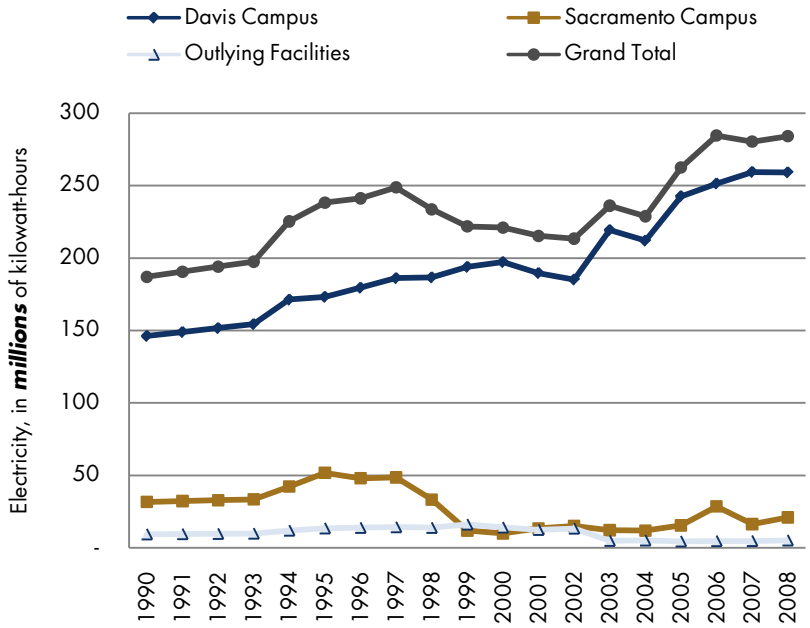


Figure 1.4: UC Davis Annual Purchased Electricity Usage

Annual Natural Gas Use, in therms:
Figure 1.5 illustrates the equally enormous demand for natural gas. Note the increase, starting in 1998, as the Sacramento campus cogeneration plant was brought on line July 1, 1998 and a large 14-story building was finished and occupied in late 1999. During deregulation (1999-2001), the Sacramento campus generated electricity well in excess of campus needs and sold that excess to the California Independent System Operator (CAISO), Department of Water Resources, and SMUD. By 2002, the practice ended, although there is still some excess capacity sent to SMUD, which offsets purchased electricity. The Davis cogeneration plant was fully decommissioned by 2005, and a corresponding dip can be seen starting in 2004. In 1990, demand was 11 million therms; by 2000 demand spiked to 32 million therms; and in 2008 equaled 23 million therms[1].

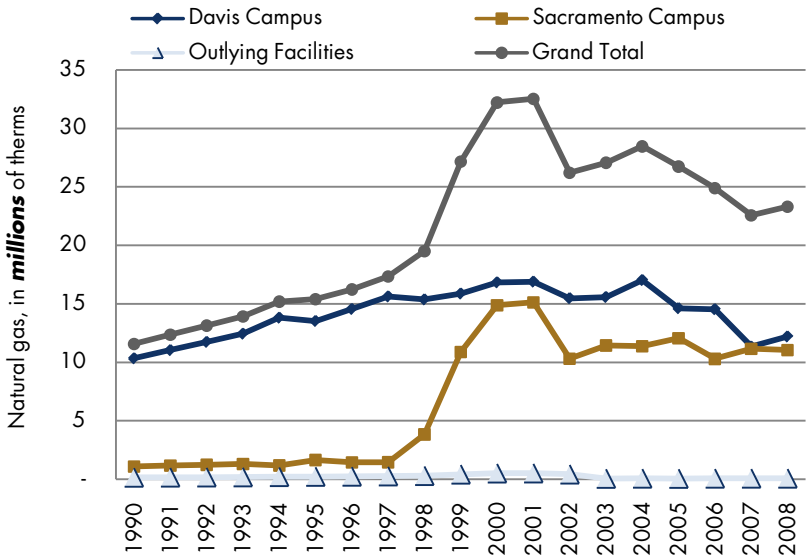


Figure 1.5: UC Davis Annual Natural Gas Usage

[1] To put the magnitude in perspective, the average California household uses about 6,000kWh/year and about 431 therms/year (http://www.energy.ca.gov/reports/400-04-009/2004-08-17_400-04-009ES.PDF).

Heating and cooling degree days: A degree day is method of describing the relative amount of energy needed to heat or cool a building from outside temperature to a balance point, typically 65°F in the United States. The degree day unit of measurement provides a way to bundle several normalized variables. Degree days vary considerably from year to year.

Heating and cooling degree days influence building level HVAC system design and operation, as well as Central Heating and Cooling Plant design and operation. Perhaps counterintuitive, Davis and Sacramento experience more heating degree days than cooling degree days. Thus, the campus uses more energy on heating than cooling. Natural gas is used to produce steam for heating, and electricity is used to power the electric chillers to make cold water for cooling.

In general, the considerable annual variation in degree days contributes to annual variation in energy use, and the GHG emissions tied to it. Actual usage, however, does not perfectly correlate due to other influencing factors.

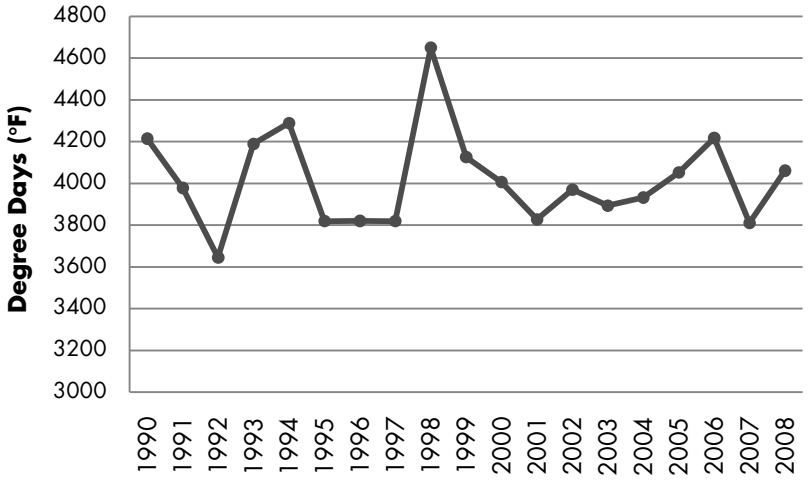


Figure 1.6: Sacramento Heating Degree Days (65 °F balance point)

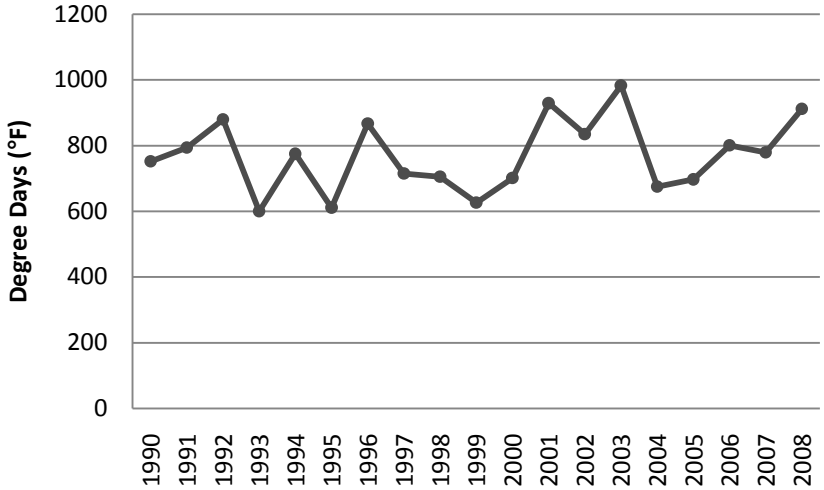


Figure 1.7: Sacramento Cooling Degree Days (65 °F balance point)

The next chapter presents greenhouse gas emissions accounting from 1990 to 2008. (As of the time of writing and publishing the 2009-2010 CAP, the 2009 GHG emissions data was still being compiled.)

CHAPTER 2: **GREENHOUSE GAS EMISSIONS**

Since the CAP is a roadmap for moving towards climate neutrality, it is critical to know the campus' starting pont before striking out on this evolving journey. The first step to meeting any performance standards or goals is to assess current performance and learn how current performance differs from desired performance. Details about how emissions were calculated are presented in Appendix 1: Basis Notes.

2.1 EMISSIONS SOURCES

In the language of emissions inventories, there are three main types of emissions, which are referred to as "scopes." Scope 1 includes emissions sources that are a direct result of an emitter's operations, usually involving fuel combustion, and generally occurring on-site. Scope 2 includes all emissions sources indirectly resulting from an emitter's consumption of purchased utilities (such as electricity) and occurring off-site. Finally, Scope 3 is something of a catch-all category and includes emissions sources that are also indirect, often off-site, and sometimes under even less institutional control than Scope 2 emissions. The following comprise the currently known emission sources for UC Davis:

2.1.1 Scope 1 – Direct emissions:

- **Mobile combustion**, including Fleet Services vehicles, Unitrans buses, Davis-Sacramento shuttle, and off-road agricultural and grounds maintenance equipment
- **Stationary combustion**, including natural gas combustion in boilers, cogeneration plant, propane, kerosene and diesel combustion in various heaters, equipment, and generators
- **Process emissions** from the Davis campus wastewater treatment plant
- **Fugitive emissions** include refrigerant usage in chillers, HVAC systems, vehicles, and research, research gases, fume hood testing, electrical switches, fire extinguishers, landfill gases, and distribution losses in natural gas lines. Most of the fugitive emissions are reported as "**de minimis**" for two reasons: 1) de minimis emissions are small and cumulatively amount to less than 5 percent of the institution's total emissions, and 2) the data for them is not verifiable, because it is based on consumption estimations, rather than on actual usage data.
- **Agricultural emissions** include animals that emit methane and soil treatments that emit CO2 and N2O. Agricultural emissions are currently unquantified. Soil emissions due to microbial respiration and denitrification, while potentially significant, are highly variable and dependent on weather. The IPCC does not endorse their quantification at this time.

2.1.2 Scope 2 – Indirect emissions related to production of electricity consumed by institution:

- **Purchased electricity** is the only indirect emission for UC Davis, and includes purchases from many different suppliers, as noted in Chapter 1. The campus also uses an approved methodology to calculate emissions associated with leased space square footage held under "full service leases," which bundle utilities into the lease price, so the campus does not have utilities use data for those spaces.

2.1.3 Scope 3 – All other indirect emissions:

- For UC Davis, Scope 3 emissions are considered for **business**, **research**, **athletics**, **study abroad related travel** and **commuting**. The campus does not report Scope 3 emissions in the verified inventories conducted annually since 2006, as these emissions are not requested by the greenhouse gas inventory registry that UC campuses use. Energy embedded in construction, outsourced/contracted activities, or the extraction, production and transportation of purchased goods are not considered at this time. As regulatory guidance develops regarding the treatment of Scope 3 emissions, perhaps to include adoption of methods that avoid double-counting of emissions, this decision may be revisited.

2.1.4 Biogenics emissions

- The campus has biogenic mobile emissions related to use of **biodiesel fuel** in some campus Fleet Services vehicles, and biogenic stationary emissions related to the **combustion of landfill gas** as fuel in some facility boilers. The campus chooses to report biogenic emissions on a voluntary basis in emissions inventories conducted annually, but reporting of biogenics is not required.

2.2 REPORTED EMISSIONS (2005-2008)

2.2.1 Verified Inventorying

In 2006, UC Davis joined the California Climate Action Registry (CCAR) and performed the first assessment of year 2005 greenhouse gas emissions for CO2 only. In 2006, the campus began reporting all six categories of gases in the annual inventory. Inventories have been verified by a third party and accepted by CCAR for all four years of verified inventories (2005-2008). The campus reports for verification all Scope 1 and 2 emissions for all facilities. Verification entails third-party, external review of reported data, site visits, interviews, and independent analysis of reported data to ensure Registry participants are accurately reporting their emissions according to required protocol. For the recently completed 2008 emissions inventory, all emission factors and calculation methods follow the CCAR General Reporting Protocol 3.1 (GRP3.1).
(See: http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html)

Four years of inventorying for direct and indirect emissions have shown consistently that the Davis campus contributes about 70 percent of the emissions total, the Sacramento campus contributes about 29 percent of the total, and the outlying facilities contribute about 1 percent of the total.

Table 2.1 provides summary data, and Table 2.2 on the next page offers greater supporting detail for this table.

Metric tonnes CO2e, by year, from verified inventories, including optional biogenic sources

Campus (Proportion)	2008 (all 6 gases)	2007 (all 6 gases)	2006 (all 6 gases)	2005 (CO2 only)
Davis (~70%)	166,709	180,534	149,563	155,681
Sacramento (~29%)	68,502	67,815	60,571	69,470
Outlying Facilities (~1%)	3,849	3,401	2,413	2,259
Total UC Davis	239,060	251,750	212,547	227,410

Table 2.1: Reported Emissions, 2005-2008, summarized

The inventory process continues to refine and improve data collection and calculation. For example, in 2007, research gases were added to the inventory; optional biogenic emissions were calculated; and a switch was made from financial control (control over expenditures) to operational control (control over operations of facilities and programs) in order to cover all leased space, including full-service leases that include the price of utilities, and for which there is institutional control over the programs in the leased space.

In general, the campus is very conservative in emissions calculations for the inventories, preferring to assume reasonable worst-case scenarios where exact data is not obtainable, especially with the de minimis sources. An example of worst-case assumption is in using headcount instead of FTE in estimating emissions associated with the wastewater treatment plant. Another example is the use of purchased amounts of refrigerants and research gases, rather than actual amounts replaced in systems or used in labs. The campus knows that not all purchased amounts are used the same year, but without exact usage data, all purchases are assumed to result in fugitive emissions during the year of purchase. Over time, the campus anticipates stronger record-keeping and refinement of calculation methods will result in continual improvement and more precision in emissions reporting. However, these reasonable worst-case assumptions have only a minor effect on overall emissions due to the small volume compared to energy-related sources of GHG.

CCAR is transitioning to The Climate Registry (TCR), a nationwide entity, and all of the UC campuses will begin reporting their inventories in TCR's reporting tool. UC Davis will begin reporting in TCR in 2010. This is mentioned here because during 2010, all of Davis' inventories will be moved over from the CCAR reporting tool to the TCR reporting tool, and the public will access the reports through TCR's site.

Table 2.2: Reported Inventories in California Climate Action Registry

all in MT CO2e	2008 Davis	2008 Sacramento	2008 Outlying*	2007 Davis	2007 Sacramento	2007 Outlying*	2006 Davis	2006 Sacramento	2006 Outlying*	2005 Davis	2005 Sacramento	2005 Outlying*
Direct Emissions												
Mobile combustion - Fleet & Unitrans	6,045	818		6,244	875		6,192	809		5,359	944	
Mobile - other fuel use	800		127	737		156	675		150	548		98
Stationary combustion	66,255	58,240	898	68,740	59,861	696	77,463	54,281	587	76,115	63,883	617
Process emissions (WWTP)	9,213			10,568								
Fugitive emissions		11	0.12	27	11		203	11		0		
subtotals	82,312	59,069	1,025	86,315	60,747	852	84,533	55,100	737	82,022	64,827	715
Indirect Emissions												
Purchased electricity	76,843	8,132	2,110	88,651	3,983	2,093	60,221	2,414	1,205	73,659	4,642	1,212
De Minimis Emissions												
Fleet vehicle refrigerant usage	7	8		212	42		106	53				
Unitrans refrigerant usage	73			120			30					
Refrigerants	1,722	1,293		3,314	3,029		4,352	3,003				
Natural gas distribution related	342			210								
Fire extinguishers	0.23	0.08		0.23	0.08		0.23	0.08				
Fumehood tests	401			152			271					
Electrical switches	87			49			49					
Research gases - SF6, CH4, CO2, N2O	4,589			1,398								
Small facilities electricity usage			518			266			276			222
Small facilities natural gas usage			197			190			194			110
subtotals	7,220	1,301	714	5,454	3,071	456	4,809	3,056	470			332
Optional Emissions												
Biogenic - mobile	106			115	13							
Biogenic - stationary (gas)	228			0								
Leased space, full service leases	2,060			418								
campus totals	166,709	68,502	3,849	180,534	67,815	3,401	149,563	60,571	2,413	155,681	69,470	2,259
(with optional biogenic) Total		**239,060**			**251,750**			**212,547**			**227,410**	
(without optional biogenic) Total		238,726			251,622							

* Outlying facilities include Bodega Bay Marine Laboratory, Tulare, Tahoe, and small offsite facilities such as irrigation pumps.

Each of these inventories can be accessed at the Registry site. Please see https://www.climateregistry.org/CARROT/public/reports.aspx. Data has been rounded to the nearest digit, in most cases. Scope 3 emissions are not included as explained in Section 2.1.3 (above). Leased space emissions already included in the indirect emissions totals for 2007 and 2008.

2.3 EXTRAPOLATED EMISSIONS (1990-2008)

The four years of GHG emissions inventorying helped provide a strong base from which to draw a portrait of emissions back to 1990, in terms of types of both data needed and understanding relationships between emission sources. For example, the Sacramento campus cogeneration plant provides electricity to SMUD (although on a much more limited basis now than it did during 2000-2001) thus there is a corresponding increase in therms and dip in purchased kilowatt-hours since 1999.

In order to build a baseline for 1990-level and 2000-level emissions, the campus has assembled hard data when available, and either projected data for sources with gaps, or omitted sources that were too small to significantly influence emissions.

As shown in Figure 2.3 below, natural gas consumption and purchased electricity make up 85 percent to 88 percent of the total Scope 1 and 2 emissions for UC Davis.

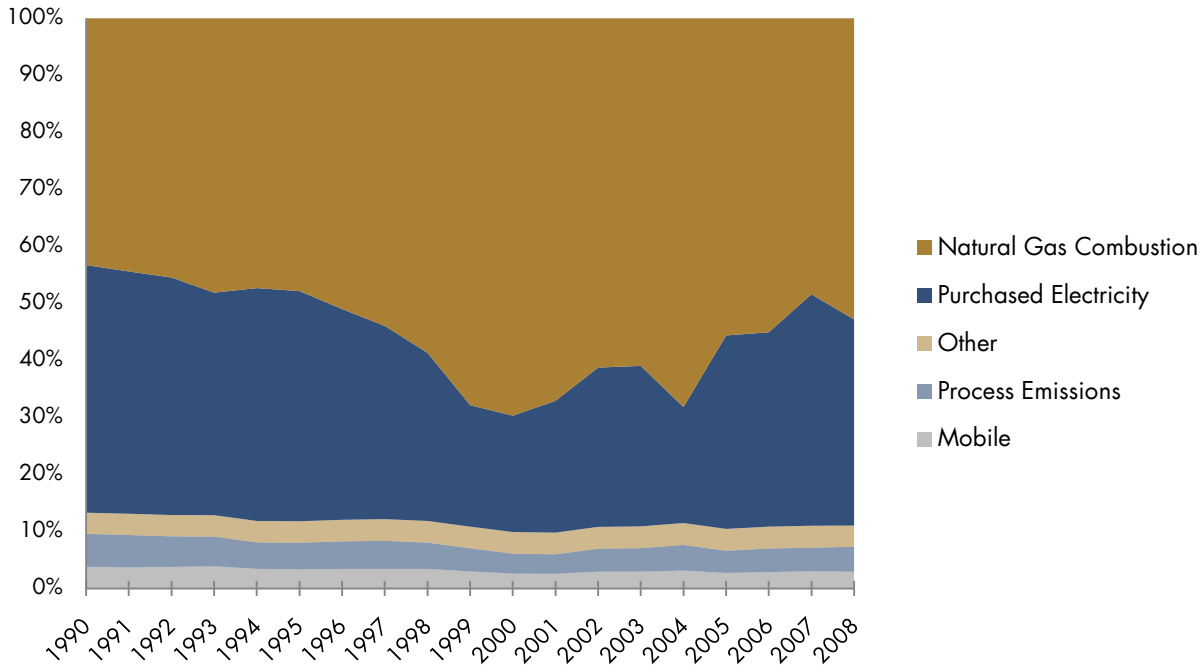


Figure 2.3: UC Davis Scope 1 & 2 Emissions (1990-2008)

2.3.1 Sources in emissions baseline

The following sources are **included** in the UC Davis extrapolated emissions baseline:
Davis campus: electricity and natural gas use, Fleet Services, Unitrans, refrigerants, Ag services vehicles, kerosene use at the Primate Center, leased space, propane use, research gases, wastewater treatment plant process emissions; **Sacramento campus**: electricity and natural gas use, Fleet Services, leased space; **Outlying facilities**: electricity and natural gas use for Bodega Bay Marine Laboratory, Tulare and small facilities.

The following sources are **omitted** in the UC Davis extrapolated emissions baseline:
Davis campus: small vehicles (Gators), diesel-fired boilers (only diesel-fired during testing and emergencies such as natural gas curtailments), emergency generators, Grounds Division fuel tanks, electrical switch and fumehood testing SF6 use, natural gas distribution line fugitive emissions, small source diesel tanks at Plant Pathology and Pomology, fire extinguishers; **Sacramento campus**: emergency generators, refrigerants, fire pump, natural gas distribution line fugitive emissions, vehicle refrigerants; **Outlying facilities**: gasoline and diesel use, propane use, Tahoe (either facility).

Because the omitted sources are very small and no data for them was readily available before 2007, these sources were not extrapolated. Before the decision was made to not include them, an analysis was done to

determine how much the sources contributed to the total emissions in the 2007 inventory. Cumulatively, they amounted to less than 3 percent of the total.

All Kyoto protocol gases are considered, with the following data variances. At UC Davis, HFCs are used in research gases and refrigerants, but PFCs are not. Because refrigerants emissions for 1990-2006 are based on projections from 2007 data, there are no PFCs considered, so PFCs have not been deliberately excluded, but they are *de facto* excluded. And, SF6 is a compound used in fumehood testing and electrical switches, but because the emissions quantities associated with that are so small, that data was not projected back. Note that annual emissions inventories count SF6, and should PFCs ever be used at UC Davis, those emissions will be counted in inventories.

Commuting emissions were derived using travel survey data, and number of parking permits by zip code to estimate miles, and emissions. The commuting data was extrapolated against campus populations. Business air travel, including research abroad, emissions were calculated used sampled data that was extrapolated against population. Similarly, athletics and study abroad travel emissions have been extrapolated against student population, using hard data from 2007 (athletics) and 2008 (study abroad). These are rough extrapolations, but in the absence of hard data, these were the best projections derivable. These data can be found in Appendix 2. A farm animals census is provided in Appendix 2, but emissions will not be estimated at this time due to recent research, by UC Davis professor Frank Mitloehner, that calls into question current emissions factors for animals.

Detailed notes on assumptions and calculations are available in Appendix 2, Baseline Data Notes. The tables below and on the next page show the baseline data by campus (Table 2.4) and by source (Table 2.5).

Table 2.4: Baseline Data Totals **by campus**

Scope 1 & 2 Only:

	MTCO2e emissions				delta: **2008**
	Davis Campus	Sacramento Campus	Outlying Facilities	Grand Total	
1990	**120,991**	**20,335**	**871**	**142,196**	**92,488**
1991	126,082	21,055	887	148,025	**39%**
1992	131,080	21,774	904	153,758	
1993	130,655	22,409	920	153,984	
1994	144,363	25,412	990	170,765	
1995	138,566	31,524	1,047	171,138	
1996	139,056	29,086	1,137	169,279	
1997	140,282	29,439	1,206	170,926	
1998	138,964	36,545	1,307	176,816	
1999	143,876	66,664	2,389	212,928	
2000	**156,403**	**87,692**	**1,743**	**245,837**	**(11,153)**
2001	166,196	90,433	1,243	257,872	**-5%**
2002	160,398	65,006	2,169	227,573	
2003	164,300	68,970	2,884	236,155	
2004	159,723	68,322	3,095	231,895	
2005	179,238	73,846	2,596	255,680	
2006	168,729	68,968	2,748	240,446	
2007	175,480	69,793	2,740	248,013	
2008	162,775	69,235	2,674	234,684	

NB: Scope 3 data is aggregated, and aside from commuting data, it cannot be separated by campus.

Table 2.5: Baseline Data Totals, **by source**

All values in MTCO2e

	Scope 1	Scope 1	Scope 1	Scope 1	Scope 2			Scope 3	Scope 3	Scope 3	Scope 3	Scope 3	All Scopes
Year	Mobile	Natural Gas Combustion	Other	Process Emissions	Purchased Electricity	Total	difference from **2008**	Commuting: Davis	Commuting: Sacramento	Air Travel: Business Only	Car Miles Reimbursed: Business	Total	Grand Total
1990	5,415	61,550	5,284	8,199	61,749	142,196	92,488	21,171	13,407	8,575	1,289	44,442	186,638
1991	5,485	65,730	5,520	8,391	62,898	148,025	**39%**	21,729	13,802	8,476	1,269	45,275	193,300
1992	5,826	69,910	5,752	8,222	64,047	153,758		21,967	13,951	8,907	1,350	46,175	199,933
1993	6,002	74,091	5,780	8,004	60,107	153,984		21,285	13,497	8,797	1,312	44,891	198,875
1994	5,884	80,807	6,423	7,914	69,738	170,765		21,276	13,491	9,065	1,352	45,184	215,949
1995	5,762	81,878	6,456	7,960	69,082	171,138		21,022	13,329	8,947	1,319	44,616	215,754
1996	5,802	86,323	6,406	8,175	62,573	169,279		21,468	13,640	9,115	1,343	45,566	214,845
1997	5,862	92,234	6,487	8,433	57,911	170,926		21,968	13,996	9,318	1,367	46,650	217,576
1998	6,076	103,721	6,725	8,139	52,155	176,816		22,542	14,399	9,718	1,423	48,083	224,899
1999	6,376	144,470	8,086	8,624	45,372	212,928		23,631	15,439	10,850	1,608	51,527	264,456
2000	6,420	171,335	9,328	8,574	50,179	245,837	(11,153)	21,783	15,089	10,399	1,539	48,811	294,648
2001	6,656	172,994	9,795	8,794	59,633	257,872	**-5%**	21,763	15,858	11,251	1,643	50,514	308,386
2002	6,719	139,404	8,688	9,170	63,591	227,573		22,985	16,459	11,718	1,703	52,865	280,438
2003	6,986	143,962	9,027	9,702	66,478	236,155		23,706	17,201	12,044	1,740	54,691	290,846
2004	6,971	151,427	8,524	9,994	54,979	231,895		24,130	17,646	12,256	1,771	55,803	287,698
2005	6,996	142,219	9,791	9,923	86,752	255,680		24,690	17,395	12,535	1,780	56,400	312,081
2006	6,909	132,407	9,244	9,918	81,968	240,446		25,760	17,551	12,733	1,824	57,868	298,314
2007	7,519	120,041	9,544	10,224	100,685	248,013		25,507	17,485	13,190	1,827	58,009	306,026
2008	6,908	123,995	8,721	10,261	84,800	234,684		25,411	17,794	13,520	1,873	58,597	293,281

NB: Emissions for 1990-2006 are calculated using the same General Reporting Protocol value for the campus's regional eGRID factor (CAMX).
Values for 2007 and 2008 use different emissions factors than 1990-2006, according to the protocols in place for those years.
"Other" includes refrigerants, research gases, fugitive emissions from natural gas distribution, fumehood testing fugitives, and combustion of propane and kerosene.
Athletics and Study Abroad travel emissions are shown in a separate table in Appendix 2. A census of farm animals is reported in a separate table in Appendix 2.

2.4 FUTURE PROJECTIONS AND EMISSIONS TARGETS

Historic emissions are presented in Figure 2.6, with the 1990 and 2000 target year points highlighted. Of note is the jump in emissions around 1999 and 2000, which correlates with the Sacramento campus cogeneration plant coming online and which has more or less persisted since then. The linear trend for "business as usual" is reflected in the dotted line on the graph, and is derived strictly by forecast trending, without accounting for any energy savings programs, such as the SEPP, or renewable energy sourcing.

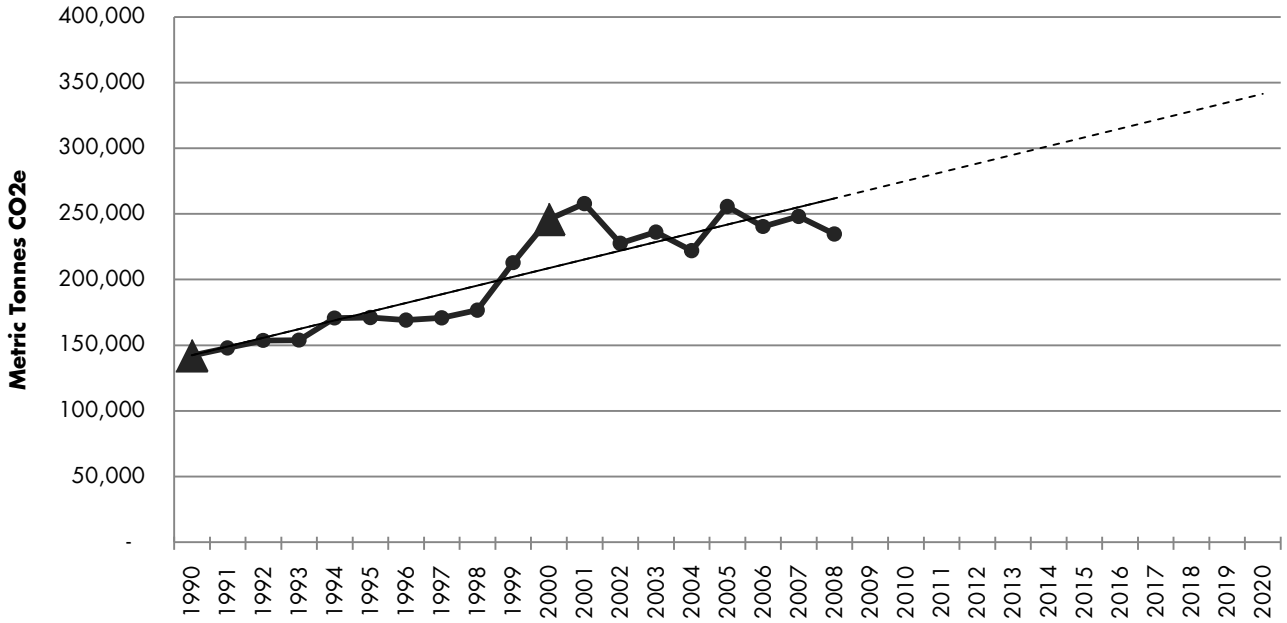


Figure 2.6: Annual Emissions Projected to 2020

UC Davis has already met the first target of emissions reductions to levels in 2000 for Scopes 1 and 2. This target is currently being met because of high natural gas use in 2000. Although this use pattern is related to the vagaries of the energy market in 2000, the achievement is nevertheless notable when stacked against the amount of growth (population, square footage, and research) during the past decade, and is in part attributable to the number of energy-saving measures undertaken by the campus. Emissions have been relatively flat since 2001. The challenge during the next decade will be to turn the trend downward, in the face of projected growth outlined in the UC Davis 2009 Ten-Year Capital Plan.

In the next chapter, the campus explores methods to reduce emissions further, to **meet a new goal of 210,000 MTCO2e by 2014**, and to meet the 2020 target in 2020. The new 2014 target is slightly less than 1999 emissions, before the Sacramento cogeneration plant was fully pressed into service during deregulation. Tables 2.7 and 2.8 show reduction targets.

Table 2.7: Targets, Scope 1 & 2 emissions only

2008 Emissions	2014 Target	% Delta	2020 Target	% Delta
234,684 MTCO2e	210,000 MTCO2e		142,196 MTCO2e	
Delta	~25,000 MTCO2e	-10.5%	~93,000 MTCO2e	-39.4%

NB: Based on modeled data

Table 2.8: Targets, including Scope 1, 2, and Scope 3 commuting and business air travel

2008 Emissions	2014 Target	% Delta	2020 Target	% Delta
293,281 MTCO2e	261,000 MTCO2e		186,638 MTCO2e	
Delta	~33,000 MTCO2e	-11%	~107,000 MTCO2e	-36.4%

NB: Based on modeled data. Excludes study abroad or athletics travel

CHAPTER 3. EMISSIONS REDUCTION ACTIONS

3.1 ENERGY USE REDUCTION TO DATE

Energy use is overwhelmingly the major source of greenhouse gas emissions from UC Davis' operations. Both the Davis and Sacramento campuses have done a number of things to reduce energy consumption over the past two decades. A detailed list of those actions is provided in Appendix 3. In summary, the actions include valve replacements to reduce loads on chillers, heat recovery systems, controls upgrades, chiller replacements, various types of improvements at the central plants, installation of variable frequency drives, building recommissioning, replacing inefficient lightbulbs (T12s) with more efficient ones (T8s) and other lighting improvements, and requiring new building performance to exceed the building energy performance requirements (called Title 24) of the California Building Code by 20 percent or more. In addition, the Davis campus has pursued United States Green Building Council Leadership in Energy and Environmental Design (LEED) green building certification at the three highest levels: Silver, Gold and Platinum buildings, both campuses follow the UC Policy on Sustainable Practices requirements for new buildings, and utilizes the U.S. Environmental Protection Agency and Department of Energy program, Laboratories for the 21st Century (Labs21), environmental performance standards for laboratory buildings.

Avoided emissions resulting from these energy use reduction actions are seen already in the annual greenhouse gas inventories, and have contributed to the relatively flat emissions since 2000. With these actions already implemented or currently in practice, UC Davis must seek additional opportunities at all facilities, but especially at the Davis and Sacramento campuses, to reduce energy consumption and reduce emissions. The following material describes possible opportunities, and where emissions reductions can be estimated, those savings are presented.

3.2 EMISSIONS REDUCTION OVERVIEW

As shown in the previous chapters, the overwhelming influence on UC Davis emissions is the use of energy to operate buildings, and laboratory, healthcare and food service buildings are the largest consumers of the energy. Consequently, options shown below largely focus on reducing energy use related to buildings. In fact, some of the scenario planning (shown below for the Davis campus and currently being modeled for the Sacramento campus) demonstrates the overwhelming importance of energy conservation and space management. To reach the 2014 and 2020 targets, the first and most important dollars to spend will be on energy conservation measures and space management methods that allow the campus to manage existing facilities for maximum conservation while still providing excellent facilities for teaching, research and public service. With energy conservation maximized, the next steps will be to secure additional renewable power supplies, and possibly sequestration efforts.

When considering the overall approach to emissions reduction, it is important to remember two factors. First, the Davis campus accounts for nearly 70 percent of UC Davis's emissions and the Sacramento campus nearly 29 percent. Second, the Sacramento campus has a great deal of fixed capital invested in a relatively new cogeneration plant fired by natural gas, which limits renewable energy options given the commitment to natural gas. These two facts suggest that the Davis campus has more room to improve overall UC Davis emissions in the near-term, and that the Sacramento campus does not have a lot of immediate options, outside of buying offsets. Therefore, energy conservation and energy efficiency measures are of prime importance on both campuses.

In the simplest of terms, there are four main ways to reduce, eliminate or offset emissions, in order of priority:
1. avoid energy use in the first place (energy conservation and efficiency measures);
2. use rapidly renewable energy sources instead of fossil fuels;
3. sequester carbon; and
4. purchase renewable energy credits, carbon offsets or cap-and-trade allowances.

3.3 ENERGY CONSERVATION AND EFFICIENCY OPPORTUNITIES

Avoiding energy use to begin with has several benefits beyond emissions reduction: monetary savings for energy not purchased, reduced production of other combustion-related gases that are regulated, and avoidance of infrastructure expansion to address energy demand. Consequently, reduced consumption of energy is the first priority for reasons beyond emissions reduction.

3.3.1 Scenario Planning for the Davis Campus Built Square Footage

Working with sustainability staff, architects and engineers at the Davis campus developed and refined a numerical model that explores the impact of buildings' energy use on campus emissions. This model will continue to be adjusted, as a flexible planning tool, and UC Davis is building a similar tool for the Sacramento campus during 2010.

The model has been developed in a manner that sets a performance baseline, and then allows for different scenarios to be tested from the baseline. Scenarios can be isolated or combined to test for overall kBtu and emissions savings.

At this time, capital planning for the Davis campus indicates that 57 percent of the planned growth between 2010 and 2020 will occur before 2014, with the bulk being occupied in 2010 and 2011. Should that growth occur at that pace, it is a noteworthy constraint against some of the scenarios described below and illustrates the challenges imposed on the future by the present.

The baseline for the model was set by modeling the current facility portfolio and projected growth (from the 2009 Ten-Year Capital Financial Plan), using energy intensity values for five key building types, and modeled in kBtu, which is then converted into kWh and therms. The energy intensity values (kBtu/sf/yr) for five key building type groups were derived from a combination of published survey data, specific building modeling results and actual energy measurements for several campus buildings.

These energy intensity values were adjusted in time by looking at:

1) State energy code changes that have occurred since 1990 and which changed building energy use performance. These calculations assume a tightening of the building code similar to what has happened every three to five years in the past.

2) The University Policy on Sustainable Practices and the campus building performance standard of 25 percent better performance than Title 24, which is 5 percent better than the UC Policy.

3) Campus programs that improved building energy use performance, including the Strategic Energy Partnership Programs (SEPP) for 2006-2008 and 2009-2011. The SEPP calculations include a decay rate over time, as building performance typically wanes after initial recommissioning.

The new Central Heating and Cooling Plant boiler efficiency is also built in and can be adjusted as the campus learns more about the boiler performance over the next few years.

These calculations set a performance baseline. This baseline can be thought of as "business as usual" for buildings, and no other energy savings measures are accounted for in this baseline.

Figure 3.1 shows the projected emissions baseline, from buildings, Davis campus only, under current building performance standards, planned growth, and energy conservation projects, for 2010-2020. There is slight variation through the years, as SEPP projects are implemented, the power of which is particularly noticeable in the drop between 2010 and 2011 as the first extensive SEPP program is completed.

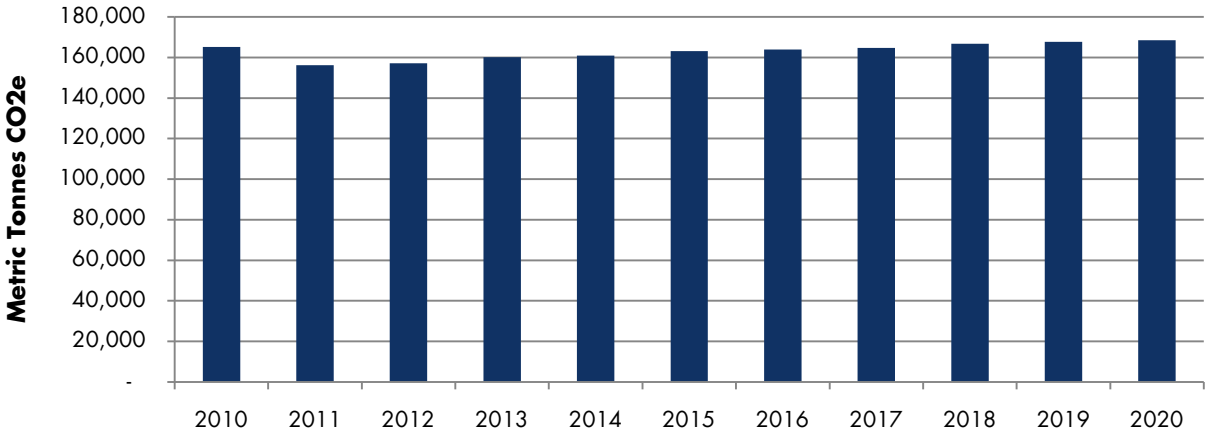


Figure 3.1: Scenario Model: Building Energy Use Baseline Emissions (Davis campus)

From this performance baseline, five scenarios were analyzed, as described below. These scenarios have rudimentary cost calculations, but have not yet been subjected to detailed cost analysis, and the cost-benefit ratios are likely to differ considerably among the scenarios.

1. Strategic Energy Partnership Program+:

This modeling scenario assumes another $25 million round of SEPP funding, for 2012-2014, that would create an additional 20,000,000 kWh and 1,240,000 therms savings over three years, approximately one-third each year. In addition, a set of measures assuming campus actions on water conservation, landscape planting for building shading, and comfort range adjustments to wider set point swings is also built into this SEPP+ package. This package also attempts to address energy use in laboratories related to very tight comfort bands. Adjustments to number of air changes per hour are not modeled in this package, although such changes could have considerable effect on laboratory buildings' energy use, because of the very high cost and uncertain safety considerations related to the technology required to safely reduce air changes in buildings being actively used for laboratory research; as regulations and technology develop, air change frequency may be analyzed in future CAPs. A decay rate is built in, like with the SEPP in the performance baseline.

Possible savings, in 2014: 18,900 MTCO2e In 2020: 18,670 MTCO2e

2. User Education:

This modeling scenario assumes a $10 million investment over 10 years in user education and energy-efficient equipment replacement (lab refrigerators and freezers; printers, copiers, other appliances). User education would consist of awareness and behavior change campaigns. The behavior change considered here is energy conservation, but transportation, waste management/reduction, and water conservation behaviors would also be targeted, which are also anticipated to result in emissions reductions, but those are not captured in this model.

Possible savings, in 2014: 3,230 MTCO2e In 2020: 4,510 MTCO2e

3. Half growth rate from 2012:

This modeling scenario assumes building square footage growth will be deferred in a manner that produces half the rate of growth projected in the current capital plan. This also assumes no new leased space to offset slower construction. The more that new capital projects and renovation projects include passive solar, solar water heating, and other, similar strategies, the lower the burden they place on the emissions footprint and the campus energy budget. This scenario illustrates the effect of slowing the growth rate. As this scenario essentially slows the rate of capital outlay, it does not have an immediate cost associated with it, but if construction cost escalation were to reoccur over the next ten years, there would be costs associated with project delay.

Possible savings, in 2014: 1,850 MTCO2e In 2020: 4,220 MTCO2e

4. Projects from 2012 are neutral:

This modeling scenario neutralizes emissions increases due to growth by requiring all projects funded after 2012 to either purchase carbon offsets to create a totally neutral project on an annual basis, based on energy consumption, or that the campus devises a pooled funding mechanism that projects pay into to essentially

offset their emissions, but which would fund campus energy conservation projects, green power production, and green power purchases to mitigate emissions. Other options are possible, but the gist of this package is that growth is neutralized by requiring projects to mitigate emissions upfront. This scenario assumes new leased space would be treated in funding models the same as campus constructed square footage. This avoids a disinvestment in campus facilities in favor of leased square footage. This scenario illustrates a method of accommodating growth with a mechanism similar to programs used by Air Quality Management Districts throughout the state to reduce criteria air pollutants. Possible costs are estimated based on either a recurring annual payment (essentially to buy offsets), or a one-time cost at time of occupancy, to be used as an investment in ongoing energy efficiency and renewable energy options. Costs are estimated to range from $1.50/sf annually for an office-type building to $3.25/sf annually for a lab building; and to range from $3.25/sf in one-time payments for an office-type building, to $7.50/sf for a lab building. These estimates were created using contemporary offset prices and averaged costs per kWh and therm from the SEPP project portfolio.
Possible savings, in 2014: 3,700 MTCO2e In 2020: 8,440 MTCO2e

5. Decommissioning:

This modeling scenario assumes removal of 100,000 gsf of building square footage (about 1% of the 2010 Davis campus space inventory), per year from 2010 through 2020, of the pre-1990 stock using the same mix of building type and energy intensity, and the reduction is discounted by 25 percent because of the assumption that the relocated uses would increase the energy intensity of the existing buildings. This scenario does not identify specific buildings, or building types, to remove. This scenario demonstrates the impact of less square footage on energy use. Uncalculated are any savings related to reduced maintenance. Preliminary cost estimates range from about $1,500,000 to remove 100,000 square feet of simple trailer space, including haul-away, disposal, utilities disconnection, and basic site restoration, to about $7,000,000 for removal of 100,000sf of lab building with abatement, demolition, and site restoration.
Possible savings, in 2014: 6,840 MTCO2e In 2020: 13,690 MTCO2e

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Strategic Energy Partnership+	1,780	2,012	7,160	12,928	18,897	19,030	19,163	19,296	19,279	18,972	18,665
User Education	1,669	1,668	1,687	3,125	3,232	3,385	3,573	3,786	4,852	4,658	4,513
Half growth rate from 2012	-	-	438	1,687	1,854	2,752	2,905	3,057	3,872	4,084	4,221
Projects from 2012 are neutral	-	-	876	3,373	3,708	5,505	5,809	6,114	7,745	8,168	8,442
Decommissioning	1,369	2,738	4,106	5,475	6,844	8.213	9,582	10,951	12,319	13,688	13,688

Table 3.2: Modeled Emissions Reductions, Davis campus only

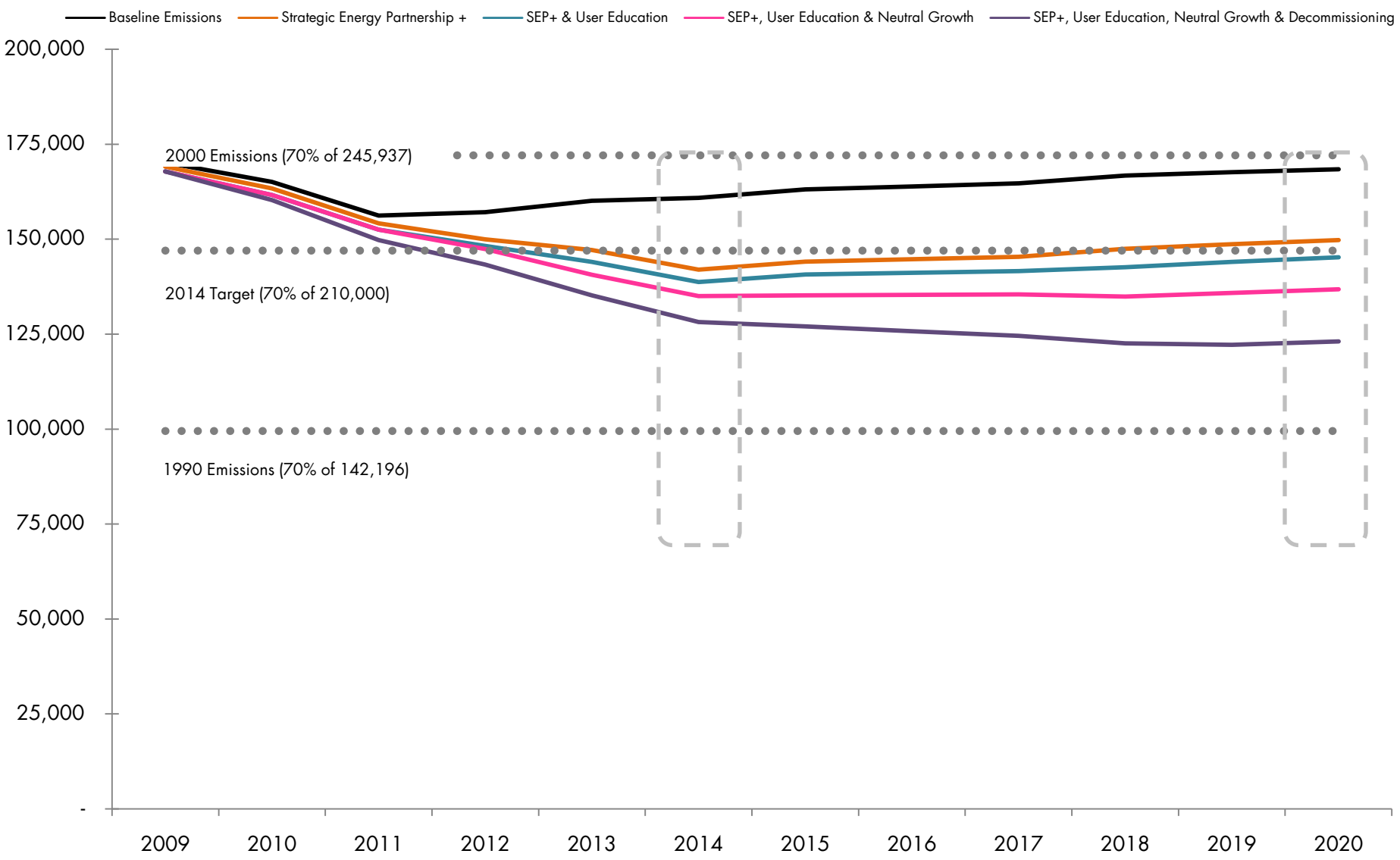


Figure 3.3: Modeled Emissions Reductions, Cumulatively, Davis campus only

As demonstrated in Table 3.2 and Figure 3.3, aggressively pursuing additional energy conservation is by far the most effective strategy the Davis campus can take in reducing emissions. Aside from certain code requirements of hospital and clinic facilities, this modeling suggests that aggressive energy conservation and pursuing energy efficiency would be the most effective emissions reductions tool for the Sacramento campus as well.

The second most effective strategy the Davis campus can pursue is to remove older facilities and not replace them with new facilities (unless they are emissions neutral) or leased space. This strategy would require very creative space management and investments to upgrade facilities that are retained, but would also clearly result in emissions savings.

As mentioned above, modeling like this is being developed at the time of writing of the 2009-2010 CAP for the Sacramento campus, using growth projections from the LRDP that is underway (expected LRDP completion in fall 2010). The model should be ready by mid-spring 2010 and will allow the Sacramento campus to investigate different implementation strategies.

3.3.2 Additional Energy Conservation Initiatives:

Beyond the current 2010-2011 SEPP and the modeled, possible 2012-2014 SEPP, there are two other major initiatives the Davis campus will investigate in 2010-11. Neither of the initiatives listed below has been approved for implementation, and the steam concept is only in the beginning stages of exploration.

1. 50 percent Lighting Initiative:

On the Davis campus, in 2008-09, roughly 50 million kWh were used for interior lighting, and 9 million kWh for exterior lighting, accounting for around 23 percent of campus electricity use. The 50 percent lighting initiative seeks to reduce the kWh used for lighting by 50 percent, or approximately 30 million kWh. The program planning anticipates a 10 year roll-out. At full roll-out, greenhouse gas emissions reductions would be approximately 6,650 MTCO2e per year over the lighting retrofit efforts already bundled in the current SEPP package. The first three years of this program are expected to cost about $3.5 million. Expenditures for future years will depend on technological advances in the rapidly evolving field.

Possible savings, in 2020: 6,650 MTCO2e

2. Regenerative Steam Concept

One of the largest sources of the Davis campus' GHG emissions is from gas fired boiler infrastructure at the Central Heating and Cooling Plant (CHCP). The system provides steam for building heat, hot water, and process loads. The steam is distributed to the buildings where it is used in this form for process loads such as in autoclaves, sterilizers, and glass washing equipment. For building heat and hot water functions the steam is used to heat water which is circulated to the air handlers and through the building to fan coil units serving individual spaces. The campus has been searching for an alternative technology to provide the function of the current steam system that produces a lower level of carbon pollution. In addition, two of the campus boilers are nearing the end of their lifespan, opening up new possibilities for consideration such as replacement with electric boilers, smaller district boilers, and/or a reconsideration of portions of the campus steam loop.

Stanford proposes a regeneration scheme as a component of their Energy and Climate Plan. During the planning exercise, analysis of real time energy use revealed that Stanford has a significant and simultaneous need for heating and cooling on campus. If the heat is reused, the campus can recover up to 70 percent of the heat now discharged from the cooling system to meet 50 percent of campus heating demands. Based on this finding, they propose to replace the current natural-gas powered infrastructure with an electricity-powered 'regeneration' plant based on heat recovery, along with conversion of the campus steam distribution system to a hot water system. The conversion from a steam to hot water distribution system requires significant up front capital investment (approximately $250 million for the first phase of work) and is projected to take from five to ten years to implement, but promises significant long term cost, GHG, and water savings for Stanford University over 40 years.

Regeneration will work by capturing the heat given off from building air conditioning systems and using it to meet simultaneous building heating and hot water needs that are now met by burning fossil fuel. Unlike residences and simpler commercial buildings, simultaneous heating and cooling of indoor air occurs in more

complex buildings such as university teaching and research laboratories to properly manage air temperature and humidity. While "heat wheels" and other systems are sometimes used for heat recovery in individual buildings, the regeneration concept would replace existing fossil fuel fired infrastructure with central energy plant that applies these techniques on a campus-wide scale. An additional positive outcome is by reusing heat rejected from the buildings instead of using evaporative cooling to eject the heat into the atmosphere, a 10- 15 percent savings in total campus water use could also be achieved.

This concept is in a very initial stage of exploration, and the viability of the project, much less size and phasing, are unknown, so emissions savings and project cost estimates are not calculated. However, due to the nature of the UC Davis steam system infrastructure, it is estimated that such a project would cost over $250 million.

3.3.3 Space utilization/planning & capital planning options:

As demonstrated in the modeling above, in the two growth plans and the decommissioning plan, space utilization, planning and management and capital projects have tremendous effect on UC Davis emissions, because buildings are the largest source of emissions related to energy consumption on campus. During interviews with space and capital planners, leasing specialists and real estate directors, and utilities and facilities managers on the Davis and Sacramento campuses, several creative ideas arose. For instance, deployment of space management tools to include all space (e.g., to include parking lots, recreation fields, etc.), and a more accurate floor space inventory with better categorization of space type could help with energy mapping and management. Space and capital planners, as well as utilities managers, advocate for allocating utilities costs to departments so that users are incentivized to reduce space and energy consumption. And, space managers are very interested in seeing server consolidation and virtualization and more centralized animal space in order to increase space efficiency.

The Sacramento campus is working on a new LRDP, which anticipates major growth in square footage over the next 15 years. As the environmental review process begins for that LRDP, the analysis will consider ways to reduce the emissions tied to growth.

3.3.4 Physical improvements, planning & landscape options

The physical planning of the campus has a critical role in energy consumption and emissions, related to building siting, circulation planning and infrastructure, and open space management. Locations for new buildings impact utility distribution systems and central system demands. Siting buildings and circulation impacts opportunities to minimize travel, to control solar access, shade buildings with trees, to build multiple storied buildings, and to have buildings share walls in order to take advantage of the temperature-moderating effects of building mass. Open space and landscape management practices influence water consumption and maintenance. Water has to be pumped, which requires electrical energy, and water spurs plant growth. Plant growth, especially lawns, requires energy to maintain, typically gasoline for mowers and other landscaping equipment.

At the Davis campus, landscaping requires about 22,500 gallons of fuel, 154,000 person-hours of work, 415 machines (edgers, mowers, etc.), and 336,000,000 gallons of water per year (the water number is an annual average over the past 13 years) to maintain. Already, the Davis campus has dramatically reduced landscape irrigation by installing central irrigation controls: water savings are approximately 60,000,000 gallons per year (data from Sal Genito, Director of Grounds, Davis campus). At the Sacramento campus, landscaping requires about 24,500 person-hours of work, 58 machines, and water from 2 on-site wells and the domestic water supply. Water use is unmetered and irrigation is not centrally controlled, and three employees are dedicated to the monitoring and repair of 56 irrigation clocks (data from Fred Jewell, Superintendent of Grounds, Sacramento campus). The Sacramento campus is in the process of seeking funding for a centralized irrigation project, and irrigation water consumption remains an area for the Sacramento campus to explore, as one of the top ten water users in the City of Sacramento.

The recent (2009) Davis campus Physical Design Framework places sustainability as one of the three main principles guiding planning and future campus growth, and from that plan, work is now starting on a landscape management plan that will identify whether and where there are resource-consumptive landscapes on campus that can be changed out to more water-conserving, slower growth plants that require less maintenance. The landscape management plan will attempt to determine how much carbon could be saved by

changing plant types and maintenance regimens The Sacramento campus will develop a Physical Design Framework from the Long Range Development Plan underway.

The Davis campus also has a 100-Year Tree Plan, which articulates a plan for expanding the campus urban forest, and which will provide carbon sequestration over time. The current estimation is that annually the campus urban forest of over 12,100 trees sequesters about 940 tons of carbon, absorb about 5,000,000 gallons of water, providing erosion control, and through shading, create about $106,000 of natural gas and electricity savings, according to a September 2004 study done by the USDA Center for Urban Forest Research and UC Davis Department of Land, Air and Water Resources.

Campus custodial services has noted that landscaping within 10 feet around buildings significantly reduces dirt inside the building, which reduces dust in air vents, and on lights and other equipment, resulting in cleaner buildings which require less use of cleaning products, and may result in energy savings.

None of these physical planning strategies have estimated or measured carbon savings at this time. These are areas for further investigation and measurement.

3.3.5 Waste Reduction, Recycling, and Purchasing programs

The Davis campus has a fairly robust waste reduction and recycling program, including the nation's first zero waste stadium, and a major organics and food waste diversion program. The waste reduction and recycling unit provided estimates of avoided emissions due to waste reduction and recycling, using the EPA WARM tool, of 586 MTCO2e for 2008. In addition, the campus has a policy regarding waste reduction, recycling/diversion, and smart purchasing (PPM 350-05, http://manuals.ucdavis.edu/ppm/350/350-05.htm).

The campus is drafting an integrated waste management plan, with zero municipal waste to the landfill as a component, and anticipates completion of that plan in 2010-2011. Information from that plan that is pertinent to emissions reduction will be captured in the 2011-2012 Climate Action Plan. The Sacramento campus has a more limited recycling program, and this is an area for additional development as part of the integrated waste management plan.

The Purchasing department has made significant strides with environmentally preferable purchasing, under the Policy on Sustainable Practices. Some examples of programs related to lowering emissions:

- Energy Star computing equipment is available at competitive prices through negotiated vendor contracts,
- Printer toner cartridges are collected and recycled to Hewlett-Packard in a program that allows the campus to replace old, energy inefficient printers with new ones based on number of toner cartridges returned;
- A vendor agreement makes 30% post-consumer content paper cheaper than virgin-content paper, which helps close the loop on materials use. Virgin papers have been eliminated as a choice from the office supply agreement when 30% post-consumer content equivalents are available.
- The Davis campus Bargain Barn, a Materiel Management unit, offers a location and creates a market for reuse/repurchase of furniture and equipment among departments.

3.3.6 User education and behavior programs

While the Davis campus model scenario #2, "user education," described above in section 3.3.1, shows that user education does not have as major an impact as energy efficiency or growth management efforts, it does make a significant contribution to reducing emissions. Perhaps even more importantly, user education and the expectation of stewardship behavior by campus faculty, staff, students and visitors is a key part of involving the whole campus community in the effort to improve our use of resources and become a sustainable institution.

The Davis campus has piloted an office "greening" project, and expects to build that into a campus-wide program at both the Davis and Sacramento campuses during 2010-11. The program encompasses actions regarding energy conservation, waste reduction and elimination, and alternative transportation methods, both for commuting and work-related travel. Some key results from the pilot are a measured 22% drop in total

weekly plug load energy use and a 67% drop in trash sent to the landfill, with a 98% increase in mixed paper recycling and 50% increase in cans and bottles recycling (baseline measurements were taken before and after the program).

A laboratory "greening" pilot is expected during 2010-2011, with the expectation it will also be built into a campus-wide program. Lab behaviors would include office behaviors, as well as stewardship efforts specific to dry and wet labs, such as fume hood sash closure, sample management and reduction in use of cold storage.

The Davis campus has held a successful refrigerator/freezer buyback program. The program encouraged campus departments to replace old, inefficient refrigerators and freezers with new units that consume much less electricity, thus reducing the campus utility costs. The program offered incentives of up to $400 in rebates on a dollar-for-dollar matching basis toward the purchase of new units and included disposal costs for the old units. The program also offered energy reduction awards of $200 for disposal of old units without replacement. Units manufactured before 1990 qualified for the initial program. The program was started in February 2008 with $200,000 in funding, with an end date of December 31, 2008. In September 2008, the Provost and Executive Vice Chancellor expanded the program to include pre-1995 units and extended the program period to June 30, 2009. The program resulted in an estimated reduction of 248,000 kWh/year, with a payback period of 4.5 years, and an estimated emissions reduction of 82 MTCO2e/year. This is a program that could be explored at the Sacramento campus.

The Davis campus is now determining how best to expand the buyback program into a more comprehensive incentive program for energy savings accomplished by campus users. The general idea is to provide departments with a portion of the savings achieved when departments implement energy conservation efforts (for example: power-down campaigns, server virtualization, and equipment replacement/retirement) that result in verifiable savings. The campus expects to have the first phases of the expanded program in place by fall 2010.

In addition, although something of a hybrid between user education and campus-level action, an information technology forum is working with the office of Environmental Stewardship and Sustainability to analyze feasibility of a range of actions available to IT professionals, from accelerated virtualization programs to remote power management, to new efficient equipment, to user education. No emissions estimates are available yet, although the program is anticipated to have such information by late 2010. This program spans the Davis and Sacramento campuses.

3.4 RAPIDLY RENEWABLE ENERGY SOURCES AND ALTERNATIVE ENERGY OPTIONS:

As UC Davis continues to implement the SEPP and other energy efficiency programs, and explores additional options for reducing energy use, another strategy for emissions reduction is to use energy generated through renewable sources (on-site, off-site, or purchased).

The Davis campus already secures renewable-sourced power annually, in the form of large-scale hydropower, but the state of California does not recognize large-scale hydropower as a viable renewable source. The Sacramento and Davis campuses both purchase some power from PG&E and SMUD. These utilities both provide some renewable energy to their customers and are subject to the Renewables Portfolio Standard (RPS), which, under Executive Order S-14-08, has a target of 33 percent renewable sources by 2020.

UC Davis has several options for pursuing additional renewable energy sources: (1) purchasing green power, at a higher cost than our existing pricing contracts, from suppliers, (2) on-site photovoltaic generation and (3) on-site waste-to-energy generation. Wind-powered generation is studied by faculty on campus, but does not at this time seem to be a reliable or large enough source to pursue on the Davis or Sacramento campuses. Off-site generation is discussed later in this chapter in regards to a University-wide solution.

3.4.1 Purchased power:

The fastest way to acquire more renewable energy is to purchase it from the utilities. PG&E offers customers an option to buy "green energy" at a premium cost (essentially the customer pays to designate all purchased kWh as coming from the renewable portion of the utility's portfolio). WAPA will purchase renewable energy

credits on customers' behalf, and then pass on the cost to the customer. It is unclear how WAPA sourcing will change under new EPA inventorying requirements, along with other changes to Federal regulation and the pursuit of national carbon emissions reduction policies, and whether WAPA, Sierra Nevada division will seek to match the state 33 percent RPS over time, although that currently is not planned. At present, the Davis campus understanding is that "green" WAPA power would cost about 3 times more than power under the present contract, or approximately $0.24/kWh instead of the current $0.085/kWh (data from David Phillips, Director of Utilities, Davis campus).

3.4.2 On-site photovoltaic generation:

As of this writing, the Davis campus has a Request for Proposals out for as much as 910kW of solar photovoltaic (PV) generation. Depending upon proposals received and contracts negotiated, much of this kW could be installed by the end of 2010, with the remainder installed in 2011, and would save the campus about 418 MTCO2e annually. The Davis campus is evaluating other locations on campus to install additional PV arrays. Actual size and configuration of the generating arrays would depend upon several variables and further study is needed.

Of notable interest, rough calculations by the Davis campus Design & Construction Management office suggest that installing PV in all viable building mounting places on the Davis campus would only meet about 8 percent of the central campus load; and to meet/offset the entire energy needs (kWh and therms) of the Davis campus and outlying facilities (not the Sacramento campus), would require a mass PV installation of approximately 1,100 acres, or put in context, roughly 40 percent of the land area designated as teaching and research fields in the 2003 LRDP. To meet only kWh needs would require about 450 acres. Currently, the payback for PV is quite long due to the low price per kilowatt-hour from the Davis campus WAPA contract; as PV costs decline, efficiency increases and electricity costs rise, PV may become more financially attractive.

The Sacramento campus is planning to install a PV system on a new parking structure that will essentially meet the needs of the structure, and therefore will result in a facility that does not add to the campus load or increase emissions, similar to the neutral-projects scenario above.

3.4.3 On-site waste-to-energy:

UC Davis composts a portion of its waste, but the majority of waste goes to the landfill. Waste-to-energy generation may be one component of an emissions reduction plan. Two key methods will be evaluated in 2010-11: a biodigester and plasma gasification. The intersection of waste management under the zero waste goal in the Policy on Sustainable Practices and waste-to-energy generation will require cross-planning during 2010, as planning for both a biodigester at the West Village campus community and the campus waste management goals could overlap.

1. Biodigester and multi-renewable technologies integration: West Village is a campus community being developed on approximately 200 acres of University-owned property located west of State Route 113 and south of Russell Boulevard. In the summer of 2009, UC Davis and West Village Community Partnership, LLC broke ground on the West Village neighborhood. This planned community creates opportunities for faculty, staff and students to live locally and participate fully in the life of the campus. The first phase of West Village, now under construction is a compact, mixed-use community that includes housing for almost 2,000 students; approximately 350 for-sale homes for faculty and staff; a multi-tier Education Center including programs and facilities for the local school district, the first community college center on a UC campus, and UC Davis; a village square surrounded by the Education Center and including buildings with active first floor commercial uses and rental housing above; a ten-acre recreation complex; and a shared environment based on walking, biking, and transit, best practices for conservation of water and energy, and on-site renewable energy.

West Village will be one of the first large scale communities to be zero net energy entirely through on-site generation. The plan employs:

- A diverse array of renewable energy sources (e.g., solar PV, solar thermal, biogas generation fueled by campus food waste, animal waste and green waste, and fuel cell technology);
- Multiple integration technologies (e.g., energy efficiency, demand response, battery storage, smart grid); and

- An economic model that is affordable to the inhabitants and financeable by the market. West Village presents an integrated solution to the challenge of creating a Zero Net energy community.

Energy modeling indicates that annually electrical energy use based on compliance with 2008 California Title 24 Energy standards would be approximately 22 million kWh. Through incorporation of standard and advanced energy conservation measures, it is anticipated that this annual demand can be reduced to approximately 9 million kWh. Renewable energy will be generated onsite to meet this demand. It will be supplied by distributed photovoltaic panels and a **waste-to-renewable energy community energy park**. Up to 5 megawatts (MW) of PV panels would be located on shade structures over parking areas and in some community open spaces. The community energy park would consist of a biodigester that would generate biogas to power an approximately 300 kilowatt fuel cell. Power generated by the **biodigester-fuel cell combination** would go directly to the community or would be stored in an advanced storage battery for use during times when power is not available from PV panels.

At times such as the middle of a summer day, energy may flow from the renewable generation at West Village to the regional grid. At other times, such as on a winter night, energy may flow from the regional grid to the neighborhood. The overall goal is for West Village to require zero net energy from the electrical grid on an annual basis. Achieving this goal will mean that the new neighborhood will not increase the carbon footprint of the campus from the use of power from the regional grid.

2. Other biomass technologies: The Davis campus is considering undertaking an evaluation of biomass technologies to identify the most cost-effective biomass options that would produce energy from the campus landfill, such as biodigesters, fuel cells or low-temperature plasma gasification. Plasma gasification is a technology designed to combust waste that would otherwise be composted or landfilled into energy. Biomass technology could provide the Davis campus 5 percent to 10 percent of its electricity by using the waste that is currently being sent to the campus landfill. Actual generation would depend upon several variables, including amount of input material. Further study with life cycle cost analysis is necessary to understand the implications of the different biomass technologies. Possible annual carbon savings could be 10,000 MTCO2e, or more, depending upon the technology and the waste volume.

3.5 INVESTIGATORY

This category lists options that are under consideration, unstudied or have an extended time-horizon, and therefore are unknown as to effect on an overall emissions reduction package of strategies.

1. **UC system-wide action**: the UC Climate Solutions Steering Committee, with members from several UC campuses, is researching options at a University-wide level to explore large-scale renewable energy sourcing to assist all the campuses in obtaining climate neutrality. The committee meets regularly and is considering a handful of different ideas and undertaking preliminary analysis.

2. **Policy changes**: the development of new and additional federal and international guidance and policy that changes energy standards or sets carbon caps would promote market and regulatory change (such as vehicle efficiency and fueling, emissions management by airlines, etc.) that UC Davis can take advantage of for emissions reduction.

In December 2009, the first information came out regarding a state cap and trade program as a market-based part of the California Air Resources Board's efforts to meet goals set out in AB32. At this time, the program is in scoping, but the general outline is that both UC Davis campuses would be required to participate as emitters of over 25,000 MTCO2e, as early as January 2012. Under the program, emitters would be required to purchase allowances at a rate of one allowance per metric ton of CO2e. This potentially could be very costly for UC Davis as allowances are removed from the market. This is an area that will be monitored in future climate action plans.

3. **Partnerships**: possible partnerships between regional entities, such as the city of Davis, Yolo County or others, may develop solutions such as shared energy generation solutions (for example, shared expansion of

PV and shared waste-to-energy use of landfilled materials), over time. There are no current proposals, but the idea is recorded for possible consideration in future climate action plans.

4. Agricultural and land-based solutions: UC Davis has a large land base that might be useful in the long-term for bioenergy production, or for sequestration options. None of these are studied, but the idea is recorded for possible consideration in future climate action plans.

5. Technological advances: Advances in, for instance, super critical water oxidation (waste-to-energy) or biochar (sequestration), may create new possibilities for emissions avoidance or reduction. Again, this idea is recorded for possible consideration in future climate action plans.

6. Reduced carbon products: products are beginning to be assessed on their climate impact by interested non-profits and for-profit firms, and this may compel manufacturers to lower GHG emissions in products purchased by UC.

3.6 MOBILE EMISSIONS AND TRAVEL EMISSIONS REDUCTIONS

Transportation-related emissions for campus-owned vehicles resulting from direct purchase of fuel are classified as Scope 1. Transportation-related emissions due to business-related travel and commuting by students, faculty and staff in vehicles not owned by the campus are classified as Scope 3 emissions. Scope 3 emissions are treated differently from Scope 1 & 2 emissions because: (1) the campus has less control over them, (2) assumptions are made regarding additional regulation on airlines over time, and (3) assumptions are made regarding efficiency improvement of the commuting fleet over time. These last two assumptions are based on recent developments in state and federal policies that are assumed will manifest changes that lead to emissions reductions.

3.6.1 Scope 1 Emissions

Scope 1 mobile emissions include vehicle use and fuel sales provided through Fleet Services on both the Davis and Sacramento campuses, the campus bus system (Unitrans), the shuttle between the Davis and Sacramento campuses, and the mobile equipment for maintaining the campus, such as Gators and lawnmowers. Put in perspective, these campus operations constitute less than 4 percent of UC Davis' GHG emissions in 2008, whereas stationary combustion accounts for 55 percent and purchased electricity accounts for 38 percent.

Unitrans has made enormous strides since 1990 in reducing emissions by changing over most of its fleet to compressed natural gas, which has far less greenhouse gas emissions than diesel. And, both the Davis and Sacramento campuses have some alternative-fueled vehicles in their fleets. However, many of the campus maintenance vehicles, such as the Gators, are not emissions efficient. Hybrid transit bus technology is a developing option that may be appropriate for consideration as a means to further reduce GHG emissions as vehicles are replaced.

With respect to scope 1 mobile emissions, the Davis and Sacramento Fleet Services managers are working on policies for their units that address the Policy on Sustainable Practices goals related to emissions and to sustainable transportation. These policies are anticipated to be developed during 2010. Campus maintenance vehicles are relatively small contributors, but there are some alternatively fueled (e.g., propane) equipment being considered. No decisions have been made, and emissions associated with these vehicles are not large enough to be first-order targets for emissions elimination and reduction. However, as old equipment is retired and replaced, fuel source and greenhouse gas emissions should be a consideration.

3.6.2 Scope 3 Emissions

Scope 3 emissions are difficult to tackle because they are not under institutional control in the manner that building energy use or other elements are. While programs are offered and encouraged for employees to use alternative transportation, these programs are not mandatory, and are unlikely to become mandatory.

For Scope 3, UC Davis considers commuting, air travel, reimbursed car miles traveled for business purposes, air travel for business purposes (such as to conferences, meetings, research sites, etc.), and student air travel related to study abroad and athletics.

The Davis campus has long been a leader in alternative transportation, with bicycling being a major share of the commuting mode split for the campus. In addition, the campus has instituted a wide range of alternative transportation programs, including most recently, bringing a car sharing service to campus (Zipcar), a ride-sharing service (Zimride), and the goClub, which is the marketing component of the UC Davis TAPS' alternative transportation program. The goClub is an incentive-based program that offers benefits to campus staff, faculty and students who choose one of the goClub commute programs as an alternative to driving alone when commuting to campus.

The goClub programs cover a wide spectrum of travel methods: bike, walk, carpool, vanpool, bus and train. UC affiliates who register with the goClub are rewarded with incentives and benefits including: reduced parking permits and reserved parking (carpool and vanpool), discounted bus and train passes, eligibility in the Emergency Ride Home Program, complimentary parking passes (for the days it is necessary to drive alone), and pre-tax payroll deduction benefits (if eligible.)

The primary goClub goal is to incentivize members of the campus community to choose an alternative to driving alone when commuting to campus. Supporting goals are to: encourage the campus community to reduce their carbon emissions; improve air quality; reduce congestion regionally and locally; contribute to the campus's sustainability goals in support of University policy; mitigate the need to build additional parking structures; and reduce wear and tear on existing lots and structures.

Eligibility requirements for the goClub include: may not purchase a parking permit (exceptions: carpool and vanpool parking permits); must be a UC Davis affiliate (student, faculty, or staff); may only receive incentives and benefits for one goClub program at a given time. Other eligibility requirements may apply for components of the goClub (for example, pre-tax payroll deduction). More detail about goClub and the campus bike program can be found at http://taps.ucdavis.edu, and http://goclub.ucdavis.edu.

The most recent campus travel survey (2008-09) documents 168,493 vehicle miles traveled are eliminated daily and 35,362,798 are eliminated annually as a result of the use of alternative modes, and these eliminated miles equate to about 13,000 MTCO2e annually.

The Sacramento campus also has an alternative transportation program, the Green Light Commuter Club, with a number of commuter choice programs available to faculty, staff and students. The programs include carpool, vanpool, transit, biking, walking and Amtrak. A car sharing service (ZipCar) is planned for the near future. The Green Light Commuter Club is free, easy to join, and offers benefits and incentives, including reduced rate parking permits for 2-person carpools, reduced-rate parking permits and preferential parking for 3-person carpools and vanpools, guaranteed ride home service, vanpool subsidies, pretax payroll deduction for Regional Transit passes, transit check subsidy for all other transit agencies, and subsidy for Amtrak. Participants can qualify for incentive drawings (for prizes such as digital cameras, gift cards, movie tickets, bike tune-ups, etc.) by using the commuter choice program at least three times a week, and recording their commute mode choice on the club Web site at www.ucdmc.udavis.edu/parking, or by faxing their mode choice to the parking office. The Sacramento campus is also linked to the Sacramento Transportation Management Association Commuter Club, which provides additional benefits, including rideshare matching.

Business-related air travel emissions are estimated and presented in Chapter 2, Table 2.5. Study abroad and athletics air travel emissions are estimated and presented in Appendix 2. With respect to air travel, UC Davis has reservations about calculating air mileage emissions because assessing air miles traveled is difficult with the data available, and because the calculation methods vary widely. For the 2009-2010 Climate Action Plan, UC Davis has calculated emissions using the TerraPass method. UC Davis would note that with new EPA requirements for emissions reporting, there could be double-counting of emissions related to air miles traveled.

Finally, the largest and most important pool of capital held by a higher education institution is its intellectual (human) capital, and emissions reductions tied to restricting travel diminishes this primary source of capital and strikes at the heart of the institutional mission. While unnecessary travel should be eliminated, not the least for economic savings, travel is and will continue to be an important part of the mission of disseminating scholarship in a global setting. For this reason, the 2009-2010 Climate Action Plan sets forth three ideas

(teleconferencing, telecommuting, and telemedicine) for consideration and further analysis in 2010-11, but does not promote arbitrary reduction goals.

1. Reduction in miles traveled through **teleconferencing:**
   Technology continues to improve teleconferencing and Web conferencing, and the Climate Action Plan recommends that additional resources be made available to improve and grow facilities and equipment for high-quality remote conferencing. In circumstances such as routine meetings, especially for short-haul travel, which has higher emissions than long, international travel (due to the impact of take-offs and landings on overall flight emissions), the Climate Action Plan recommends that teleconferencing be adopted as the default meeting mechanism, and in-person flight travel be reserved for special cases.

2. Reduction in miles traveled through **telecommuting:**
   Similarly, the Climate Action Plan recommends that UC Davis explore an aggressive telecommuting policy, with a goal of reducing on-campus population on any given workday in a manner that will bolster space planning/management efforts so that old, inefficient building space can be removed without impacting space requirements, and in a way that will enable employees to avoid commuting trips, so that two reductions of emissions occur: those related to building energy use, and those related to commuting trips. UC Davis has one of the foremost experts on telecommuting, Dr. Patricia Mokhtarian, on faculty, and the Climate Action Plan recommends that a study committee be formed, and invite her to provide expertise to that committee.

3. Reduction in miles traveled through **telemedicine:**
   Telemedicine or telehealth is the use of high-speed telecommunications for medical consultations, distance education, critical care and emergency services, as well as health-care training. Telehealth technologies have the promise of transforming and improving health care, especially in communities and regions that are far from large, urbanized areas with a full range of health-care services and medical specialists. The innovative use of telecommunications tools in the delivery of clinical services can increase access to health care and help advance health, especially for areas of California where physician shortages are a persistent problem. Telehealth offers the potential of improving quality of care by enabling clinicians at one location to monitor, consult and even care for patients in distant locations (information taken from *UC Davis to establish California Telehealth Resource Center in Sacramento*, posted January 10, 2010 at http://www.ucdmc.ucdavis.edu/welcome/features/20100120_Telehealth_groundbreaking/index.html). The UC Davis Medical Center and the School of Medicine have been at the forefront of telemedicine, which promotes both strides in human health and reduces emissions related to avoiding travel by patients and medical professionals to and from remote areas. The Climate Action Plan recommends that telemedicine continue to be supported and grown as a center of excellence at UC Davis.

3.7 SEQUESTRATION, CREDITS AND OFFSETS

3.7.1 Carbon Sequestration Options:

Carbon sequestration is somewhat akin to stuffing the genie back in the bottle (i.e., taking already emitted carbon out of the atmosphere). However, there are some ways in which the campus is already taking advantage of nature's services to achieve some minor, unmeasured, level of sequestration. In particular, the campus has converted 380 acres from agricultural uses (kiwi, tomato, and grain farming) to native bunch grasses at the Russell Ranch Habitat Mitigation Area. Bunch grasses have been shown to store considerable carbon in their deep roots, and a comparative study might be a worthy area for research at UC Davis. Likewise, the campus urban forest sequesters carbon, and the Climate Registry is developing a protocol for forest sequestration. Again, the amount is likely to be very small, but worth cataloging, as part of the value of the urban forest. Finally, the campus has a landfill, and under ICLEI-Local Governments for Sustainability protocol, landfills provide sequestration. Should the campus mine the landfill for plasma gasification, it would most likely release that stored carbon. No amounts of MTCO2e are provided here, but that could be an area for further analysis in the 2011 Climate Action Plan.

3.7.2 Renewable Energy Credits and Carbon Offsets Options:

Renewable Energy Credits (RECs) and carbon offsets should be viewed as options of last resort, because they are a recurring annual cost and do not offer a long-term solution to the institution for emissions reduction. However, they may prove useful for bridging gaps, and for managing persistent and difficult emissions sources,

such as commuting emissions, or air travel emissions, until there are wide-scale policy and technological changes that address these sources. Using offsets would require a UC Davis policy directive and a financing strategy, both will be discussed in the 2011-12 Climate Action Plan.

A limited survey of the offset market in December 2009 indicates that carbon offset prices appear to be rising slightly for high-quality, well-verified offsets. If UC Davis were to purchase offsets for all emissions, Table 3.3 shows what type of financial cost might be incurred.

	2008 Scopes 1 & 2	2008 Scope 3	1990 Scopes 1 & 2	1990 Scope 3	Scopes 1 & 2: new 2014 target	Scopes 1 & 2: new 2014 - 1990
MTCO2e	237,613	58,597	142,196	44,442	210,000	65,804
US$/ MTCO2	Offset all 2008 Scopes 1 & 2	Offset all 2008 Scope 3	Offset to 1990 Scopes 1 & 2	Offset to 1990 Scope 3	Offset 30,000 (new 2014 target)	Offset to 1990 from new 2014 target
$10	$2,376,128	$585,970	$954,168	$141,550	$300,000	$ 658,040
$12	$2,851,353	$703,164	$1,145,001	$169,860	$ 360,000	$ 789,648
$15	$3,564,192	$878,955	$1,431,252	$212,325	$ 450,000	$ 987,060

Note: Scope 3 includes only commuting and business-related air travel emissions; study-abroad and athletics air travel emissions are excluded in this table.

Table 3.4: Offset Pricing, December 2009

Note that climate neutrality through offsets would be retrospective to each year's emissions inventory, as the campuses can't know what emissions need to be offset until inventorying for the year.

A related idea would be for UC Davis to commit to buying offsets, but to "buy local," in the sense of investing offset money in verified energy savings or renewable energy on-site generation measures on campus, very much akin to the Strategic Energy Partnership Program. This could be explored as a financing mechanism. If capital projects from 2012 on were to be expected to be climate neutral in their operations, setting up an Emissions Reductions Infrastructure Fund to which the projects could pay "local offsets" to reduce energy use on the campus may be one of the best ways to make that happen.

In the earlier Investigatory section (3.5) of this chapter, a brief discussion was provided of a proposed state cap and trade program. If and when UC Davis is required to buy allowances, it definitely will be worth exploring whether a "local offsets" program could be implemented, since the allowances will most likely become more expensive over time as they are slowly withdrawn from the market.

3.8 CONCLUSIONS

The following conclusions are drawn from the information presented in the previous chapter on emissions inventories and this chapter on possible reduction actions:

1. As of 2008, UC Davis was meeting the required policy target for 2014 emissions reductions to 2000 levels, but given projected growth, it will require aggressive additional effort to hold that target and continue to reduce. Modeling demonstrates that energy conservation is the most effective means for reducing emissions, followed by removing appropriate old, inefficient building stock, and requiring new building stock to be climate neutral.

2. The Davis campus accounts for nearly 70 percent of the emissions, and the Sacramento campus for nearly 29 percent. Consequently, investment strategies will need to focus on major overall reductions in energy consumption at the Davis campus, and planning and starting to implement an aggressive energy conservation program for the Sacramento campus in light of the planned growth in the new Sacramento campus LRDP, in order to hold the line and begin to reduce emissions at the Sacramento campus. The Sacramento campus will also need to develop additional commuting reduction measures, similar to the Davis campus goClub measures, in order to manage commuting emissions under the projected growth scenarios in the new LRDP.

3. The Davis campus has much more flexibility than the Sacramento campus to pursue renewable energy sources due to the large amount of purchased electricity used by the campus. The Sacramento campus may need to plan for purchase of carbon offsets because of the natural gas-fueled cogeneration plant, and it may be strategically more useful to develop a "local/UC Davis" offsets program to assist the Davis campus in deep reductions and on-site generation to help reduce total overall UC Davis emissions. Both campuses should investigate pursuing strategies together that will result in overall reductions, which may be deeper at one campus than the other.

4. Partnership among the four campuses with cogeneration plants to explore system-wide solutions is likely to be the most effective way to handle the fixed investments in fossil-fueled plants over the long-term. One possible idea might be to investigate solar-powered hydrogen generation, if cogeneration plants can be retrofitted to burn hydrogen.

CHAPTER 4. SUSTAINABLE SECOND CENTURY: CAMPUS EDUCATION, OUTREACH AND SERVICE

The University of California is one of the world's foremost research and teaching institutions, and **UC Davis is the system's flagship campus for environmental studies**. One of the nation's top public research universities, UC Davis is a global leader in studies relating to air and water pollution; water and land use; agricultural practices; endangered species management; invasive plants and animals; climate change; resource economics; information technology; and human society and culture.

UC Davis offers a wealth of educational opportunities about climate change, alternative energy sourcing, alternative transportation engineering, and sustainability in general, to both students and a wide-ranging community from on-campus employees to a regional and even global audience.

4.1 Public Service

The following descriptions highlight just a very few of the notable, interesting and unique ways that **UC Davis shares expertise and resources with the world** on topics related to climate change, emissions reductions, energy efficiency, alternative-fueled vehicles, and sustainable living:

1. **Institute for Transportation Studies** (http://www.its.ucdavis.edu)
   The Institute of Transportation Studies at UC Davis (ITS-Davis) is a multi-faceted, internationally recognized program with more than 60 affiliated faculty and researchers, 100 graduate students, and a $6 million annual budget. Collaborative research projects are organized within three primary research areas: 1) Travel behavior and transport systems modeling; 2) Environmental vehicle technologies; 3) Climate change, air quality, and other environmental impacts.

Recent examples of shared expertise and resources from ITS include:

Mark Delucchi, a research scientist, co-authored a paper analyzing how the world could achieve 100 percent renewable energy by 2030 through a combination of "millions of wind turbines, water machines and solar installations," acknowledging limiting factors, but also providing a vision of a renewable energy path forward.

Researchers David McCollum and Gregory Gould, together with David Greene of Oak Ridge National Laboratory, co-authored the recent report, "Aviation and Marine Transportation: GHG Mitigation Potential and Challenges." The authors' research found that reductions of more than 50% below projected business-as-usual greenhouse gas emission levels by 2050 from global aviation and more than 60% for global marine shipping are possible. Published by the Pew Center on Global Climate Change, the report is available at http://pubs.its.ucdavis.edu/publication_detail.php?id=1363.

2. **California Lighting Technology Center** (http://cltc.ucdavis.edu/)
   The concept of the California Lighting Technology Center (CLTC) was developed through a collaborative effort between the California Energy Commission, the US Department of Energy and the National Electrical Manufacturers Association to advance energy efficient lighting and daylighting technologies. Established in 2003 at UC Davis, CLTC's mission is to stimulate, facilitate and accelerate the development and commercialization of energy efficient lighting and daylighting technologies. The facility includes full-scale lighting and daylighting application laboratories for development and demonstration of next-generation, emerging lighting and daylighting technologies. Comprehensive in-house and outreach training programs are developed in cooperation with industry and utility groups to complement demonstration and application labs.

Recent examples of shared expertise and resources from CLTC include:

The CLTC worked with UC Davis staff in Facilities Maintenance and Transportation and Parking Services to install demonstration bi-level lighting in some of the campus parking structures and lots. This demonstration project is one of many conducted by the CLTC, ranging from kitchen lighting, to office lighting, outdoor lighting, and retail lighting. Details of these projects can be found at the CLTC Web site, and also in their new facility in Davis, where lighting application demonstrations are available.

In addition, the CLTC has created a poster of the top ten ways a homeowner or renter can save money on lighting at home: http://cltc.ucdavis.edu/images/images/Downloads/michael_topten.pdf.

3. Energy Efficiency Center (http://eec.ucdavis.edu/)

The EEC was established in 2006 with a challenge grant from the California Clean Energy Fund as the first university-based energy efficiency center in the United States to focus on the transfer of technology into the marketplace.

Recent examples of shared expertise and resources from EEC include:

The EEC provides global leadership in clean technology. For instance, Professor Andrew Hargardon recently addressed the Qatar Supreme Council of Information and Communication Technology, describing how innovation happens and some of the innovations in information and communication technology that could harness energy efficiency to mitigate climate change effects.

4. John Muir Institute of the Environment (http://johnmuir.ucdavis.edu/)

The John Muir Institute of the Environment was created in 1997 to harness and integrate the dispersed environmental strength of UC Davis. It provides leadership and promotes visibility to benefit all the environmental units of the campus. The institute supports innovation and discovery aimed at solving real-world environmental problems. The institute links science and technology to policy by providing the intellectual setting for interactions between researchers, regulatory agencies, policymakers and the public.

Recent examples of shared expertise and resources from JMIE include:

The Climate Change 101 seminar series, "Climate Change and its Impacts on California," was presented to the California Legislature and CalEPA in 2008. This seminar series for non-specialists on the science, technology and policy aspects of climate change is available as Webcasts (http://lawr.ucdavis.edu/climatechange101). The series was sponsored by the Department of Land, Air and Water Resources and by the John Muir Institute of the Environment.

5. UC Davis Arboretum, Valley-Wise Gardening and All-Stars program (http://arboretum.ucdavis.edu/valleywise_gardening.aspx)

The UC Davis Arboretum is committed to practicing, promoting, and teaching about Valley-wise gardening and sustainable horticulture for California's Central Valley, as one important component of its mission.

Recent examples of shared expertise and resources from the Arboretum include:

The Arboretum horticulture staff have identified 100 Arboretum All-Stars—tough, reliable, easy-to-grow plants for the Central Valley. These water-conserving, heat-tolerant plants include both native plant species and adaptable non-natives, many selected for their value to birds, beneficial insects, and other native pollinators. These plants are now available through retail nurseries, in a project with the California Center for Urban Horticulture at UC Davis (http://ccuh.ucdavis.edu/projects/arboretum/arboretum-all-stars).

Beyond the five examples listed above, the campus has many other existing resources for gaining and imparting knowledge about a more sustainable future.

4.2 Education

Appendix 4 lists some of the many sustainability related classes taught at UC Davis. While only some of these classes focus on climate change, all of the classes work to build environmental science literacy among the student body of UC Davis.

4.3 Research

A few additional examples of very recent climate change related research include: Frank Mitloehner's work on animal emissions factors. His research demonstrates that animal management practices make all the difference in whether animals farmed for meat and milk contribute significantly to global carbon emissions, and proposes

that animal emissions have been considerably overcounted in global emissions estimates; Jessica Oster's and Isabel Montanez' geological research work on links between droughts and climate change; and research by faculty affiliated with the UC Davis Agricultural Sustainability Institute and the Sustainable Agriculture Research and Education Program to investigate nitrous oxide emissions and nitrogen use in various farming systems.

4.4. Student Life

There are numerous student organizations devoted to sustainability efforts on the UC Davis campus, and the student-run Campus Center for the Environment acts as a clearinghouse for the many organizations, helping them strategize, broadcast their messages, and advertise events.

Student Housing on the Davis campus has an "Eco-Rep" program in the residential halls, and a sustainability intern program, both of which help disseminate information to students about energy conservation, among other topics.

The California Student Sustainability Coalition has a chapter on the UC Davis campus, and this student group focuses on policy and working with administration to affect change towards a sustainable future.

4.5 Policy and Governance

UC Davis participates in the Yolo County Climate Compact, a compact of regional governmental agencies that partner on climate change action. (http://www.yolocounty.org/Index.aspx?page=1485)

4.6 Sustainable 2nd Century

In 2008-09, UC Davis celebrated its centennial year. The campus is seizing the momentum of that celebration to focus attention on the concept of sustainability through the "Sustainable 2nd Century" communication initiative. Using tools including a Web site, campus home page stories, a forthcoming annual report, and other Sustainable 2nd Century-associated efforts, the campus is exploring, documenting and sharing how to build a sustainable future for itself and the world over the next 100 years.

CHAPTER 5. RECOMMENDATIONS AND NEXT STEPS

Inventories of current and past GHG emissions indicate that UC Davis currently meets the first of three targets, to reduce emissions to 2000 levels by 2014. However, due to anticipated growth during the next five years, as outlined in the Davis campus Ten-Year Capital Financial Plan, and in the Sacramento campus Long Range Development Plan, it will be challenging to maintain that first target and move towards the target of reaching 1990 levels by 2020. Accordingly, the 2009-2010 CAP recommends the following actions for the implementation analyses that will be prepared in 2010-11.

5.1 Actions

Both campuses:

1. Conduct a detailed feasibility study regarding keeping growth neutral (as described in the modeling section 3.3.1, scenario 4), in order to meet a reduction target below 2000 levels in 2014. In this, and each study proposed below, prepare cost study and outline funding sources, implementation responsibility, and schedules.
2. Launch a comprehensive user education campaign, together with a rebate/incentive program. Begin with the Davis campus, outline a strategy for spreading the program to the Sacramento campus and outlying facilities.
3. Propose Fleet Services standards and policies, including emissions reduction goals that will align with the UC Policy on Sustainable Practices. Study, and implement as appropriate, a commuting mode-split improvement goal.
4. Study, and implement as appropriate, a "local offsets" program in order to fund energy conservation and neutral growth measures, incorporating both the Davis and Sacramento campuses.

Davis campus:

1. Propose a new round of projects to reduce at least another 20 million kWh and 1.24 million therms in an additional round of the Strategic Energy Partnership Program and begin the process of advocating for inclusion in the next round with PG&E, UCOP, and the CPUC. Include potential cap and trade costs as part of the analysis.
2. Study, and implement as appropriate, a program for moving to department-borne utilities and space costs, with coupled incentives, and bundle space efficiency into these costs.
3. Study, and implement as appropriate, a program for removing 100,000 sf per year of old, inefficient building square footage.
4. Conduct a detailed feasibility study of additional on-site generation, and explore purchase costs for "green" power.

Sacramento campus:

1. Propose additional energy conservation programs at the Sacramento campus, possibly along the lines of the Strategic Energy Partnership Program at the Davis campus; identify projects as part of the proposal. Include potential cap and trade costs as part of the analysis.
2. Study additional alternative transportation measures, and propose an implementation plan with appropriate measures. Monitor whether patients and hospital vendors are likely to be included in Scope 3 emissions inventorying.

In 2011-12, a revised Climate Action Plan should be prepared, which will update UC Davis GHG emissions and forecast whether the 2014 and 2020 goals are on target to be met, and if not, assess what options will allow the goals to be met.

APPENDICES

1. Baseline Data Notes

2. Scope 3 Data: Athletics and Study Abroad Travel Emissions; Farm Animals Census

3. Detailed List of Energy Conservation Measures

4. UC Davis Courses Related to Sustainability

5. Normalized Emissions: All UC campuses, 2008 emissions, by full-time equivalent and by gross square feet; UC Davis emissions by heating degree days and cooling degree days

APPENDIX 1. BASELINE DATA NOTES

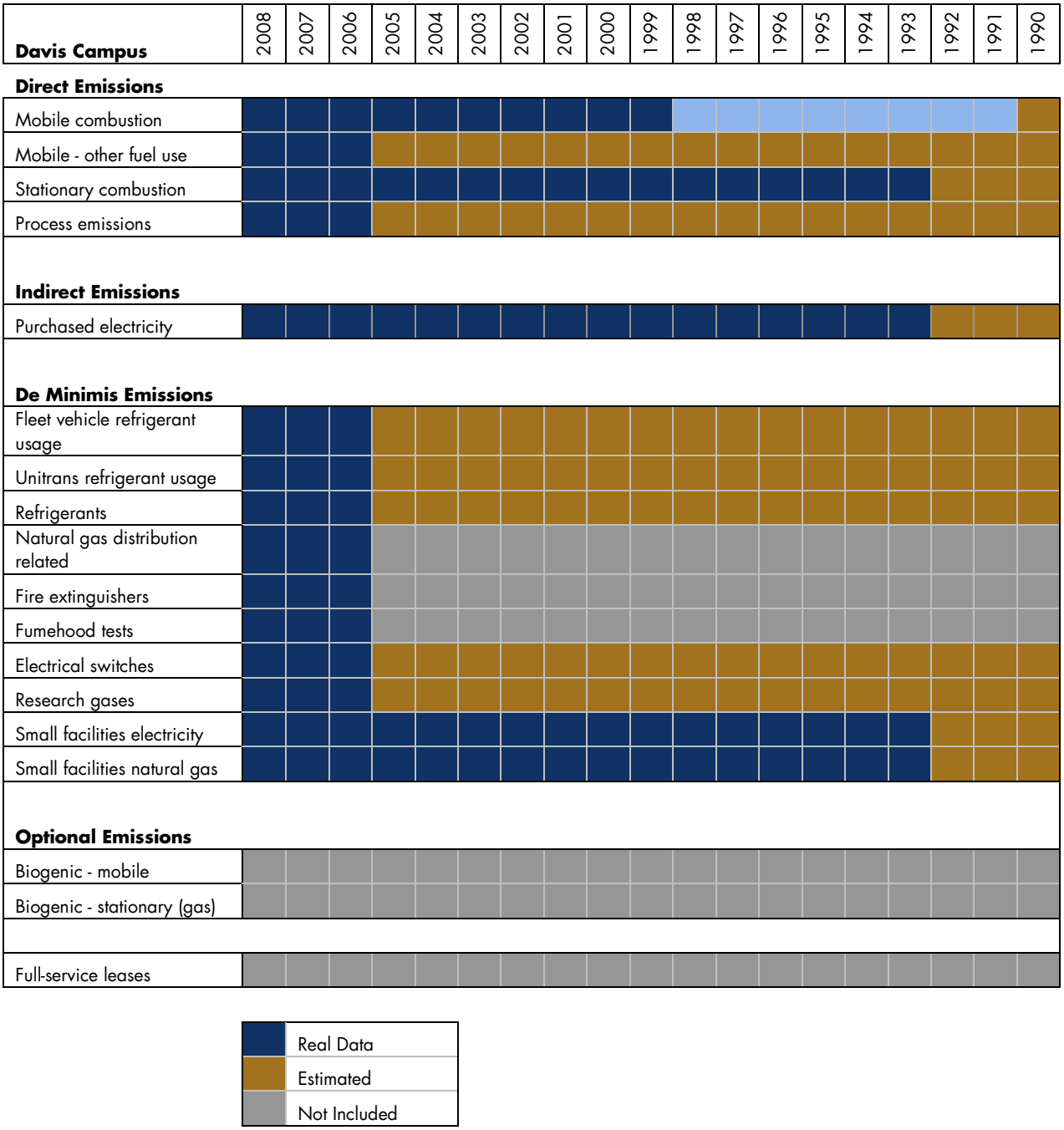
This section documents the baseline data. To ask questions, review the data, or obtain a copy, please contact the Sustainability Planner, Camille Kirk, in the Office of Environmental Stewardship and Sustainability. The office is located at 376 Mrak Hall and is open during normal business hours.

This section covers the following topics:

- General Information
- Estimation Methods
  - De minimis emissions
  - Natural gas and electricity emissions
  - Leased space emissions
- Detailed Information on Data Sources
  - Purchased Electricity
    - Electrical Consolidation File and PG&E Reconciliation
    - SMUD
    - WAPA
  - Natural Gas
    - Gas Consolidation File and PG&E Reconciliation
  - Davis Campus Fleet Vehicles
  - Wastewater Treatment Plant
  - Scope 3 Emissions
    - Davis Campus Commuting
    - Sacramento Campus Commuting
    - Air Miles
    - Other Scope 3
- Emission Factors
  - List of emission factor tables
  - Carbon dioxide equivalencies
  - Electricity
  - Natural Gas
  - Wastewater Treatment Plant
  - Fleet

GENERAL INFORMATION

The consumption data from campus emission sources have been gathered from corresponding departments. These data have been analyzed and converted into emissions by using the most recent California Climate Action Registry General Reporting Protocol (GRP 3.1)[2]. Because the emissions inventory aims to quantify emissions in 1990, not all data could be collected. The missing portions of the emissions were estimated using the default values suggested by the GRP or by using linear regression where appropriate. The tables below show the data availability in Sacramento and Main Campus.



Although the table shows that mobile combustion data were available from 1991 onwards, the light green areas (1991-1998) represent the years for which only Unitrans data were available. Unfortunately, no data existed for Campus Fleet Services prior to 1999.

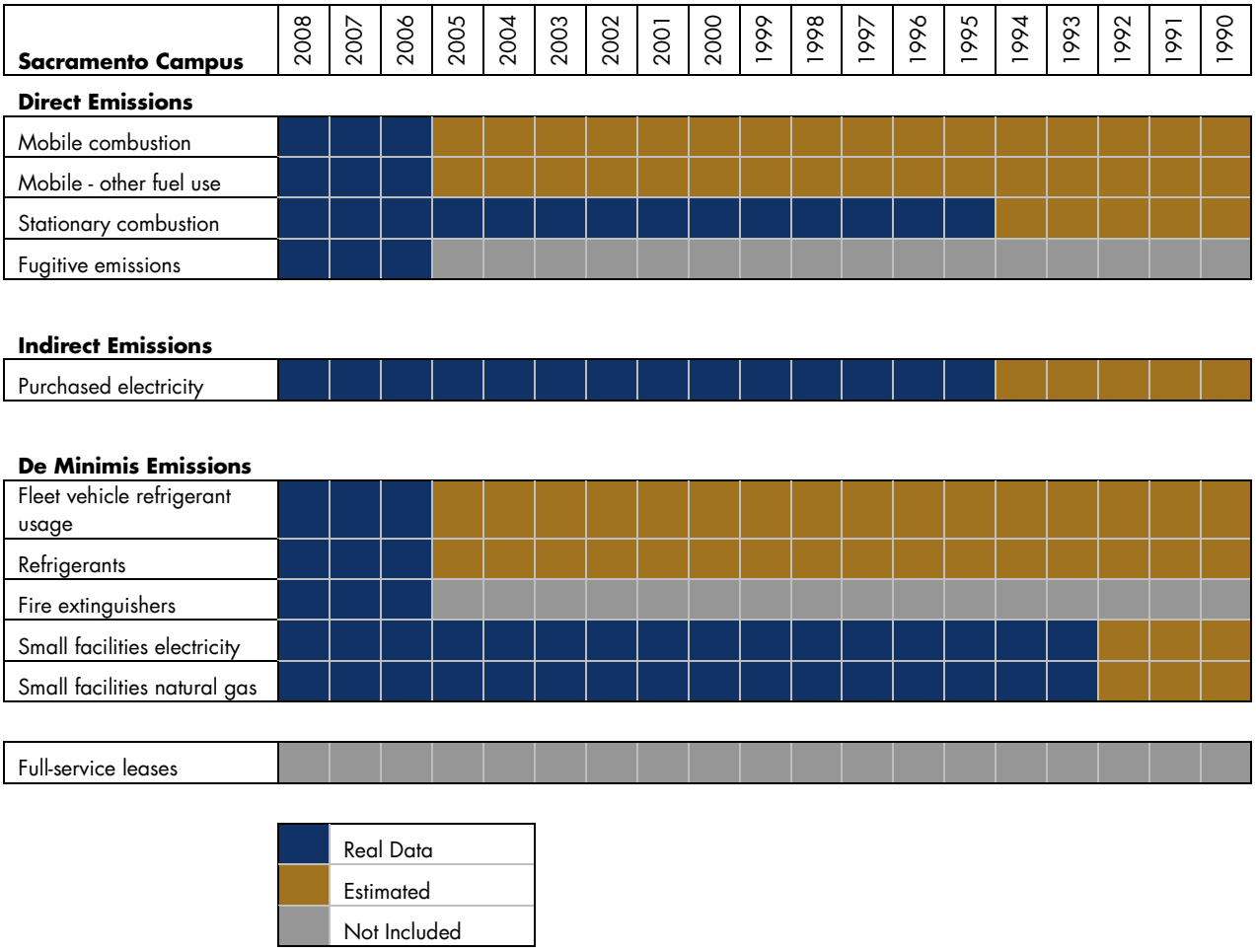
[2] An electronic copy of the protocol is available for downloading at http://www.climateregistry.org/

Natural gas consumption of the departments under the management of campus Facilities Management was recorded starting from 1994. Consumption regarding other departments, which are responsible for their own gas purchases, was obtained from PG&E. These departments included some on-campus facilities as well as leased buildings located outside the borders of main campus, but located in Davis and related to main campus activities. PG&E provided natural gas consumption data of these facilities from 2003 onwards. Therefore, consumption before 2003 was estimated using appropriate estimation methods mentioned in the next section.

A similar situation exists with purchased electricity on the main campus. While Facilities Management maintained records of departments under its management going back to 1992, purchased electricity data of some buildings on and off campus were obtained from PG&E.

The emissions under De Minimis section except for outlying facility utilities comprise approximately 2% of the total UC Davis emissions. Therefore, lack of data on those emissions does not significantly impact the accuracy of emissions. It is crucial to note that the items marked with yellow are in fact included in the baseline, but they were approximated using the estimation method explained in Estimation Methods section. De Minimis emissions marked as red were excluded from the baseline due to lack of data and these three items comprise less than 0.2% of total UCD emissions.

Electricity and natural gas consumption of small outlying facilities were recorded by Campus Facilities Management and to some extent by PG&E. Although there are other emission sources in those facilities– emergency generators, automobiles, etc.–the majority of emissions belong to natural gas and electricity. Full-service leases are excluded from the baseline because of lack of data and the complexity of obtaining the gas and electricity consumption of these facilities. Since the utilities are included in the rent in these lease agreements, it is impossible in most cases to obtain the consumption information going back in time.



No historical data were received from UC Davis Medical Center (UCDMC) Fleet Services, so all the mobile emissions regarding UCDMC were estimated using the available data. Natural gas consumption data were

received from UCDMC Business Office, and 1990-1993 levels were estimated using linear regression. Similarly, purchased electricity data were obtained from the Business Office, and partly from Sacramento Municipal Utility District (SMUD) and PG&E.

All yearly entries in the inventory represent calendar year and emissions are reported in metric tons of carbon dioxide equivalent.

ESTIMATION METHODS

De Minimis Emissions

The estimation method of smaller emissions, where very little or no data are available, is explained below. All 2007 emissions for the fugitive emissions and small emissions without any past data are summed and their ratio to the total 2007 emissions calculated. Then, these proportions are assumed to remain constant throughout the history of the campus. For instance, if main campus fleet refrigerants comprised 1% of all UC Davis emissions in 2007, fleet emissions comprised 1% of the total emissions in 1990 as well. The emissions of the sources below are calculated by this approach.

- Propane
- Kerosene
- Unitrans refrigerant
- Fume hood tests
- Refrigerant shop on campus
- Research gases
- Campus fleet refrigerants
- Agricultural services diesel and gasoline usage
- Grounds services diesel and gasoline usage
- UCDMC fleet refrigerants
- UCDMC refrigerants
- UCDMC fleet emissions

Natural Gas and Electricity Emissions

The consumption data of natural gas and electricity were fairly complete compared to other smaller emission sources. Natural gas purchases and combustion records were kept by campus Facilities Management as well as UCDMC Business Office since 1993. Electricity purchase records were similarly recorded by those departments. Emission estimations between 1990-1993 were made using linear regression. The years before the cogeneration plants were online were used in regression to reflect the conditions of 1990.

On the other hand, natural gas and electricity consumption of leased spaces had to be obtained from utility distributers such as PG&E and SMUD. So, the data were limited to what those vendors could provide: from 2001 onwards from SMUD, and 2003 onwards from PG&E. The consumption was estimated by adopting an approach similar to that of De Minimis emissions. The ratio of leased space emissions to the overall UC Davis emissions were calculated and past years' emissions were estimated by assuming that fraction was constant through the years. The ratios used in estimating are: 0.015 for SMUD, 0.213 for UCDMC Business Office electricity consumption data, and 0.032 for PG&E.

Leased Space

We do not have available data for the Davis campus before 2000, and incomplete data in the year 2000. We have limited data for the Sacramento campus. We will provide a brief summary of leased space activity to document the late 1990's surge and decline in leased space for clinics during the startup of the Primary Care Network. Otherwise, we are not disaggregating leased space from utilities data, and we are not adding a percentage for full service leases because we cannot know whether full services leases were less common during the period before 2000. The extremely limited data we have from 2000 and 2008 suggests that full service leases have become more common over time, and that they average about 12% of leased space. However, 2000 data is based on incomplete records and no data is available prior to 2000 for the Davis campus. We will describe what a full service lease is and describe leasing policy options as a CAP strategy (no full service leases, e.g.).

DETAILED INFORMATION ON DATA SOURCES

Purchased Electricity

There are four main data sources for purchased electricity.

- Campus Facilities Management (Electrical Consolidation File)
- PG&E
- SMUD
- Western Area Power Administration (WAPA)

Some of the buildings and facilities show up more than once in these data files. Therefore, a data manipulation is necessary to weed out the multiple entries. The Service Address ID and Account ID numbers are used to identify and remove the multiple entries. The multiple entries were removed from PG&E and SMUD files, because the Facilities Management records go back to 1992. The majority of the remaining items in SMUD and PG&E files represent the leased buildings as leased buildings receive their electricity from SMUD and PG&E. Below are some instructions on how to modify the data to prepare it for emissions calculations.

Electrical Consolidation File (EC) and PG&E Reconciliation

First, check the account numbers in both files and identify the duplicates. Note that all the account numbers in the PG&E file are 10-digit numbers. However, in the EC, some PG&E accounts have those 10 digits plus a hyphen and some number. Make sure you are checking the PG&E account numbers against the first 10 digits of the account numbers in the EC.

Checking only the account numbers is not enough to identify the duplicates because in some entries in the EC, SA_ID from the PG&E bills are entered as Account Numbers. So, some entries do not have correct account numbers. They will not be removed as a duplicate because the account numbers do not match. What should be done is to compare the Account Numbers in the consolidation files with the SA_ID number in the PG&E file in addition to checking Account Numbers against account numbers in PG&E. This problem exists in natural gas files, too.

After the duplicated are removed from PG&E, make sure to remove non-Davis UC entities –if any. The non-Davis entities can easily be identified checking the Entity Name column. Any kind of data received from utilities may have this problem because other UC System schools or UC owned entities may show up in accounts.

SMUD

SMUD data overlaps with the files received from UCDMC Business Office. Make a similar duplicate check against those two files and remove the duplicates from SMUD. In addition, the business office spreadsheets show excessive electricity purchases for the cogeneration plant in some months. These are the months that the cogeneration plant was down for maintenance.

WAPA

In the WAPA Summary file "Base Resource Allocation" and "Total KWH" rows have accurate kWh numbers. You have to divide BRA by Total to find the Hydro percentage. However, Facilities Management started to keep this file in 2005. So, for the past years, WAPA provided data on the total electricity sold to UC Davis. Along with energy consumption numbers, the fraction of hydroelectric power generated by WAPA to the total energy generated was provided for each year starting with 1992. These ratios help to remove the hydroelectric power UC Davis used. We assumed that the overall power mix of WAPA represented the mix of power provided to UCD over the years. For 1990 and 1991 levels, we assumed that the hydroelectric power to overall power ratio remained constant at 1992 level.

Natural Gas

Gas Consolidation/PG&E Reconciliation

There are some items in the Gas Consolidation (GC) file whose account number columns are blank. Since the first duplicate check was based on the account numbers, there are still duplicate entries.

Remove all the entries which have the following info:

Address: GARROD DR & LA RUE UCD CAMPUS
Acct #: 5085111476
This belongs to Unitrans and Unitrans natural gas is captured in the files given by Unitrans itself.

The UCDMC Cogeneration plant shows up in the PG&E file. That entry is removed in PG&E Final Query (ACCT_ID<>"9845491333")
UCDMC Business Office Multiplier 0.095 where Year<1995
PG&E_Leased multiplier 0.015 where Year<2003

Main Campus Fleet Services Vehicles

The following assumptions are made for biofuel content in Fleet Services vehicle fuels.

- BF1 = Unleaded and Ethanol are assumed to be unleaded only.
- BF3 = Unleaded and Natural Gas are assumed to be natural gas only.
- HB-1 = Electric and Unleaded are assumed to be unleaded only.

BF1 and BF3 are assumed to be a single type of fuel both because of simplicity and lack of data beyond 2007 and 08. In addition, there's not enough evidence to assume that the same fraction of ethanol/natural gas was used in past years as in 2007/08 because of enormous technological advancements and availability of biofuels and biofuel burning vehicles.

Voyager system keeps track of the amount of fuel purchased from outside gas stations. FleetAnnualMiles spreadsheets provide information about the miles driven per each vehicle. Fuel pump screenshots provide information on the amount of fuel dispensed from Fleet Services' fuel pumps.

Wastewater Treatment Plant (WWTP)

Local Government Operations Protocol for the Quantification and Reporting of Greenhouse Gas Emissions is used to assess WWTP emissions. The default values are used, with only the population numbers input. The list below shows the emission sources from WWTPs according to the report.

1- Incomplete combustion of digester gas at a centralized WWTP with aerobic digestion of biosolids.
2- Anaerobic and facultative treatment lagoons.
3- Septic Systems
4- Centralized WWTP with nitrification/denitrification
5- Centralized WWTP without nitrification/denitrification
6- Effluent Discharge to receiving aquatic environments

Items 2, 4, and 6 are used to calculate emissions for the current plant. Items 1, 2, 5, and 6 are relevant for the old plant. The new plant was opened in 2000. The equations have default values for all the numbers except for population. Therefore, the WWTP emissions are based on population served.

SCOPE 3 EMISSIONS

Main Campus Commuting

Transportation and Parking Services (TAPS) Permit sales data is used to estimate the commuter miles driven at the main campus. Daily, special events, and visitor permits are excluded in the study, because there is no data available for those permits to estimate the distance travelled.

The permit sales included regular permit holders on campus. Although these permits had address information of their holders, it was not certain that the addresses associated with the permits were the actual addresses that the permit holders commuted from. The considerable amount of out-of-California addresses increased our suspicion on the reliability of the addresses. Therefore, we used the average trip distance of 12.1 miles (single trip) from TAPS Campus Commuting Survey to calculate the total miles driven.

Permit data was available for 1998-2008, a population-based estimation is performed for the years 1990-1998.

UCDMC Commuting

Similar permit data is obtained from UCDMC Parking and Transportation Services. The average commuting distance of the permits that have less than 100 miles commuting distance is applied to the total number of permits. The commuters are assumed to come to the UCDMC five days a week excluding holidays.

Air Miles

Air miles traveled:

- Business (faculty, staff): sampling queries in MyTravel database were performed and extrapolated to calendar year and projected based on population. The query construction was constructed as follows:

Air travel query in MyTravel:
Report-------Approval status ----------Equal ------- Report Type
Value --------Approved ----------AND --------
Report-------Length----------Equal ------- Travel 30 day
Value --------1. 1-29 ----------AND -------- (or whichever
Report-------Submit Date ----------Equal ------- period wanted)
Value --------(date chosen) ----------
(Entry -------Class of Service----------Equal -------
Value --------1. Coach----------OR
Entry --------COS----------=
Value --------Business ----------OR
Entry --------COS----------=
Value --------First Class----------) (the open/closed parens are important)

- Athletics and study abroad air travel methodology is explained in Appendix 2.

Other Scope 3

1. No records available on fertilizer blend ratios (NPK), or records on how much was applied, only purchase records, and those are very spotty. No response from queries to CAES or faculty.
2. No attempt to document tillage – no protocol to use.
3. Animal waste management information is missing.

EMISSION FACTORS TABLES

Carbon dioxide equivalencies

Taken from GRP 3.1 Appendix C, Table C1 (page 94)

Table C.1 Comparison of GWPs from the IPCC's Second and Third Assessment Reports

Greenhouse Gas	GWP (SAR, 1996)	GWP (TAR, 2001)
CO_2	1	1
CH_4	21	23
N_2O	310	296
HFC-23	11,700	12,000
HFC-32	650	550
HFC-125	2,800	3,400
HFC-134a	1,300	1,300
HFC-143a	3,800	4,300
HFC-152a	140	120
HFC-227ea	2,900	3,500
HFC-236fa	6,300	9,400
HFC-4310mee	1,300	1,500
CF_4	6,500	5,700
C_2F_6	9,200	11,900
C_3F_8	7,000	8,600
C_4F_{10}	7,000	8,600
C_6F_{14}	7,400	9,000
SF_6	23,900	22,000

Source: U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003 (April 2005).

Electricity

Taken from GRP 3.1 Appendix E Electricity Emissions for Historical Reporting Purposes

Table E1 Carbon Dioxide electricity Emission Factors, Calendar Year 2007

Table E.1 Carbon Dioxide Electricity Emission Factors, Calendar Year 2007

eGRID Subregion Acronym	eGRID Subregion Name	CO_2 Output Emission Rate (lbs/MWh)
AKGD	ASCC Alaska Grid	1,257.19
AKMS	ASCC Miscellaneous	480.10
AZNM	WECC Southwest	1,254.02
CAMX	WECC California	878.71
ERCT	ERCOT All	1,420.56

Table E2 Carbon Dioxide electricity Emission Factors, Calendar Years 1990-2006

Table E.2 Carbon Dioxide Electricity Emission Factors, Calendar Years 1990 - 2006

eGRID Subregion Acronym	eGRID Subregion Name	CO_2 Output Emission Rate (lbs/MWh)
AKGD	ASCC Alaska Grid	1,399.95
AKMS	ASCC Miscellaneous	757.81
CALI	WECC California	804.54
ECMI	ECAR Michigan	1,632.06

Table E3 Methane and Nitrous Oxide electricity Emission Factors by State, Calendar years 1990-2007

Table E.3 Methane and Nitrous Oxide Electricity Emission Factors by State, Calendar Years 1990 - 2007

Region/State	CH_4 (lbs/MWh)	N_2O (lbs/MWh)
Alabama	0.0137	0.0223
Alaska	0.0068	0.0089
Arizona	0.0068	0.0154
Arkansas	0.0125	0.0203
California	0.0067	0.0037
Colorado	0.0127	0.0289
Connecticut	0.0174	0.0120

Note: All the emission factors for 1990-2006 have the same values for each year. However, both 2007 and 2008 are different from the past and from each other.

Table C.2 Carbon Dioxide, Methane and Nitrous Oxide Electricity Emission Factors by eGRID Subregion

eGRID Subregion Acronym	eGRID Subregion Name	CO_2 (lbs/MWh)	CH_4 (lbs/MWh)	N_2O (lbs/MWh)
AKGD	ASCC Alaska Grid	1,232.36	0.0256	0.0065
AKMS	ASCC Miscellaneous	498.86	0.0208	0.0041
AZNM	WECC Southwest	1,311.05	0.0175	0.0179
CAMX	WECC California	724.12	0.0302	0.0081
ERCT	ERCOT All	1,324.35	0.0187	0.0151
FRCC	FRCC All	1,318.57	0.0459	0.0169

Natural Gas

Taken from GRP 3.1 Appendix C, Table C7 Carbon Dioxide Emission Factors for Stationary Combustion (pg 101) (53.06 kg Co2/MMBtu)

Petroleum Products (Gaseous)	kg C/ MMBtu	Btu/ standard cubic foot		kg CO_2/ standard cubic foot	kg CO_2/MMBtu
Natural Gas (weighted U.S. average)	14.47	1,029	1.00	0.0546	53.06
Acetylene (C_2H_2)	19.48	1,476	1.00	.1043	71.42

Taken from GRP 3.1 Appendix C, Table C8 Methane and Nitrous Oxide Emission Factors for Stationary Combustion by Fuel Type and Sector

Table C.8 Methane and Nitrous Oxide Emission Factors for Stationary Combustion by Fuel Type and Sector

Fuel Type/End-Use Sector	CH_4 (kg/MMBtu)	N_2O (kg/MMBtu)
Coal		
Residential	0.316	0.0016
Commercial/Institutional	0.011	0.0016
Manufacturing/Construction	0.011	0.0016
Electric Power	0.001	0.0016
Petroleum Products		
Residential	0.011	0.0006
Commercial/Institutional	0.011	0.0006
Manufacturing/Construction	0.003	0.0006
Electric Power	0.003	0.0006
Natural Gas		
Residential	0.005	0.0001
Commercial/Institutional	0.005	0.0001

Commercial/Institutional methane=0.005 kg/MMBtu, nitrous oxide=0.0001 kg/MMBtu

WWTP

The calculations used the Local Government Operations Protocol for the quantification and reporting of greenhouse gas emission inventories version 1.0 September 25, 2008:

- Part 10.2 Emissions Unique to Wastewater Treatment (page99)
- Equations 2,4,6 are relevant for the current WWTP
- Equations 1,2,5,6 are relevant for the old WWTP

Fleet

Gasoline and diesel carbon content taken from GRP 3.1 Appendix C, Table C3 Carbon Dioxide Emission factors for Transport Fuels (page 96)

Table C.3 Carbon Dioxide Emission Factors for Transport Fuels

Fuel	Carbon Content	Heat Content	Fraction Oxidized	CO_2 Emission Factor
	kg C/MMBtu	MMBtu/barrel		kg CO_2/gallon
Aviation Gasoline	18.87	5.048	1.00	8.32
Biodiesel (B100)* +	NA	NA	1.00	9.46
Crude Oil	20.33	5.80	1.00	10.29
Diesel	19.95	5.825	1.00	10.15
Ethanol (E100)* +	17.99	3.539	1.00	5.56
Jet Fuel (Jet A or A-1)	19.33	5.670	1.00	9.57
Kerosene	19.72	5.670	1.00	9.76
Liquefied Natural Gas (LNG)+	NA	NA	1.00	4.46
Liquefied Petroleum Gas (LPG)+	17.23	3.849	1.00	5.79
Ethane	16.25	2.916	1.00	4.14
Isobutane	17.75	4.162	1.00	6.45
n-Butane	17.72	4.328	1.00	6.70
Propane	17.20	3.824	1.00	5.74
Methanol	NA	NA	1.00	4.10
Motor Gasoline	19.33	5.218	1.00	8.81
Residual Fuel Oil (#5, 6)	21.49	6.287	1.00	11.80
	kg C/MMBtu	Btu/standard cubic foot		kg CO_2/therm
Compressed Natural Gas (CNG)+	14.47	1027	1.00	5.31

Methane and nitrous oxide emissions per mile by vehicle and fuel type and model year taken from GRP 3.1 Appendix C, Table C4 Methane and Nitrous Oxide Emissions factors for Highway Vehicles by Model Year (page 97)

Table C.4 Methane and Nitrous Oxide Emission Factors for Highway Vehicles by Model Year

Vehicle Types/Model Years	N_2O (g/mile)	CH_4 (g/mile)
Gasoline Passenger Cars		
Model Years 1984-1993	0.0647	0.0704
Model Year 1994	0.0560	0.0531
Model Year 1995	0.0473	0.0358
Model Year 1996	0.0426	0.0272
Model Year 1997	0.0422	0.0268
Model Year 1998	0.0393	0.0249
Model Year 1999	0.0337	0.0216
Model Year 2000	0.0273	0.0178
Model Year 2001	0.0158	0.0110
Model Year 2002	0.0153	0.0107
Model Year 2003	0.0135	0.0114
Model Year 2004	0.0083	0.0145
Model Year 2005 - Present	0.0079	0.0147
Gasoline Light Trucks (Vans, Pickup Trucks, SUVs)		
Model Years 1987-1993	0.1035	0.0813
Model Year 1994	0.0982	0.0646
Model Year 1995	0.0908	0.0517
Model Year 1996	0.0871	0.0452
Model Year 1997	0.0871	0.0452
Model Year 1998	0.0728	0.0391
Model Year 1999	0.0564	0.0321
Model Year 2000	0.0621	0.0346
Model Year 2001	0.0164	0.0151
Model Year 2002	0.0228	0.0178
Model Year 2003	0.0114	0.0155
Model Year 2004	0.0132	0.0152
Model Year 2005 - Present	0.0101	0.0157

Methane and nitrous oxide emissions for CNG vehicles taken from GRP 3.1 Appendix C, Table C5 Methane and Nitrous Oxide Emissions factors for Alternative Fuel Vehicles (page 99)

Table C.5 Methane and Nitrous Oxide Emission Factors for Alternative Fuel Vehicles

Vehicle Type	N_2O (g/mile)	CH_4 (g/mile)
Light Duty Vehicles		
Methanol	0.067	0.018
CNG	0.050	0.737
LPG	0.067	0.037
Ethanol	0.067	0.055
Heavy Duty Vehicles		
Methanol	0.175	0.066
CNG	0.175	1.966
LNG	0.175	1.966
LPG	0.175	0.066
Ethanol	0.175	0.197
Biodiesel*	0.050	0.060
Buses		
Methanol	0.175	0.066
CNG	0.175	1.966
Ethanol	0.175	0.197

APPENDIX 2. ATHLETICS AND STUDY ABROAD AIR TRAVEL EMISSIONS; FARM ANIMAL CENSUS

UC DAVIS ATHLETICS AIR TRAVEL EMISSIONS

Low End Calculations for Athletics Department Air Travel					High End Calculations for Athletics Department Air Travel				
Year	Total Miles Traveled	Medium Haul Miles	Long Haul Miles	CO2 Emissions (M.T.)	Year	Total Miles Traveled	Medium Haul Miles	Long Haul Miles	CO2 Emissions (M.T.)
1990	**389,580.45**	**211,573.65**	**178,006.80**	**74.68**	**1990**	**649,300.75**	**352,622.75**	**296,678.00**	**124.46**
1991	389,580.45	211,573.65	178,006.80	74.68	1991	649,300.75	352,622.75	296,678.00	124.46
1992	389,580.45	211,573.65	178,006.80	74.68	1992	649,300.75	352,622.75	296,678.00	124.46
1993	389,580.45	211,573.65	178,006.80	74.68	1993	649,300.75	352,622.75	296,678.00	124.46
1994	389,580.45	211,573.65	178,006.80	74.68	1994	649,300.75	352,622.75	296,678.00	124.46
1995	389,580.45	211,573.65	178,006.80	74.68	1995	649,300.75	352,622.75	296,678.00	124.46
1996	389,580.45	211,573.65	178,006.80	74.68	1996	649,300.75	352,622.75	296,678.00	124.46
1997	389,580.45	211,573.65	178,006.80	74.68	1997	649,300.75	352,622.75	296,678.00	124.46
1998	389,580.45	211,573.65	178,006.80	74.68	1998	649,300.75	352,622.75	296,678.00	124.46
1999	649,300.75	352,622.75	296,678.00	124.46	1999	1,038,881.20	564,196.40	474,684.80	199.13
2000	**649,300.75**	**352,622.75**	**296,678.00**	**124.46**	**2000**	**1,038,881.20**	**564,196.40**	**474,684.80**	**199.13**
2001	649,300.75	352,622.75	296,678.00	124.46	2001	1,038,881.20	564,196.40	474,684.80	199.13
2002	649,300.75	352,622.75	296,678.00	124.46	2002	1,038,881.20	564,196.40	474,684.80	199.13
2003	1,818,042.10	987,343.70	830,698.40	348.48	2003	1,818,042.10	987,343.70	830,698.40	348.48
2004	1,818,042.10	987,343.70	830,698.40	348.48	2004	1,818,042.10	987,343.70	830,698.40	348.48
2005	1,818,042.10	987,343.70	830,698.40	348.48	2005	1,818,042.10	987,343.70	830,698.40	348.48
2006	1,818,042.10	987,343.70	830,698.40	348.48	2006	1,818,042.10	987,343.70	830,698.40	348.48
2007	2,597,203.00	1,410,491.00	1,186,712.00	497.84	2007	2,597,203.00	1,410,491.00	1,186,712.00	497.84
2008	3,213,586.00	1,500,262.00	1,713,324.00	609.32	2008	3,213,586.00	1,500,262.00	1,713,324.00	609.32

Table A2.1: Low-End and High-End Calculations for UC Davis Athletics Department Air Travel

Notes regarding calculations:

1. The low end and high end figures were based on a telephone conversation between ESS Sustainability Planner, Camille Kirk, and UC Davis Athletic Director, Greg Warzecka. According to Mr. Warzecka, the athletic department's air travel from 1990-1998 was approximately 15-25% of its air travel in 2007. Air travel from1999-2002 was approximately 25-40% of 2007 air travel, and air travel from 2003-2006 was 70% of 2007 air travel. The low end columns represent 15% for 1990-1998 and 25% for 1999-2002, while the high end columns represent 25% for 1990-1998 and 40% for 1999-2002. Both columns have 70% for 2003-2006, per information from Athletic Director Warzecka.

2. All data from 1990-2006 was estimated off of the hard data from 2007. Hard data was only available for 2007 and 2008.

3. Emissions calculation uses Terra Pass model. Terra Pass designates three different emission factors for three different lengths of trips. A short haul (0-280 miles) is given an EMF of 0.64 lb CO2/mile, a medium haul (281-993 miles) is given an EMF of 0.45 lb CO2/mile and a long haul (994+ miles) is given an EMF of 0.39 lb CO2/mile.

APPENDIX 2. ATHLETICS AND STUDY ABROAD AIR TRAVEL EMISSIONS; FARM ANIMAL CENSUS

UC DAVIS STUDY ABROAD AIR TRAVEL EMISSIONS

Year	Student Population	EAP Air Miles Traveled	SA Air Miles Traveled	QA Air Miles Traveled	CO2 Emissions (M.T.)
1990	**21,920**	**3,009,506**	**6,864,566**	**1,235,979**	**1,965**
1991	23,318	3,201,445	7,302,370	1,314,806	2,091
1992	22,528	3,092,982	7,054,970	1,270,261	2,020
1993	22,086	3,032,297	6,916,551	1,245,339	1,980
1994	21,596	2,965,023	6,763,100	1,217,710	1,936
1995	21,791	2,991,795	6,824,167	1,228,705	1,954
1996	22,372	3,071,564	7,006,116	1,261,465	2,006
1997	23,187	3,183,459	7,261,345	1,307,419	2,079
1998	23,729	3,257,873	7,431,080	1,337,981	2,128
1999	24,191	3,321,303	7,575,762	1,364,031	2,169
2000	**24,033**	**3,299,611**	**7,526,282**	**1,355,122**	**2,155**
2001	25,315	3,475,623	7,927,759	1,427,409	2,270
2002	26,426	3,628,158	8,275,685	1,490,053	2,369
2003	28,236	3,876,662	8,842,513	1,592,112	2,532
2004	29,122	3,998,305	9,119,976	1,642,070	2,611
2005	28,799	3,953,959	9,018,824	1,623,857	2,582
2006	28,484	3,910,711	8,920,177	1,606,095	2,554
2007	29,221	4,011,897	9,150,980	1,647,652	2,620
2008	29,626	4,067,502	9,277,811	1,670,488	2,656
2009	30,403	4,174,180	9,521,140	1,714,300	2,726

Table A2.2: UC Davis Study Abroad Air Travel Emissions

Notes regarding calculations:

1. EAP = Education Abroad Program. SA =Summer Abroad. QA=Quarter Abroad.

2. Population figures were taken from the addition of on-campus and off-campus student totals from the population spreadsheet. Since the years are broken up by school years, the school year with two quarters was used. For example, the 1990-1991 school year population was used for the 1991 population in this estimation, because winter and spring quarters fall in the 1991 calendar year, while only fall quarter falls in the 1990 calendar year.

3. The population-based estimation of air travel was taken by normalizing each year's student population from 1990-2008 against the 2009 air miles traveled.

4. Emissions calculation uses Terra Pass model. Terra Pass designates three different emission factors for three different lengths of trips. A short haul (0-280 miles) is given an EMF of 0.64 lb CO2/mile, a medium haul (281-993 miles) is given an EMF of 0.45 lb CO2/mile and a long haul (994+ miles) is given an EMF of 0.39 lb CO2/mile. All Study Abroad flights were international, so they were all given the long haul EMF because all international capitals are more than 994 miles from SFO.

APPENDIX 2. ATHLETICS AND STUDY ABROAD AIR TRAVEL EMISSIONS; FARM ANIMAL CENSUS

COMBINED UC DAVIS STUDY ABROAD AND ATHLETICS AIR TRAVEL EMISSIONS

Year	Medium Haul Miles	Long Haul Miles	CO2 Emissions (M.T.)
1990	**352,622.75**	**11,406,728.67**	**2,089.84**
1991	352,622.75	12,115,298.50	2,215.19
1992	352,622.75	11,714,890.66	2,144.35
1993	352,622.75	11,490,865.00	2,104.72
1994	352,622.75	11,242,510.76	2,060.79
1995	352,622.75	11,341,345.61	2,078.27
1996	352,622.75	11,635,822.78	2,130.37
1997	352,622.75	12,048,901.76	2,203.4
1998	352,622.75	12,323,611.95	2,252.04
1999	564,196.40	12,501,618.75	2,326.71
2000	**564,196.40**	**12,735,781.32**	**2,368.14**
2001	564,196.40	12,655,699.75	2,353.97
2002	564,196.40	13,305,475.52	2,468.92
2003	987,343.70	15,141,984.47	2,880.17
2004	987,343.70	15,591,049.47	2,959.61
2005	987,343.70	15,427,338.42	2,930.65
2006	987,343.70	15,267,682.12	2,902.41
2007	1,410,491.00	15,997,240.76	3,117.84
2008	1,500,262.00	16,729,125.14	3,265.63

Table A2.3: Combined UC Davis Study Abroad and Athletics Air Travel Emissions

Notes regarding calculations:

1. These figures come from the previous tables, A2.1 and A2.2.

2. This estimation was made using the high end values for Athletics Air Travel.

APPENDIX 2. ATHLETICS AND STUDY ABROAD AIR TRAVEL EMISSIONS; FARM ANIMAL CENSUS

UC DAVIS FARM ANIMAL CENSUS

Year	Poultry	Sheep/Goats	Swine	Cows (beef, dairy)	Horses
1990	**N/A**	**659**	**234**	**1288.5**	**55**
1991	N/A	740	231	485	53
1992	N/A	618	217	1400.5	35
1993	N/A	588	209	1416.5	32
1994	N/A	599.5	189.5	1782	40
1995	N/A	585.5	167	1718	35.5
1996	N/A	607	200.5	1470	42.5
1997	N/A	516.5	229.5	1366	37
1998	N/A	456	216.5	1593.5	44
1999	N/A	528	200	1414	44
2000	**N/A**	**526.1**	**203.3**	**493.1**	**39.9**
2001	N/A	419.6	280.8	524.7	41.8
2002	N/A	392.3	321.5	680.8	43.2
2003	N/A	394.3	304.2	239.6	42.4
2004	N/A	407.9	290.3	569.8	40.3
2005	N/A	430.7	285.8	1359.1	40.3
2006	N/A	452.4	341.6	1423.5	48.2
2007	1525	419	294	1282	308

Table A2.4: UC Davis Farm Animal Census

Notes regarding calculations:

1. All data is defined as the average daily census for each type of animal.

2. The 2007 data was provided by the Center for Laboratory Animal Science, the Center for Equine Health, and the Department of Animal Science.

3. Data for 1990-2006 was received from only the Department of Animal Science. That data did not include any census figures for poultry, although poultry data was provided in the 2007 summary.

APPENDIX 3. DETAILED LIST OF CONSERVATION MEASURES

UC Davis has undertaken many conservation measures over the past decade. Many, though not all, are documented here for reference.

1. Programs undertaken by Davis campus Facilities Management

2009 & 2008 TAPS parking structure and parking lot lighting retrofit, combined 1,360,000 kWh
The exterior lighting retrofit initiative has reduced energy consumption by installing more efficient technology and introducing occupancy control. The technologies selected for these projects are induction fluorescent (no electrode) and light emitting diode (LED). Infrared sensing devices were added to the fixtures, allowing the light output to be reduced to acceptable minimums and energy consumption to be halved.

2009 Correct excessive steam loss through DA vent condenser at Central Plant 32,230 Therms
This project reduced the amount of steam that had been discharged along with air, from the boiler feedwater deaerating and storage tank. Analysis revealed that the operating pressure of the tank could be reduced, allowing us to install a smaller orifice in the vent line.

2008 Replace landfill gas blower and optimize flow control to primate boiler 26,571 Therms
A new blower, variable frequency drive (VFD) for the blower motor, and control scheme were installed in the landfill gas delivery system. The new equipment and controls allow the maximum amount of landfill gas to be consumed in the Primate boilers. The savings represents the volume of pipeline natural gas displaced by this improvement.

2008 Optimize cooling tower performance at CHCP and TES 493,745 kW
This project introduced dynamic control of cooling tower fans and pumps to optimize efficiency using real time chiller performance and weather data.

2007 Efficiency Enhancements for Steam Expansion Phase 1 1,061,297 kWh/102,350 Therms
Through PG&E's Savings By Design program, a number of enhancements were incorporated into the project design, above the level specified by Campus Standards (e.g., variable frequency drive and premium efficiency motor for boiler forced draft fan, reverse osmosis water treatment system, condensate polishing system, boiler blowdown heat recovery unit).

2007 Replace steam absorption chillers with electric driven chillers 1,246,278 Therms
The savings represents the difference between the energy consumption of the new chillers vs. the energy consumption of equivalent, new steam absorption chillers.

2007 Test and replace defective steam traps 392,490 Therms
Defective steam traps were located, tested and replaced throughout the high pressure steam distribution system, as well as low pressure traps throughout the building mechanical systems. Defective traps waste energy by allowing steam to pass into the condensate return system.

2006 Insulate exposed valves and boiler fittings at CHCP 56,541 Therms
Custom fitted insulating blankets were installed on exposed surfaces to reduce heat loss to the environment. The additional heat is retained by the boiler and steam distribution system.

2006 WWTP controls upgrade & VFD installation 560,000 kWh
Implement a new control scheme and install variable frequency drives (VFD) on the motors used to drive the aerobic digester pumps. Variable control of the pump speed matches the motor load to actual conditions, instead of operating the motors at constant speed.

2005 Building recommissioning at Neuroscience 141,770 kWh and 667 Therms
Building HVAC and energy system performance were measured and evaluated in comparison to original design conditions. Discrepancies identified during the process were corrected, resulting in improved performance and energy savings.

1996-2004 PG&E Power Savings Partners Program 76,000,000 kWh

This multi-year program, sponsored by PG&E, supported energy efficient lighting retrofits across campus. Following a wide scale fixture replacement, the campus received monthly incentive payments (avg $35,000) based on the results of a rigorous quarterly monitoring program. Data loggers deployed at random sampling points measured occupancy, which served as the basis for a statistical determination of energy use.

A list of 2006-08 Energy Conservation Projects is included in PDF format here and can be accessed at: (http://facilities.ucdavis.edu/EnergyCons/projects/).

2. Programs undertaken by Davis campus Student Housing

Over the past three academic years, energy use at the residence halls and apartments has decreased by 5 percent in part due to a wide variety of practices and projects.

- 4.2 kw photovoltaic system at the Tri-Cooperatives housing (completed in 2002)
- Solar hot water at Leach and Solano Park (completed in 1983)
- Monitoring-based commissioning (MBCx) at Alder, Kearney, Laben , Miller, and Thompson Halls
- Lights connected to motion sensors and/or photocells in some spaces
- Electronic ballasts and fluorescent lights retrofit in residence halls (completed in 1997)
- Axis (daylight harvesting) ballasts in lounge areas (completed in 2006)
- ENERGY STAR washing machines
- White roofs to reduce heating and cooling loads
- Energy management systems in the buildings
- Thermostat controls allow user control in an efficient range
- Provide each student a low energy fluorescent desk lamp (completed in 2008)
- Educate residents, and provide information (http://www.housing.ucdavis.edu/Sustainability/energy.asp

The following projects have measured results:

Student Housing Projects	Annual Savings		Year of Completion
	kWh	therms	
Solano and Orchard AC unit replacement (SEP)	149,472		2008
Melink hood controls in Tercero DC (SEP)	275,265	8,856	2008
Webster/Emerson hybrid vanity lights	8,000	*	2006
ENERGY STAR washing machines in all facilities	11,500	*	2003

* Unquantified savings

3. Programs undertaken by Sacramento campus Facilities Management

A 1996 report documenting energy conservation projects showed that with installation of centralized monitor and control systems and installation of small HVAC units to allow larger chillers to be shut down after hours yearly savings of nearly $800,000 were expected. A 2009 report documented several energy conservation measures over a two year period, including lighting retrofits and controls, energy recovery system, energy management system improvement, and boiler energy reduction strategy, which are expected to produce annual savings of over $210,000 and savings of over 1,500,000 kWh and 140,000 therms annually.

APPENDIX 4. UC DAVIS COURSES RELATED TO SUSTAINABILITY DECEMBER 2009

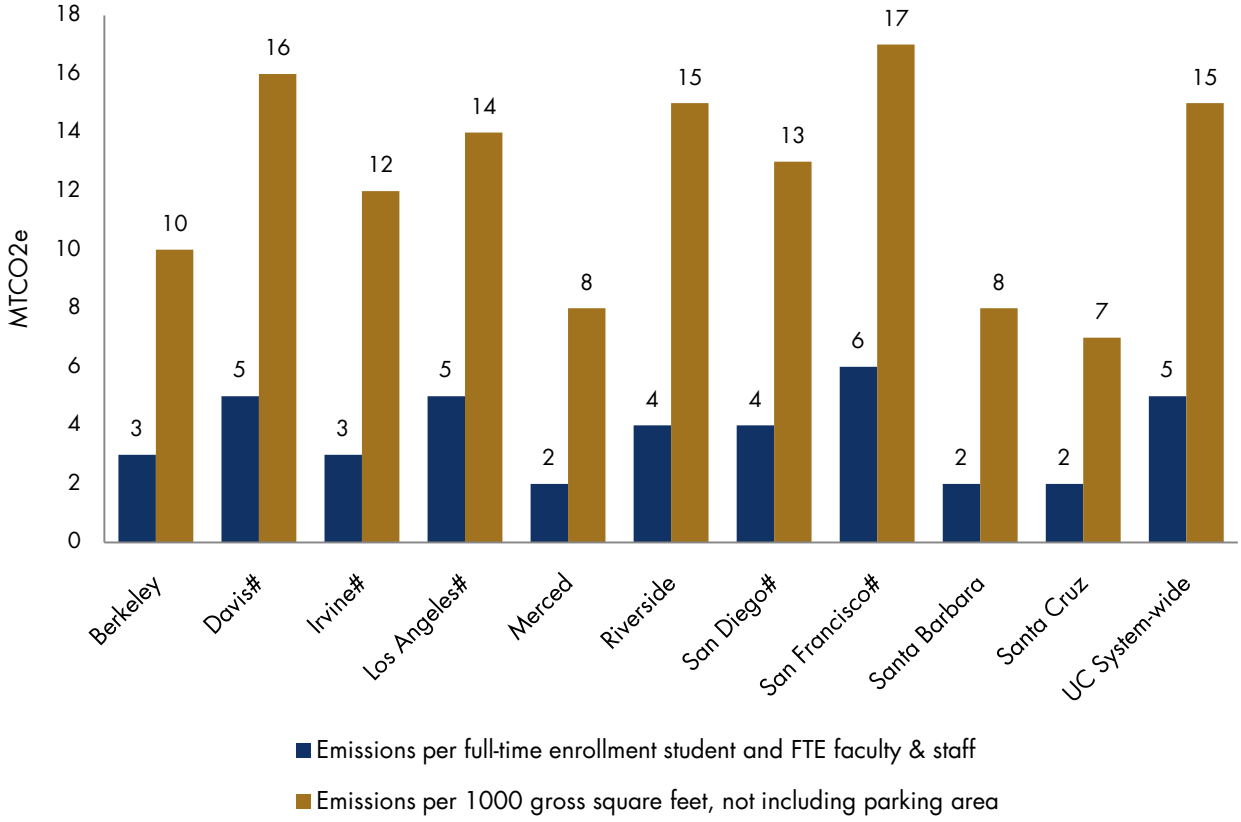
Note: These are courses with the words "sustainable" or "sustainability" in their title or catalog description, as well as others that have been suggested to date by faculty. Other courses may also touch upon sustainability topics. Check with the appropriate department or faculty member. All courses may not be offered every year, and some have prerequisites or restricted enrollment. The number is the number of credits for the class. Please send additions or corrections to Stephen Wheeler at smwheeler@ucdavis.edu.

Agricultural and Resource Economics 175: Natural Resource Economics
Anthropology 126A: Anthropology of Development (4)
Design 127 Critical Issues in Design and Art: Environmental Consciousness (4)
Design 127A Introduction to Sustainable Design (4) (Savageau)
Design 127B Studio Practice in Sustainable Design (4) (Savageau)
Design 138: Materials and Methods in Interior Design (4) (every other year; may be restricted to majors)
Ecology 216: Ecology and Agriculture (4)
Ecology 217: Conservation and Sustainable Development in Third World Nations (4)
Ecology 290/CRD 290: Integrated Agroecosystem Assessment (4)
Engineering 123: Urban Systems and Sustainability (4)
Engineering 126 (initially ECI 189): Integrated Planning (open by permission of the instructor)
Engineering 127 (initially ECI 189): Integrated Design
Engineering 143: Green Engineering Design and Sustainability (4) (limited to engineering students)
Engineering/Environmental Sciences 252: Sustainable Transportation Technology and Policy (3)
Environmental Horticulture/Plant Sciences 160: Restoration Ecology (4) (every spring)
Environmental Resource Science/Plant Biology 144: Trees and Forests (4)
Environmental Science and Policy 125C: Applied Conservation Biology (4)
Environmental Science and Policy 163 Energy and Environmental Aspects of Transportation (4)
Environmental Science and Policy 167 Energy Policy (4)
Environmental Science and Policy169: Water Policy and Politics (4) (Lubell)
Environmental Science and Policy 171 Urban and Regional Planning (4) (Handy; every spring)
Environmental Science and Policy 172: Public Lands Management (4) (Lubell)
Geology 10: Modern and Ancient Global Environmental Change (3)
Hydrology/Science and Society 10: Water and Power and Society (3)
International Agricultural Development 162: Field Course in Tropical Ecology, Sustainable Agricultural Development
International Agricultural Development 202N: Analysis and Determinants of Farming Systems (4)
International Agricultural Development 217: Conservation and Sustainable Development in Third World Nations (4)
Landscape Architecture 3: Sustainable Development Theory and Practice (4) (Wheeler; every spring)
Landscape Architecture 180G (2): Landscape and Regional Land Planning (Wheeler; every winter)
Landscape Architecture 181G (3): Landscape and Regional Land Planning Studio (Wheeler; every winter)
Landscape Architecture 180P (2): Water in Community Planning and Design (Loux; every fall)
Landscape Architecture 181P (3): Water in Community Planning and Design Studio (Loux; every fall)
Management 291: Greening Business: Moving Beyond Compliance and Toward Green Strategy (4) (Beamish)
Plant Biology 146: Rhizosphere Ecology (3)
Plant Science 1: Agriculture, Nature and Society (3)
Plant Science 49: Organic Crop Production Practices
Plant Science 101: Agriculture and the Environment (3)
Plant Science 160: Agroforestry: Global and Local Perspectives (3)
Plant Science 190: Seminar on Alternatives in Agriculture (2)
Plant Sciences 150: Cropping Systems of the World (4)
Plant Sciences 162: Urban Ecology (3) (Cadenasso)
Science and Society 25: Global Climate Change (4)
Science and Society 105: Organismal Interactions in Everyday Life (3)
Sociology 160: Environmental Sociology (4) (Beamish)
Sociology 295: Social and Political Ecology (4) (Beamish)
Soil Science 10: Soils in Our Environment (3)
Soil Science 109: Nutrient Cycling and Management (5)

Appendix 5. NORMALIZED EMISSIONS

ALL UC CAMPUSES, 2008 EMISSIONS, BY FULL-TIME EQUIVALENT AND BY GROSS SQUARE FEET

(Data from UCOP http://www.universityofcalifornia.edu/regents/regmeet/mar10/gb6attach3b.pdf)



UC DAVIS EMISSIONS BY HEATING DEGREE DAYS AND COOLING DEGREE DAYS