CONCEPTUAL PLAN

FOR

CARBON NEUTRALITY

AT THE

UNIVERSITY OF COLORADO AT BOULDER

Prepared by:
CU Carbon Neutrality Working Group
August 2009

Approved:
October 8, 2009

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PRESIDENTS CLIMATE COMMITMENT

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University of Colorado at Boulder

Office of the Vice Chancellor for Administration

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October 14, 2009

Ms. Toni Nelson, Director
The American College and University Presidents Climate Commitment
c/o Association for the Advancement of Sustainability in Higher Education
213 ½ N. Limestone
Lexington, KY 40507

Dear Ms. Nelson:

This letter accompanies the transmittal of the university's climate action plan, "Conceptual Plan for Carbon Neutrality at the University of Colorado at Boulder." The plan, in addition to the previously submitted emissions inventory, serves as the next step in fulfillment of the university's participation in the higher education community's efforts to address global climate change.

This campus has a legacy of leadership in climate action, sustainability and energy dating back more than fifty years. Students, faculty, staff and community partners continue to build on these historic achievements. The university's climate action plan reflects a continued focus on reaching carbon neutrality by providing leadership and instilling the necessity of practical solutions and efforts.

The concept of carbon neutrality here on the Boulder campus is best thought of as a powerful incentive for vigorous short term goals. Therefore, the plan sets deadlines for aggressive short term actions, describes multiple phases for longer term actions, and provides for transparent performance monitoring. These actions will alter CU's carbon emissions trajectory towards a tangible neutrality point as quickly as possible. As CU implements these short term actions, long term carbon projections will be revisited and a date certain for the 80% reduction established.

This carbon neutrality plan represents a body of work compiled by countless campus and community members over the past two years — and I deeply appreciate the significant effort and commitment of everyone involved. Their efforts produced a vision for moving forward that is not static or awaiting implementation. This summer, we began the actions necessary to begin meeting the short term goals envisioned by the plan, actualizing the university's commitment to the review and update process.

The strength of the PCC commitment is not just about directly mitigating carbon but that it incorporates integration of campus operations, education, research and community efforts. Without the ACUPCC assisting with those conversations, final delivery of long term societal climate action would remain unachievable. Thank you again for your leadership and vision in crafting this remarkable campaign to bring all of higher education together. The plan that follows details how the University of Colorado at Boulder will do its part in this visionary work.

Sincerely,

Frank W. Bruno
Vice Chancellor for Administration

University of Colorado at Boulder

Carbon Neutrality Working Group
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August, 2009

Frank Bruno, Vice Chancellor for Administration
University of Colorado at Boulder
24 UCB
Boulder, Colorado, 80339

Dear Vice Chancellor Bruno,

The Carbon Neutrality Working Group is honored to have been given the opportunity to contribute to the historic climate action efforts being pursued by CU leadership. Accordingly, we are proud and excited to transmit this "Conceptual Plan for Carbon Neutrality at the University of Colorado at Boulder."

While numerous current faculty, staff, students and community members contributed mightily to this effort, it would not have been possible without the collective legacy of leadership of the many CU and Boulder community members who have championed sustainability for decades before us.

Likewise, we are very appreciative of our team leaders who contributed countless additional hours to coordinating and refining data and information as this report took shape. Moe Tabrizi, Curt Huetson, John Morris, Ghita Carroll, Rob Hall, Casey Jones, and Erika Smith all deserve special recognition for their time and dedication.

Our student staff also committed valuable hours to this effort as well. Special thanks are deserved for Lisa Bingham, Brad Queen, Dan McGrath, Jessie Lucier, Celene Sheppard, Jacob Golding and Dan Omasta without whom this report would not have been completed.

The above students were also central to the preparation and testing of CU's own carbon emissions projection model, prepared in cooperation with the Boulder County Office of Sustainability. That model was later tested and affirmed by scientists at the National Renewable Energy Laboratory to whom we also own special thanks. The model underpins all the carbon analysis in this report and establishes a credible platform from which to launch CU's entire carbon neutrality effort. We are very appreciative of everyone's efforts on that pivotal element of this plan.

Many others also added value and insight to this effort; too numerous to all thank here but deeply appreciated nonetheless.

Finally, I personally appreciate the degree of professionalism and support from all members of the Vice Chancellors Office staff, particularly Robin Bryant, Kristin Epley, and Maureen Holland who worked tirelessly to facilitate meeting, revise documents, and shortcut roadblocks. Thanks to all.

Respectfully submitted,

Dave Newport

Dave Newport, Chair
Carbon Neutrality Working Group

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Contents

1 Executive Summary

As an original signatory to the American College and University Presidents Climate Commitment (ACUPCC) in 2007, the University of Colorado at Boulder formed the Carbon Neutrality Working Group (CNWG) and charged this group with analyzing and projecting a date by which the campus could attain carbon neutrality. Additionally, the group was charged with creating a plan and ensuring completion of a biannual greenhouse gas emission (GHG) inventory.

After nearly two years of work, the CNWG has recommended an overall short-term implementation approach, phasing in actions and activities over four time periods and implementing a list of projects designed to pursue carbon neutrality as soon as possible. These four time windows and their GHG reduction benchmarks (2005 baseline), with some overlap between the first two, are listed below:

- Governor's Executive Order Phase (2009–2012)
  - Goal: 20 percent energy, vehicle fuel, and materials reduction by 2012
- Phase 1, Conservation and Cogeneration (2010–2020)
  - Goal: 20 percent GHG reduction by 2020
- Phase 2, Large-Scale Renewables (2020–2030)
  - Goal: 50 percent GHG reduction by 2030
- Phase 3, Innovative Technologies (2030+)
  - Goal: 80 percent GHG reduction by 2050

The above phases and primary GHG emission reduction goals were informed by the literature and CNWG deliberations and then projected by a GHG emissions model developed by CU and reviewed by the National Renewable Energy Laboratory. The plan sets out challenging but achievable short term goals that will alter CU's carbon emissions trajectory towards a tangible neutrality point as soon as possible (see page 79). As the university implements these short term actions, long term carbon projections will be revisited.

Secondary GHG sources such as commuting and purchasing are seen as areas where CU can pursue a "beyond carbon neutrality" approach by working to reduce upstream and downstream GHG emissions that are not included in CU's inventory but are emitted into the atmosphere nonetheless.

Carbon Risk

Campus carbon neutrality planning efforts are based on understanding three types of risk associated with global climate change: direct risk from the direct impacts of climate change (e.g. drought, hotter climate, etc.); indirect risk from the impacts of potential mandatory caps on GHG emissions placed on energy suppliers and the increased costs of electricity and associated supplies; and market-related risk from changes in consumer preferences and the University's environmental reputation.

Carbon Footprint

The university's GHG emissions have grown on average 2.6 percent per year since 2005, and without mitigation are projected to further increase 1.3 percent per year through 2030. In FY 2008, the university's GHG emissions were 153,954 tons CO_2e or 4.5 metric tons CO_2e per full time equivalent (FTE) student.

Financial Analysis

The CNWG divided into project teams, organized by sector (including areas such as Energy Supply, Policy, and Behavioral Programs) and developed project proposals to reduce GHG emissions. Once drafted, proposals were subjected to a thorough evaluation by the Fiscal Team using the following assessment tools: financial analysis identifying project costs, cost avoidance, revenue generated, NPV and IRR; risk value determination; creation of a carbon estimate; identification of strategic opportunities; review of next steps; and detailing of critical success factors.

Funding Opportunities

Financing carbon neutral projects can be accomplished with dollars derived from internal and external sources or a mix of the two. Internal funding sources include campus units and/or central administration contributions, user fee charges, and loans from the university treasury. External funding includes local, state, and federal sources and private contributions that will remain available as the economic situation continues to stabilize. A hybrid funding mechanism could include using third party venture capitalists.

Current Campus Activities

Campus efforts to manage and measure success for sustainability goals both in the carbon neutrality plan and *Greening of the State Government* have created an unwieldy list of activities and projects. In June 2009, Vice Chancellor Frank Bruno formed campus Sustainability Action Teams – Data Collection, Energy and Water, Materials, and Recycling – and each group has begun to actively create plans and pursue efforts to meet stated goals. Additionally, these teams will disburse information about sustainability.

Furthermore, a faculty exploratory committee appointed by the Chancellor to advance the “Strengthening of Sustainability in the Curriculum” will help the university better address the growing need to fully integrate sustainability. The committee will assay the availability of campus resources, the promulgation of a campus-wide initiative to leverage campus resources beyond faculty, including a strong commitment to facilities, and by student and community partners.

Synergies

Three forces have come together to create great synergy and connection on campus – adoption of the Presidents Climate Commitment, *Flagship 2030*, and an update to the university’s master plan. Elements of each plan operate along similar timelines and provide goals that easily align creating a broad campus plan. Each plan works together to enhance the strength of the other two plans. Together, they create a very powerful synergy that allows us to connect, communicate and move forward with one plan while positively impacting and communicating about the other two plans.

Moving Forward

While the original intent of this analysis was to pinpoint a specific neutrality date, the CNWG instead believes that efforts must be focused on the next three to five years. Short-term conservation goals and activities are meant to rapidly alter the university’s trajectory towards carbon neutrality as soon as possible. The financial analysis of recommended projects indicates a positive cash flow position for these necessary investments.

This short-term focus also integrates ongoing efforts and creates an enhanced culture of sustainability and climate action that permeates campus life from residence halls to Regent Hall. The university’s strategic plan, master plan, academic plans, and community partnerships can maintain and consolidate the university’s position as a vanguard of the global academic community.

2 Introduction

"We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win."

President John F. Kennedy, 1962

The University of Colorado at Boulder is at the center of the climate action universe. The university's scientific and intellectual talent continues groundbreaking technical and policy advancements in energy and climate research and curriculum. CU's campus operations are recognized national and global sustainability leaders. CU's students have for 40 years led national green campus efforts.

Likewise, Colorado business and government leadership on renewable energy, conservation, and sustainable economic development has nurtured and advanced a robust New Energy Economy. City and county governments have developed game changing initiatives to improve climate action on local levels. Colorado voters have time and again voted in support of aggressive climate action agendas. Combined, this unique array of leadership assets and circumstances provides unrivaled capacity for CU to define the path to sustainable climate action that our civilization desperately needs.

Yet while these assets and circumstances provide CU with great opportunity, they evoke tremendous responsibility as well. CU is mindful of its role as a leader and of the need to make use of its strengths to address problems that the university is uniquely capable of resolving. With the onset of climate disruption already emerging globally, the university's assets and capacity for heightened leadership combine to create a simple but urgent argument for the need to act immediately.

The work described throughout this report documents CU's efforts to fulfill the American College and University Presidents Climate Commitment (ACUPCC[1]). These efforts began as a mathematical exercise to calculate a date by which the university could attain definitional carbon neutrality[2]. A Carbon Neutrality Working Group (CNWG) was created in 2007 and charged with creating an analysis[3] to determine a date for neutrality and formulate a list of projects necessary to accomplish this goal.

Quickly, the focus of staff, faculty and students involved in this analysis turned to implementing rapid and ambitious short-term actions. CU's administrative leadership team listened to these requests for commitment and took immediate action. Existing programs were redefined or retooled to address this compelling responsibility.

[1] From ACUPCC Commitment. http://www.presidentsclimatecommitment.org/html/commitment.php
[2] Carbon neutrality is defined as "no net emissions of green house gases (GHGs)."
[3] The analysis was performed by the CU Carbon Neutrality Working Group (CNWG) during the period September 2007 to May 2009

Before completion of this plan in June 2009, the Vice Chancellor for Administration organized and launched an aggressive three-year, campus-wide campaign to dramatically reduce CU's energy and carbon emissions footprint. Student government pledged and funded the nation's first student-led carbon neutrality effort. Additionally, the Chancellor has asked faculty leaders for a blueprint that will enhance existing climate and sustainability literacy and will propose additions across the breadth of the curriculum.

To date, the outcome of the original charge has been to identify synergies between a variety of planning processes and documents and to create bridges and opportunities that did not previously exist. These plans can help the university cut emissions, save money, hedge risk, enhance community standing and partnerships, leverage the success of the university's strategic plans, enable economic development and job creation opportunities, and address emerging challenges related to the social impacts of climate change.

In addition to creating bridges, using this broader approach has allowed the university to view its resource supply as an opportunity to foster leadership "beyond carbon neutrality."[4] "It takes two to emit carbon,"[5] and with this perspective, CU can vigorously pursue upstream and downstream carbon reductions in its supply chain. These actions won't directly benefit CU's carbon emissions inventory. Instead, they will forge leadership pathways for the university and our nation. CU's leadership role in research provides a recognition and understanding of broader carbon emissions drivers and associated mitigation protocols. The university's efforts will also boost climate literacy and create new research and service opportunities.

The ACUPCC commitment has spawned great creativity and synergy among members of the campus community. This commitment has facilitated conversation and an outcome that has elevated the best and positive talents among its participants. Because of this vision, the scope and synergy of the recommendations in this plan are far-reaching and profound.

The plan's carbon modeling and associated recommendations clearly identify inaction as the primary negative outcome. Ongoing work and recommended efforts benefit the university in the short and long term. Work has already commenced on many fronts that will well serve the university and the broader global community; however, many opportunities will yet emerge. With the energy, spirit, creativity, learning, research and action this plan will spawn, CU affirm our ability to win—in this case, a more challenging victory than merely going to the Moon.

[4] From "Beyond Neutrality: Moving Your Company Toward Climate Leadership," Business for Social Responsibility, October 2007, www.bsr.org

[5] Ibid.

3 Hedging Carbon Risk

3.1 Costs and Impacts from Three Types of Carbon Risk

The context of CU's carbon neutrality planning effort is based on an understanding of the carbon risks CU faces. In other words, before mitigation efforts can be fully evaluated, the direct effects on CU as a result of climate change and/or simply maintaining traditional mitigation efforts must be understood.

CU faces at least three types of risk associated with global climate change that may influence the development and execution of CU's Climate Action Plan. Types of Carbon Risk are:

Direct risk: These result from the direct impacts of climate change on the university and surrounding communities (e.g. drought, hotter climate etc). CU may face direct risks such as impacts on water supplies, irrigation and potable water costs. Drought scenarios for Colorado are seen as likely; however, the impact on water costs is unclear. Likewise, increased temperatures and longer summers forecast for Colorado may increase CU's cooling costs. These potential direct impacts are summarized in Table 1.

Table 1: Change in Colorado River Basin Temperature, Precipitation, and Snowpack, 1976 to 2085[6]

Major River Basins in Colorado	**Winter Temperature** Degrees Celsius			**Precipitation** Centimeters/year			**Snowpack** (cm) of Snow Water Equivalence on April 1		
	1976	2085	Change (degrees Celsius)	1976	2085	Change (percent)	1976	2085	Change (percent)
Arkansas-White-Red	-0.7	4.4	+5.1	42	40	-5	4.3	2.0	-53
Upper Colorado	-5.7	-0.3	+5.3	39	41	+6	8.8	4.1	-53

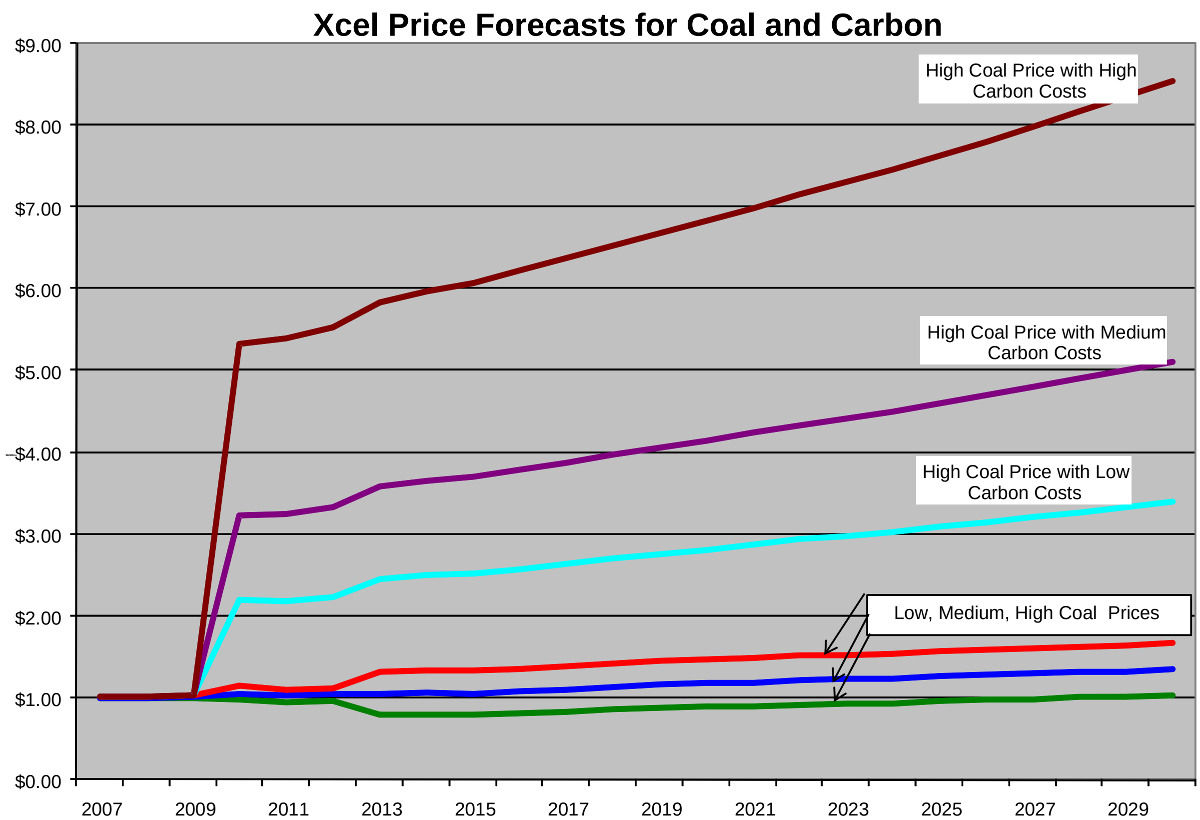
Table 1 shows projected precipitation and temperature changes in Colorado's two major river basins, the Arkansas and Colorado basins, that appear to project major challenges to Front Range populations—and CU.

[6] Hecox, Walter, et al (2007), *The 2007 State of the Rockies Report Card*, Colorado College,

Indirect risk: CU must contemplate impacts from potential mandatory caps on GHG emissions placed on energy suppliers and the increased costs of electricity and supplies that may result from these caps. These costs may be passed along to CU. Xcel Energy has projected a range of carbon costs through 2030 that could be levied as a result of potential federal legislation.

The impact on CU's energy costs range from marginal to significant across the range of estimates. Given that CU currently purchases most of its electricity from Xcel, these impacts are important to watch and perhaps integrate into planning and analysis. Xcel has predicted the future costs of coal, along with a range of carbon costs that could price up coal as seen in Figure 1.

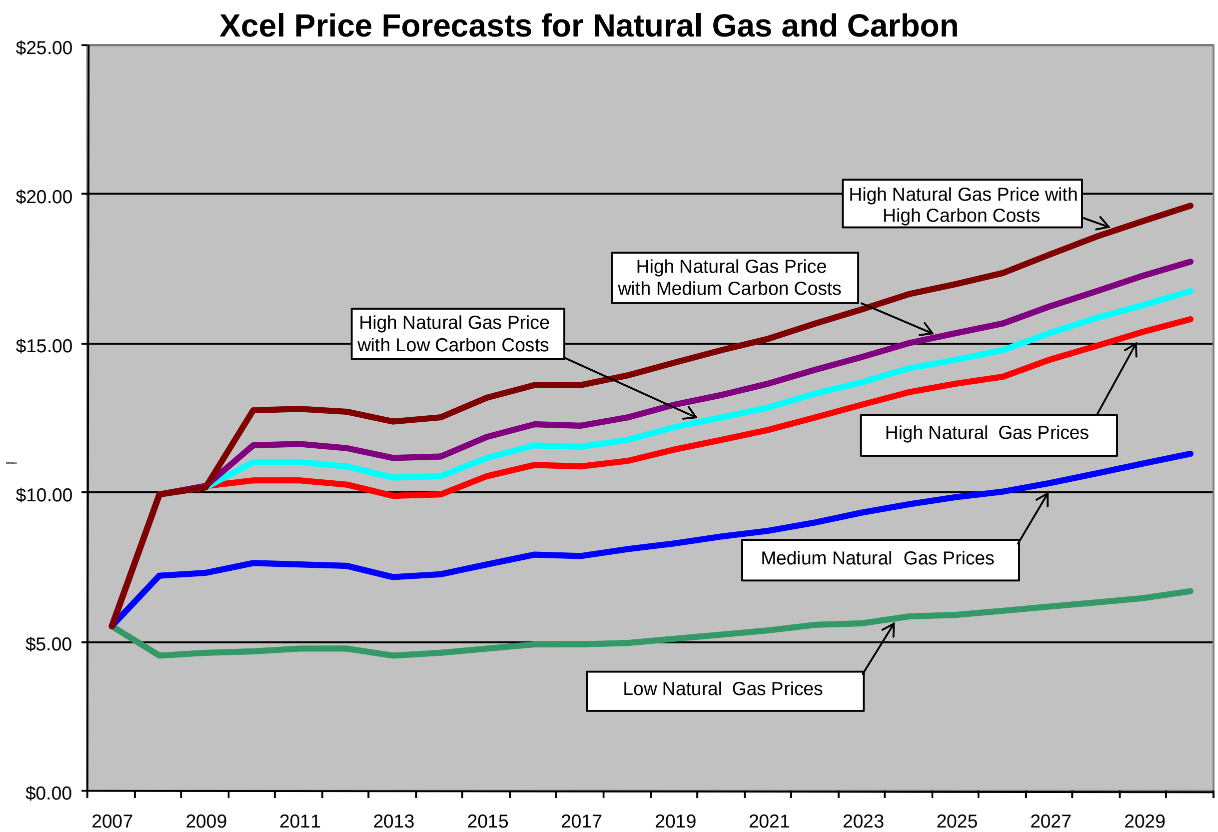
Figure 1: Xcel Energy Price Forecasts for Coal and Carbon



In order to present conservatively evaluated mitigation strategies to hedge this risk, the financial analysis detailed later in this report did not overlay potential carbon prices seen above on a project-specific basis [see page 33]. Instead, each mitigation project is financially evaluated by traditional measures.

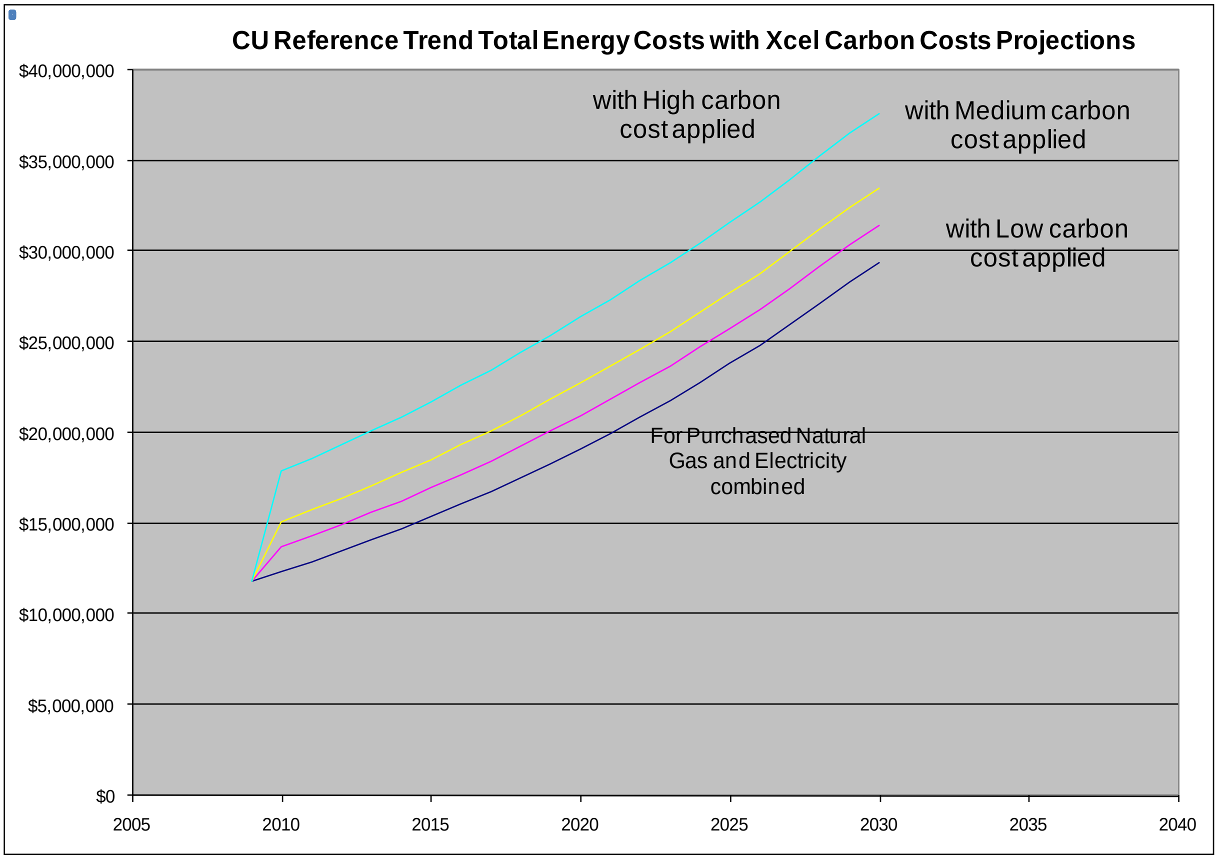
Similar natural gas and carbon price prediction were also prepared by Xcel Energy:

Figure 2: Xcel Energy Price Forecasts for Natural Gas and Carbon



The aggregate influences of future potential carbon costs on CU's total energy bill are seen in Figure 3. This projection shows CU's projected total energy costs and low, medium and high carbon costs in a scenario where CU maintains historic building and energy conservation practices and does not implement the recommendations in this report. The resulting Reference Trend Energy Cost Estimates are calculated from Xcel Energy's carbon costs sensitivity analysis and projected CU energy usage.

Figure 3: CU GHG Emissions Reference Trend Carbon Risk Estimates (2010-2030)[7]



It is important to note that Figure 3 shows estimated total energy costs if CU's carbon emissions follow the Reference Trend (unmitigated) trajectory. Increased costs are projected as a result of potential state or federal carbon-reduction legislation. These data do not include adjustments for inflation. Likewise, the prices seen in Figure 3 could vary significantly with the price of natural gas, which has shown some volatility in recent years but is currently relatively inexpensive. While purchase price of fuels may move the combined costs projections up or down the graph, the carbon costs are seen as a fixed adder, unaffected by energy market fluctuations.

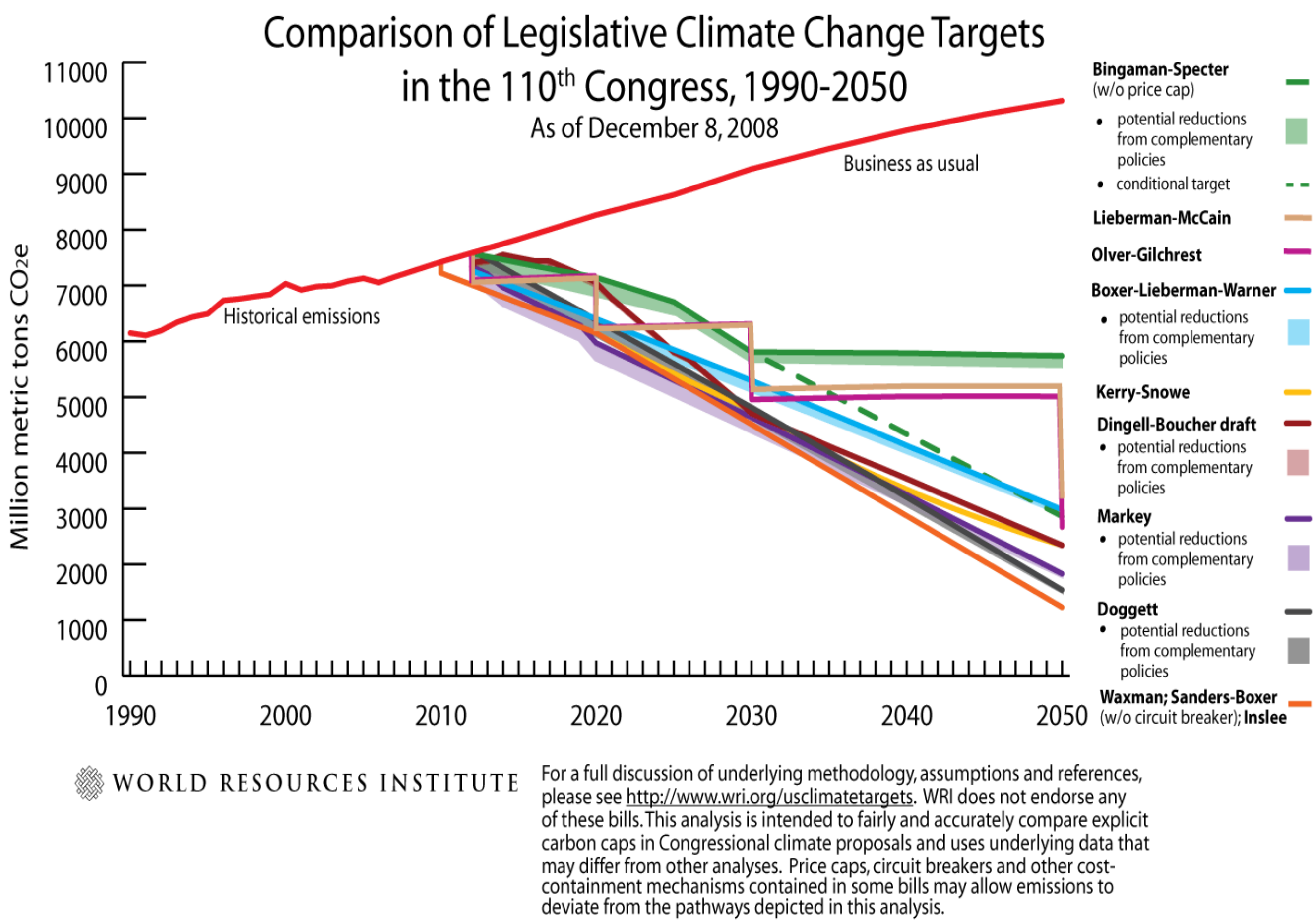
Just as carbon prices could be passed along to CU in the form of higher energy bills, increased energy costs for CU's suppliers may increase the cost of producing goods and services purchased by CU. These costs may also be passed along to CU.

The likelihood of federal legislation that may induce carbon pricing is unknown; although, the recent approval of a cap and trade bill in the US House of Representatives increases the likelihood that carbon pricing will at some point impact CU.

[7] Calculated from projected CU electrical consumption versus predicted carbon prices from Xcel Energy's *2007 Colorado Resource Plan*, Table 2.2-3, 2007 "CRP CO2 Price Scenarios (Prices in nominal dollars)," Volume 2 Technical Analysis, pp2-30

Irrespective of the outcome of 2009 federal legislation, it is reasonably foreseeable that some form of carbon legislation will be approved either in 2009 or subsequent years. A look at current federal legislation and its affect on regulatory carbon emissions seems to indicate that something resembling the projections in Figure 4 will eventually become law.

Figure 4: Economy-wide Cap-and-Trade Proposals in the 110th Congress [8]



[8] Pew Climate Center. (2008). *Economy-wide Cap-and-Trade Proposals in the 110th Congress.* http://www.pewclimate.org/docUploads/110thCapTradeProposals10-15-08.pdf, Retrieved October 3, 2008

Market-related risk: This form of carbon risk is a result of changes in consumer preferences and reputational assets related to how an organization or market is perceived to respond to changing societal expectations. For instance, as public and political pressure for action on climate change grows, the perception of CU by key stakeholders could change depending on CU's activities. Significantly, CU is currently seen as a national leader in climate action; however, any diminution of efforts could undercut that perception. Table 2 summarizes CU's carbon emissions intensity position as compared to selected campuses.

Table 2: 2007 GHG Intensities at Selected Institutions (Scopes 1 & 2)

Campus	*GHG Emissions per FTE Student (Metric Tons CO_2e)**	*GHG Emissions per 1,000 sq. ft. (Metric Tons CO_2e)**	*Percent Offset (percent)*	*FTE Enrollment*
University of North Carolina- Chapel Hill	20.9	30.9	0.0	25,895
Oberlin College	17.5	18.2	0.0	2,744
Georgia Tech	16.5	23.4	0.0	18,742
University of Pennsylvania	15.1	25.1	35.2	19,816
Cornell University	13.3	17.7	4.2	19,800
University of Arkansas	9.7	27.1	0.0	14,939
University of Maryland at College Park	8.6	27.7	0.0	32,467
UCLA	8.1	10.3	0.0	35,612
University of Florida	7.8	21.1	0.0	47,178
UC-Denver	7.7	20.9	0.0	15,321
Colorado State University	7.1	22.9	0.0	24,700
Oregon State University	7.0	18.7	0.9	18,793
University of New Mexico	5.7	17.7	0.0	20,559
UC-Berkeley	4.8	10.3	0.0	33,948
University of Colorado at Boulder	**4.5**	**14.4**	**4.1**	**29,998**
Arizona State University	4.4	25.0	0.0	63,278
University of Vermont	4.0	9.1	0.0	10.956
University of Montana	2.7	7.7	0.0	11,186
Portland State University	2.3	7.2	0.0	14,971

4 CU's Carbon Footprint

4.1 Three Types of Carbon Emissions

While international convention identifies six different gases as greenhouse gases, for the purposes of this planning effort only carbon dioxide (CO_2) is included, as it comprises 98.7 percent of CU's direct emissions. Any of the other gases are considered *de minimis*.

CO_2 is released from three different categories of emission sources. Under international convention, these categories are parsed as described in Table 5.

Table 3: Types and Characteristics of GHG Emissions

Category	*Sources*	*Ownership of the Carbon Emitted*	*Control of the Emission*	*Options for Direct Mitigation*
Scope 1	CU's vehicle fleet, natural gas burned to create steam heat, chilled water, and/or electricity on-campus in CU-owned facilities	CU	Direct	1. Conservation 2. Efficiency 3. Fuel switching to renewable sources 4. Offsets
Scope 2	Electricity or heat purchased from a third party such as Xcel Energy	Third party	Indirect	1. Conservation 2. Efficiency 3. Fuel switching to renewables sources 4. Offsets
Scope 3	Faculty/staff/student commuting, university-paid jet travel, agricultural emissions, waste disposal emissions, embedded emissions from purchased goods and/or services, etc	Third party	Third party	1. Limited conservation & efficiency options 2. Offsets

4.2 *Inventory*

From a carbon emissions perspective, the challenge faced by the University of Colorado at Boulder is to reverse the course of history—and early data indicate that goal is within our grasp. However, CU's GHG emissions have grown on average 2.6 percent per year since 2005, and are projected to further increase 1.3 percent per year through 2030 absent the aggressive response outlined in this plan. CU's total greenhouse gas emissions from Scope 1 and 2 sources during the Fiscal Year 2007-2008 was 153,954 Tons CO_2e (carbon dioxide emitted), roughly equal to the yearly total emissions from about 8,100 US households.

Table 4: CU GHG Emission Trends

Year	Short Tons CO_{2e}	Percent Change	Campus Gross Square Feet	Percent Change	Pounds CO_{2e}/ Square Foot	Percent Change
2005	142,602	–	8,648,728	–	32.98	–
2008	153,954	7.96	9,685,160	11.98	31.79	-3.59

While campus growth and changes in energy sourcing have led to recent emissions increases, CU has shown the ability to abate emissions where they have been a focus. While the campus physical plant has grown by nearly 12 percent since 2005, total emissions per square foot have dropped more than three percent during the same period.

This intensity reduction is the direct result of constructing and renovating buildings to greener building standards. When comparing CU's new LEED-Gold buildings with average buildings on campus, energy reductions are about 24 percent for electricity, 74 percent for steam, and 35 percent for chilled water[9]. Comparable carbon and cost savings attend these dramatic energy reductions.

Table 5: Wolf Law Building vs. Average Campus Building Utility Intensities, 2008

	Usage per Square Foot	Campus Avg. for Same Size Building	Unit	Percent Lower than Campus Average
Electricity	9.74	12.9	kWh/ft^2	24
Steam	16.43	62.08	lbs/ft^2	74
Potable Water	20.72	31.94	gal/ft^2	35

CU has compiled its inventory of Green House Gas (GHG) emission sources and quantities according to the accepted "GHG Protocol" methodology published by the World Resources Council and the World Business Council for Sustainable Development[10].

[9] Tabrizi, Moe, "Campus Resource Conservation Progress Report," February 2009, PowerPoint presentation, Slide 26, http://ecenter.colorado.edu/envs4100

[10] Greenhouse Gas Protocol. (2009). The Greenhouse Gas Protocol Initiative. Available online at: http://www.ghgprotocol.org/

Figure 5: CU GHG Emissions, All Sources, 2007–2008

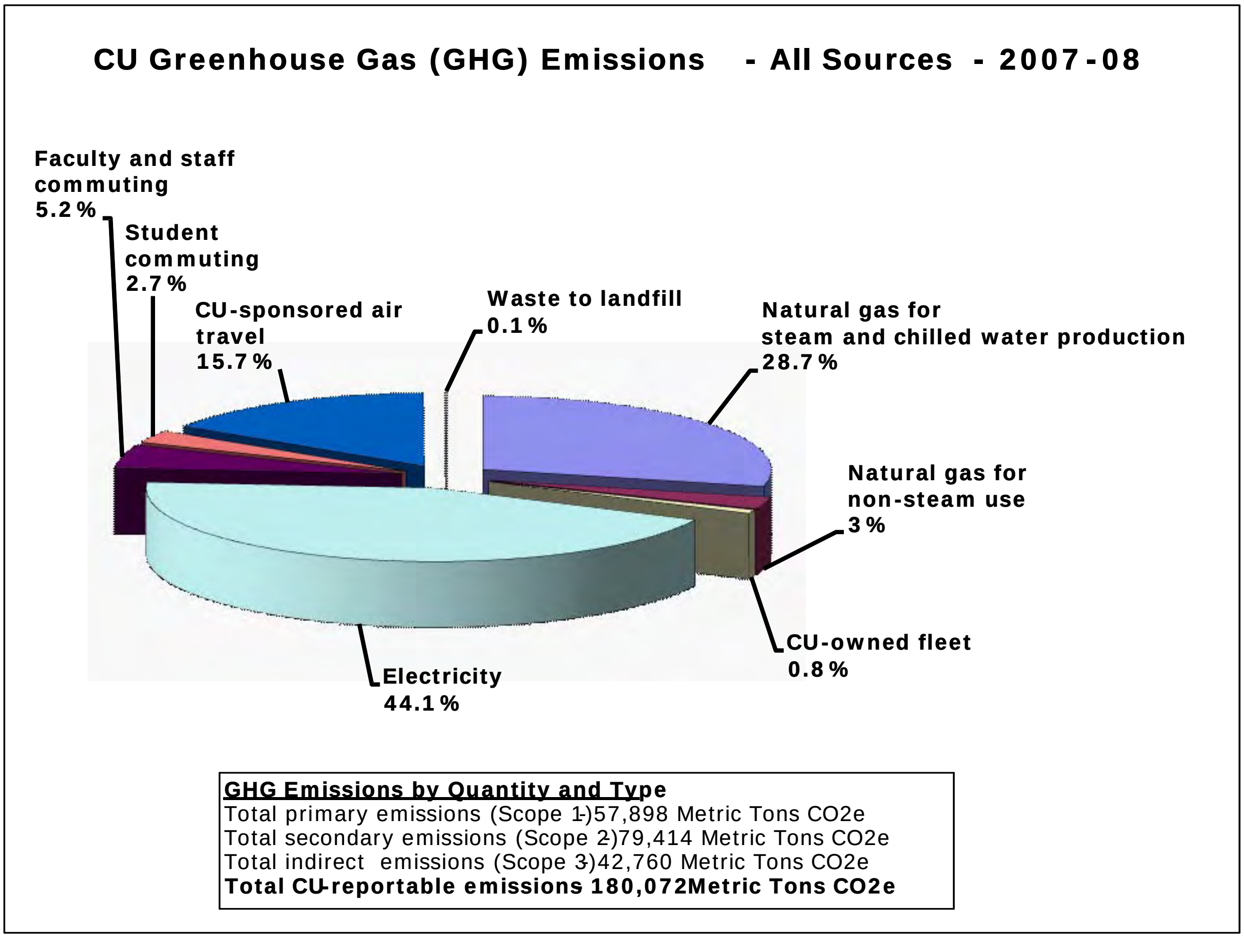


Figure 6: CU Scope 1 & 2 Emissions FY 2008

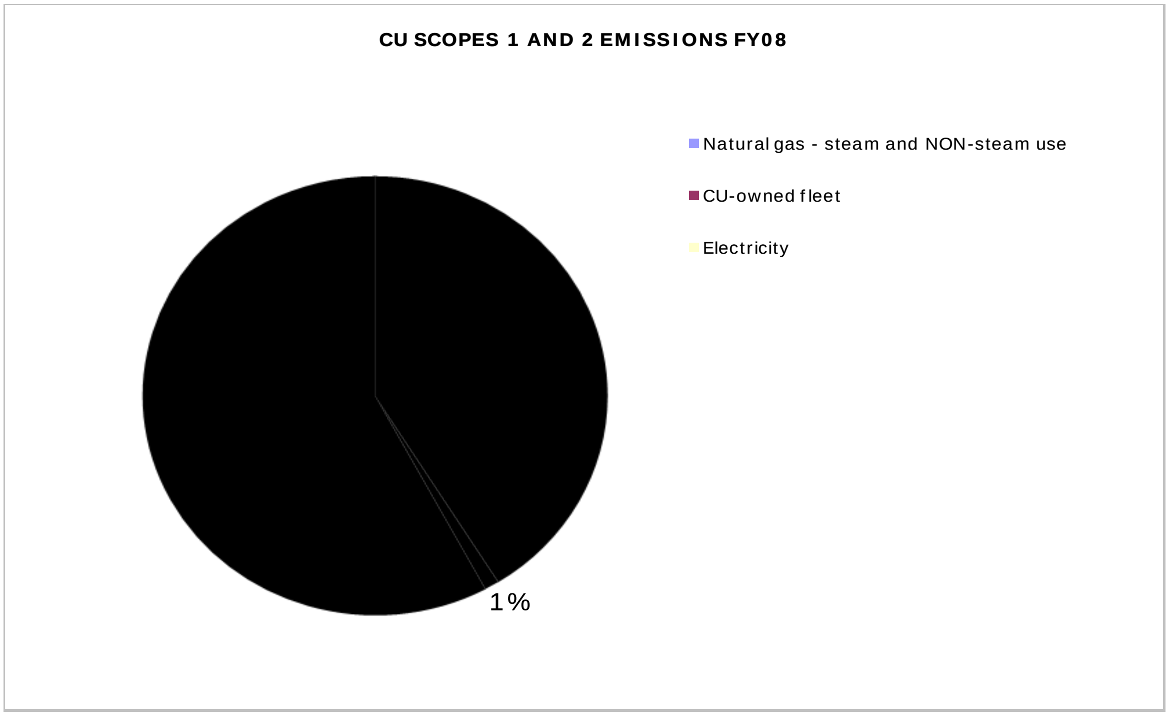
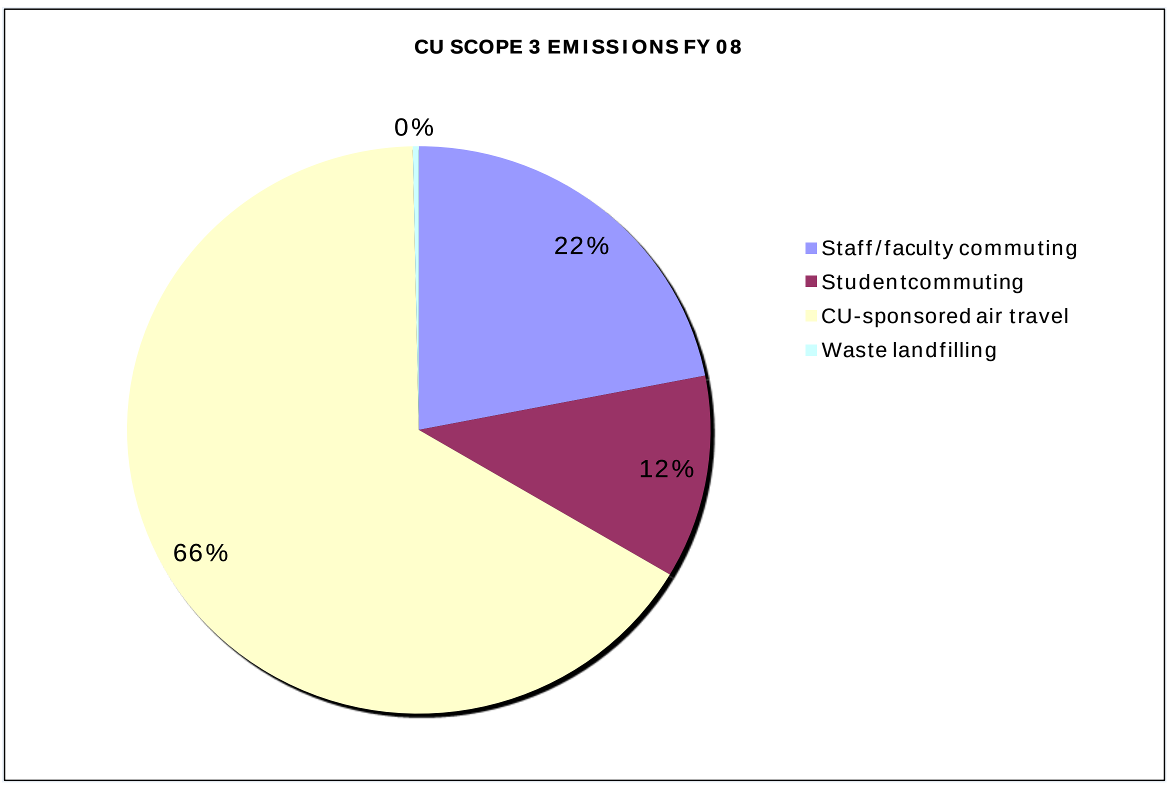


Figure 7: CU Scope 3 Emissions FY 2008

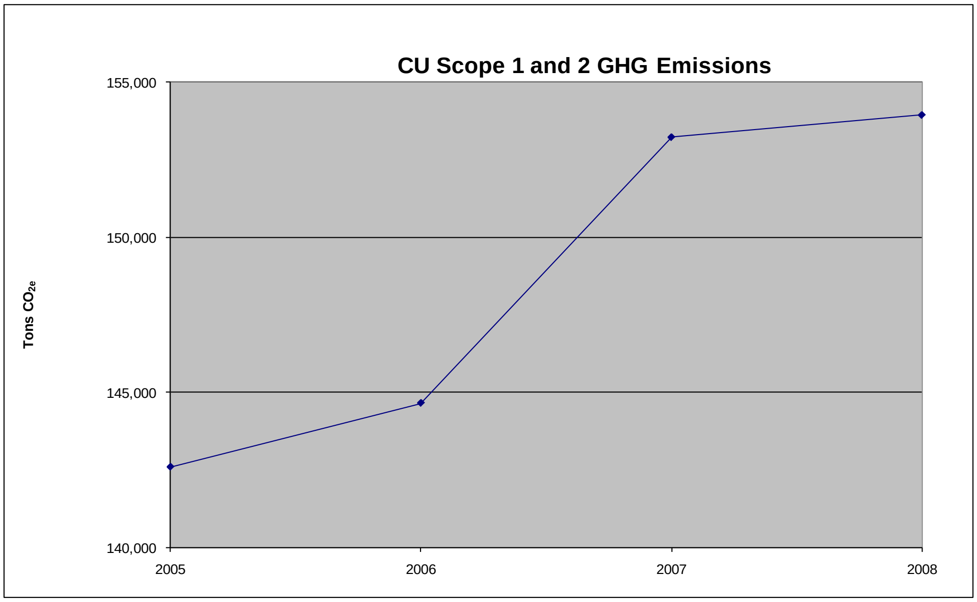


The relative proportions of CU's GHG emission sources are consistent with typical campus GHG emission profiles at similar institutions of higher education nationwide.

CU's GHG emissions per student are 4.5 metric tons of CO_2e per full time equivalent (FTE) student (see Table 2). Likewise, CU's per square foot GHG emission intensity is lower than some similar campuses. While some context can be seen in these data, caution should be observed as the data are not corrected for seasonal conditions or variations in the types of facility use, among other factors. The ACUPCC does not require the data be reported in that manner.

CU's 2008 GHG emissions are 7.96 percent higher than the 2005 reference year. Growth in the campus physical plant of 11.9 percent combined with a transition away from a natural-gas fired, on-campus cogeneration system account for the growth in emissions from the reference year.

Figure 8: CU Scope 1 &2 GHG Emissions (2005-2008)



4.3 *Carbon Emissions Trend Projection*

4.3.1 CU's Reference Trend

In order to evaluate new opportunities to reduce campus GHG emissions, a projection of CU's GHG baseline must first be estimated as a Reference Trend. This evaluation answers the question: "If CU continues on with current growth and conservation practices without doing anything differently, what is the likely GHG emissions trend?"

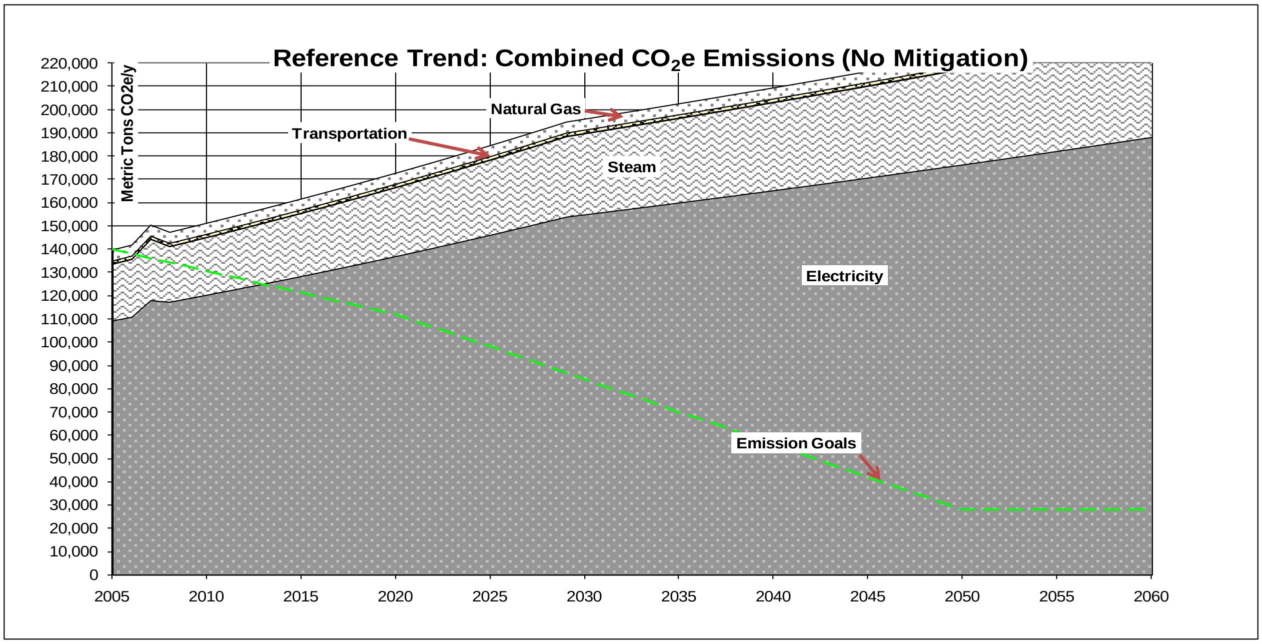
The Carbon Neutrality Working Group (CNWG) found that four ongoing influences temper the rise in GHG emissions that would normally be expected from the addition of new facilities to the campus and increased enrollment as projected in CU's strategic plan, *Flagship 2030*. These influences include:

1) A gradual "greening" of the electricity purchased from Xcel Energy as the utility adds more renewable energy sources to its portfolio over the coming decades
2) A continued reduction in per square foot energy consumption as a result of CU's ongoing energy conservation programs in existing facilities
3) A continued reduction in per square foot energy consumption as a result of expected enhancements in green building standards that would decrease the energy load of new and renovated facilities

4) A continued decrease in campus fleet fossil fuel usage as the fleet continues to become more efficient and smaller

Notwithstanding these mitigating forces, the continued growth of the campus and increased per capita energy consumption result in robust continued growth in campus GHG emissions if left unchecked.

Figure 9: CU GHG Emissions Reference Trend (Without Mitigation)



4.4 Carbon Mitigation Plans

4.4.1 Carbon Model, Scope 1 and 2

The predictive GHG Emissions model used in this analysis (See Appendix 9) is a composite of historical emissions inventory data and future projections. The model was used to project Scope 1 and 2 emissions only. All emissions are represented in equivalent short tons of carbon dioxide (Tons CO_2e).

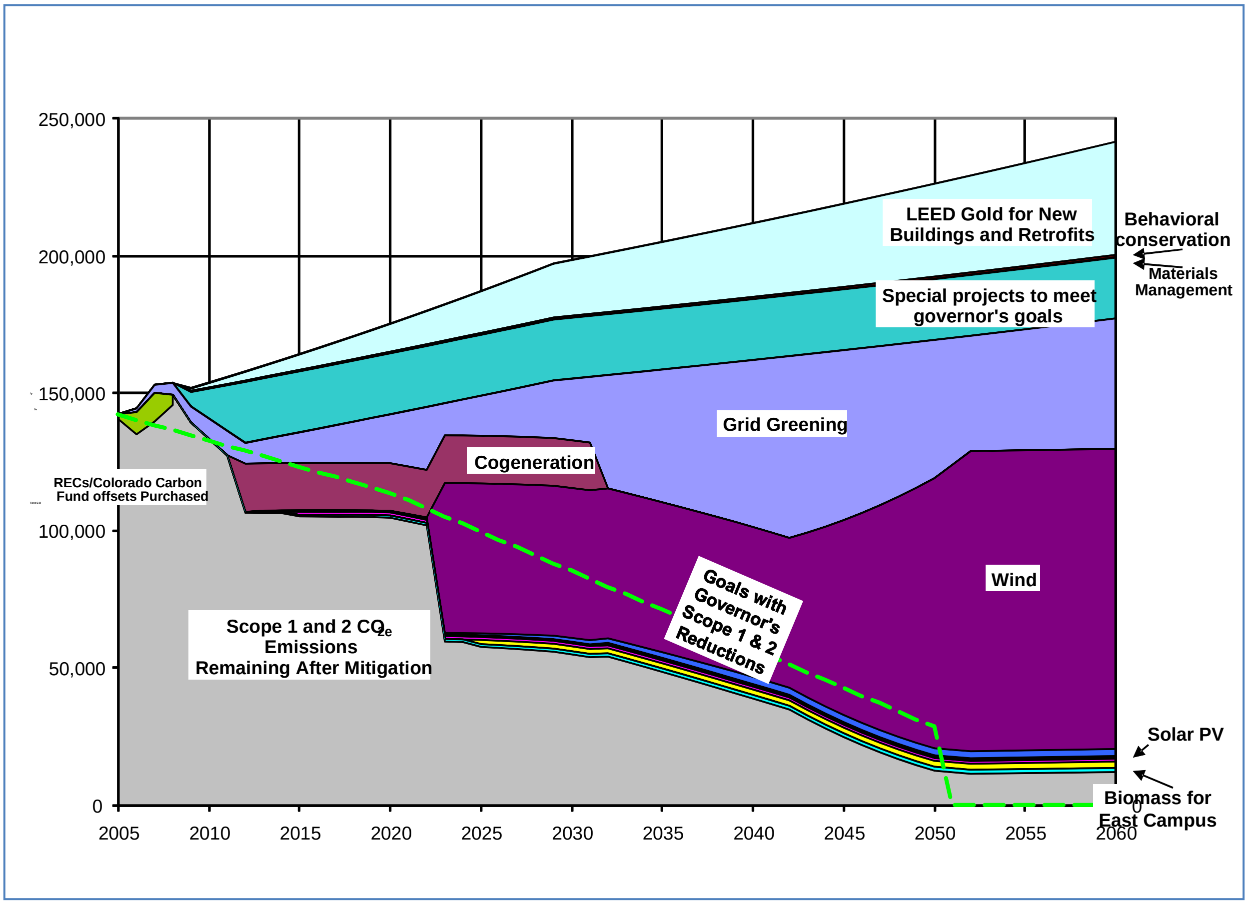
Future emission trends are based on predictions of campus facility growth (square feet) as it relates to projected energy intensity (e.g. kilowatt hours/square foot), the carbon quality of the energy supplies (CO_2 emission factors from EPA, Xcel Energy and historical trends), the effect of projected improvements in building codes, and long term estimates of the influence of emerging technologies on the availability of renewable energy supplies and other utility-scale technological innovations. After compiling these data, the model was organized to allow it to be queried on the effectiveness of various mitigation options.

The model was then subjected to testing for logic, validity of assumptions, and arithmetic rigor by the National Renewable Energy Laboratory in Golden, Colorado. The results of their review were positive with some minor technical comments and corrections suggested. (See Appendix 2)

In the model, energy supplies (electricity and steam) are separated into separate worksheets and balance the energy demand as projected on the "Building Energy Use" sheet. Projects to mitigate emissions are then listed on the worksheet where the projects occur; energy supply in the case of renewable generation technologies and building energy use in the case of LEED construction and retrofit standards.

Model results are depicted in two graphs. The goals from the Governor's Executive Order for reductions in on-site energy use are depicted as a dotted line in both graphs. All emission growth and mitigation wedges are driven by parameters controlled via the worksheet "Parameters & Assumptions."

Figure 10: CU GHG Projected Scopes 1 & 2 Emissions with Mitigation



4.4.2 Phasing

Planning of CU's carbon neutrality approach was divided into three temporal phases with disparate levels of certainty and strategic approach. However, for the purposes of emphasizing the importance of short-term implementation, an additional three year phase is set out as the kick off of Phase 1: the Governor's Executive Order Phase (2009–2012). Accordingly, the phasing of the plan is:

- Governor's Executive Order Phase (2009–2012): This period is characterized by the robust and aggressive pursuit of The Greening of State Government goals detailed in Colorado Governor Bill Ritter Executive Order. Implementation efforts are being spearheaded by the Sustainability Action Teams charged by the Vice Chancellor of Administration in June 2009. The challenge is to by 2012 attain the following goals as compared to a 2005 baseline:

  - 20 percent energy intensity reduction
  - 20 percent reduction of paper consumption
  - 10 percent reduction in water consumption
  - 25 percent volumetric reduction in petroleum fuel use
  - A "zero-waste" goal for all construction projects and the operations of all facilities.

- Phase 1 (2010–2020), Conservation and Cogeneration: This phase emphasizes robust conservation and cogeneration projects and programs in order to drive down CU's costs, risk, and fossil energy use. This phase benefits from the greatest level of certainty and the most credible planning data. CU has an overall goal of:

  - 20 percent reduction in GHG emissions by 2020

- Phase 2 (2020–2030), Large-Scale Renewables: The phase relies on the emergence and increased emphasis on utility-scale, renewable energy projects such as wind and solar generation. A moderate confidence level attends this phase. This phase is defined by:

  - 50 percent reduction in GHG emissions by 2030

- Phase 3 (2030+), Innovative Technologies: This phase attempts to credibly foresee the emergence of breakthrough technologies and strategic developments that could shape enhanced carbon mitigation opportunities. While difficult to predict post 2030 circumstances, a conservative approach to these external developments characterizes this scenario. Depending on how strongly CU can embrace post-2030 developments, various carbon neutrality dates could be targeted. This phase centers on:

  - 80 percent reduction in GHG emissions by 2050

4.4.3 Governor's Executive Order

The first three years of plan implementation are crucial to achieving long term success and short term cost savings. Accordingly, CU can kick off its heightened carbon neutrality plan with a three year campus wide sprint to meet The Greening of State Government goals set out by Colorado Governor Bill Ritter's Executive Order. These goals pair nicely with CU's carbon neutrality initiative by focusing on a robust short term implementation process.

The following table summarizes the performance benchmarks that must be met to achieve this goal.

Table 6: Governor's Executive Order Goals and Benchmarks

			Estimated Annual Reduction Targets			
	2005 Baseline	**2012 Goals (percent)**	**2009**	**2010**	**2011**	**2012**
Electricity kWh/sf/yr	13.11	-20	12.24	11.63	11.04	10.49
Steam klb/sf/yr	0.068	-20	0.060	0.058	0.056	0.055
Chilled Water ton-hr/sf/yr	3.31	-20	2.74	2.71	2.68	2.65
Water* gal/sf/yr	35.81	-10	31.30	30.68	30.06	29.46
Petroleum gal/yr	103,043	-25	95,830	89,647	83,465	77,282
Paper cases/yr	15,000	-20	14,186	13,416	12,688	12,000

*** Water** reduction goals have been achieved. In 2008, water use had been reduced to 31.94 gal/sf/yr, and an additional 2 percent reduction per year is projected through 2012.

4.4.3.1 Sustainability Action Teams

To implement the projects and programs necessary to attain the goals of this phase, the Vice Chancellor for Administration (VCA) in June 2009 assembled Sustainability Action Teams (SATs) comprised of faculty, staff, and students. The teams are charged with creating efficiencies needed to meet these goals, implementing programs and projects, and monitoring results.

Teams will coordinate the short term work along with ongoing carbon neutrality plan implementation which include:

- Vehicle petroleum reduction – pursue the Governor's 25 percent volumetric fuel reduction goal
- Material, paper reduction and waste management – pursue the Governor's 20 percent paper reduction goal and develop plans for a campus wide Zero-Waste system.
    - This team is separated into two sub-teams; one for materials reduction planning and one for Zero-Waste system planning.
- Energy and water conservation – pursue the Governor's 20 percent energy reduction goal and 10 percent water reduction goal
- Centralizing data and reporting metrics – develop uniform and centralized data gathering and reporting efforts for the campus
- Carbon Neutrality Working Group – coordinate overall implementation of ongoing carbon mitigation activities

Teams have been challenged to identify short-term, high impact projects and develop them. Teams will meet separately on an ongoing basis and each quarter as a group. Metrics quantifying movement toward these goals will be consolidated and reported quarterly. Team members were allowed by the VCA to prioritize the activities high on work plans. Funding for project implementation is being developed by the VCA's office. A communications plan for the broader campus is being developed and coordinated.

With the implementation of the projects and programs envisioned by the SATs, an estimated 22,121 tons CO2e can be cut from CU's emissions, about a 5.2 percent reduction of Scope 1 and 2 sources. This will, along with CU's ongoing efforts and continued greening of the Xcel electricity grid, significantly alter CU's GHG emissions trajectory toward a more robust downward slope while saving costs and hedging carbon risks.

4.4.4 Phase 1: Conservation and Efficiency

Between 2009 and 2020, enhanced conservation projects and programs combined with increased on-campus electric and heat generation should produce a net GHG emissions decrease of about 23 percent. These potential projects include a base-load cogeneration system for the central heat plant, a transition to a biomass-fired boiler at Williams Village, a robust behavioral conservation campaign, enhanced ad hoc conservation infrastructure in existing buildings, a transition to LEED Gold Plus building standards for new and renovated facilities—and the anticipation that green building standards will continue to be improved every three years.

An interim benchmark aligned with the Governor's Executive Order goal of a 20 percent energy reduction by 2012 helps drive aggressive conservation programs, kick off CU's carbon neutrality effort, and show leadership and coordination with state climate and energy policies.

It is important to note that CU is aggressively pursuing the installation of and/or direct connection to utility-scale renewables during this phase. However, under the restrictions of the "lease to own" financial arrangements commonly used to fund and implement these systems, CU cannot count the carbon reductions until ownership of the equipment flips to the university in seven to ten years.

Table 7: Phase 1 Mitigation Projects- Timeline and Carbon Reductions

Phase 1: Mitigation Projects Timeline and Carbon Reductions											
	Tons CO_{2e}/y (1000s)										
Projects	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
University Emissions Prior to Mitigation	154.2	156.2	158.3	160.4	162.5	164.6	166.8	168.9	171.2	173.4	175.7
Cogeneration			17.6	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3
Wind *											
Solar Thermal											
Solar PV *											0.1
Grid Changes	7.3	8.8	7.5	8.7	9.9	11.1	12.4	13.7	15.0	16.4	17.7
LEED Gold Plus	1.5	2.3	3.1	3.9	4.7	5.5	6.4	7.3	8.2	9.1	10.0
Behavioral Campaign	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Materials Management	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Energy Reduction Projects	10.8	16.5	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1
Replace Main Boilers				0.4	0.4	-0.4	0.4	-0.4	0.4	0.4	0.4
Biomass – Williams Village						1.2	1.2	1.2	1.2	1.2	1.2
Biomass – East Campus											
Transportation Reduction	-0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.8
Carbon Offset Purchases											
University Emissions After Mitigation	126.2	118.6	99.2	97.9	96.7	94.3	92.9	91.6	90.2	88.7	87.1

* Carbon reductions from lease to own renewables cannot be counted until ownership reverts to the university.

4.4.5 Phase 2: Large Scale Renewables

Phase 2 reductions are a result of the gradual increase of CU-affiliated large-scale wind energy projects such as the CU/CSU wind energy project. These projects, while at presently nascent, are being actively developed. Given that some funding models defer the transfer of wind energy credits, GHG reductions from these types of projects are not anticipated until Phase 2 even though CU could begin receiving some "green" electricity during Phase 1. An East Campus biomass district heat plant and an increasingly "green" Xcel Energy grid also contribute to projected GHG reductions.

Table 8: Phase 2 Mitigation Projects- Timeline and Carbon Reduction

Phase 2 Mitigation Projects Timeline and Carbon Reductions	Tons CO_{2e}/y (1000s)										
Projects	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
University Emissions Prior to Mitigation	175.7	178.0	180.3	182.7	185.1	187.5	190.0	192.5	195.0	197.5	198.8
Cogeneration	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3
Wind *				54.6	54.6	54.6	54.6	-54.6	54.6	54.6	54.6
Solar Thermal											
Solar PV *	0.1	0.3	0.4	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.5
Grid Changes	17.7	20.2	22.8	11.6	13.0	14.5	16.0	17.5	19.2	20.8	22.3
LEED Gold Plus	10.1	11.0	12.0	13.0	14.0	15.1	16.2	17.3	18.4	19.5	20.2
Behavioral Campaign	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Materials Management	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Energy Reduction Projects	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1
Replace Main Boilers	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Biomass – Williams Village	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Biomass – East Campus						1.5	1.6	1.6	1.7	1.8	1.8
Transportation Reduction	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.2
Carbon Offset Purchases											
University Emissions After Mitigation	87.1	83.2	79.3	48.1	46.5	43.3	41.4	39.4	37.4	35.2	32.7

* Carbon reductions from lease to own renewables cannot be counted until ownership reverts to the university.

4.4.6 Phase 3: Innovative Technologies

Phase 3 efforts include the continuation of programs from earlier phases, as well as the emergence of reasonably plausible technologies, including carbon capture and storage sequestration technologies (CCS), a small amount of nuclear energy, and the continued growth of on grid-renewables such as wind and solar. Another Phase 3 option for campus heating may result from the building conversion of steam to hot water system that enables more robust renewable energy technologies.

Table 9: Phase 3 Projects- Timeline and Carbon Reduction

Phase 3 Mitigation Projects Timeline and Carbon Reductions	Tons CO_{2e}/y (1000s)										
Projects	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
University Emissions Prior to Mitigation	198.8	200.1	201.4	202.8	204.1	205.4	206.8	208.1	209.5	210.9	212.2
Cogeneration	17.3	17.3									
Wind *	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6
Solar Thermal											
Solar PV *	1.5	1.6	1.8	1.9	2.0	2.2	2.3	2.5	2.6	2.7	2.7
Grid Changes	22.3	23.8	44.1	43.5	45.8	48.2	50.6	53.1	55.5	58.0	60.7
LEED Gold Plus	20.2	20.8	21.4	22.1	22.7	23.4	24.1	24.7	25.4	26.1	26.7
Behavioral Campaign	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Materials Management	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Energy Reduction Projects	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1
Replace Main Boilers	0.4	0.4	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Biomass – Williams Village	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Biomass – East Campus	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.9
Transportation Reduction	1.1	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3
Carbon Offset Purchases											
University Emissions After Mitigation	32.7	30.2	13.1	8.9	4.7	0.4	-3.8	-8.2	-12.6	-17.1	-21.7

* Carbon reductions from lease to own renewables cannot be counted until ownership reverts to the university.

4.5 *Emission Reduction Projects*

4.5.1 Ongoing, New, and Future Projects

The CNWG identified numerous potential new projects to evaluate for carbon reduction, financial viability, risk, strategic fit, and related benefits. Likewise, ongoing conservation and efficiency programs have been considered for their contributions to carbon emissions mitigations (See Chapter 6.3, “Existing Programs and Policies”). External activities that impact the carbon quality of CU’s energy sources and the effect of emerging technologies are discussed in the next section, “External Activities and Developments.” Finally, as yet undetermined additional efforts to meet the Governor’s Executive Order goals will be sought by the Sustainability Action Teams discussed in the Section 4.4.3, “Governor’s Executive Order’s Goals.”

Accordingly, Tables 10 and 11 summarize new capital and administrative projects that have been evaluated and ranked by project viability.

Table 10: CU Carbon Mitigation- Capital Projects, Financials, and Carbon Reduction

Sustainability Capital Projects					NPV		IRR		Carbon	
Project Rank	**Projects**	**Total Cost ($)**	**Total Project Savings ($)**	**Risk**	**No Risk ($)**	**With Risk ($)**	**No Risk (%)**	**With Risk (%)**	**Reduction (tCO_{2e})**	**Cost/Ton ($\$/tCO_{2e}$) ($)**
Well-Defined Projects										
1	Pursue Photovoltaic Options	(400,000)	474,185	0.80	171,217	80,119	——	——	7,551	10
2	Roofs - Insulation	(500,000)	1,278,425	0.70	893,588	475,512	32.2	20.8	4,102	190
3	Smart Power Strips for Dormitories	(180,000)	751,774	0.60	776,077	393,646	63.1	37.4	1,015	563
4	Heat Recovery in Laboratories	(500,000)	644,843	0.90	46,725	(7,948)	6.8	4.7	1,690	86
5	Roofs - Polymer Coating	(1,500)	3,267	0.95	1,124	993	17.8	16.4	8	221
6	Insulation - Pipes	(150,000)	257,937	0.75	112,428	46,821	17.8	10.7	772	140
7	Windows Replacement - Sealing & Weather Stripping	(50,000)	232,484	0.90	147,110	127,399	46.8	41.9	580	315
TOTAL		**(1,881,500)**	**3,466,264**	**0.80**	**1,902,182**	**1,174,377**	**27.9**	**20.2**	**15,718**	**101**
Projects in Development										
8	Wind Farm	(23,768,675)	(4,513,157)	0.20	(17,277,257)	(19,757,852)	——	——	546,662	-52
9	Room Occupancy Sensors	(300,000)	322,422	0.75	28,035	(53,974)	6.8	1.3	3,496	6
10	Solar Thermal - Central Ground Mount	(2,352,000)	212,956	0.80	(1,878,411)	(1,982,413)	-30.7	-36.7	2,987	-716
11	Kitchen Efficiency	(250,000)	343,916	0.60	187,380	12,428	17.8	6.0	650	144
12	Solar Thermal - Rooftop	(630,000)	54,683	0.60	(560,457)	(588,274)	-24.7	-29.4	597	-964
13	Biomass at East Campus	0	0	0.00	0	0	0	0	17,359	0
14	Biomass at Williams Village	0	0	0.00	0	0	0	0	11,820	0
15	Ground Source Heat Pumps	0	0	0.00	0	0	0.0	0.0	0	——

Table 10: CU Carbon Mitigation- Capital Projects, Financials, and Carbon Reduction (continued)

Sustainability Capital Projects											
					NPV		IRR		Carbon	
Project Rank	Projects	Total Cost ($)	Total Project Savings ($)	Risk	No Risk ($)	With Risk ($)	No Risk ($)	With Risk ($)	Reduction (tCO_{2e}) ($)	Cost/Ton ($/$tCO_{2e}$) ($)
Projects in Conceptualization										
16	Cogeneration System	(12,540,000)	0	0.10	0	0	0	0	173,644	(72)
17	Energy Conservation in the Data Centers	(250,000)	573,192	0.65	0	0	0	0	6,797	48
18	Windows - Replacement	(500,000)	9,664	0.50	0	0	0	0	42	(11,675)
19	Optimization of Chilled Water	(2,000,000)	0	0.80	0	0	0	0	0	——
Long Term Projects Past Planning Horizon										
20	Transit System for East Campus									
21	University Village									

NOTES:

- Project Rank - Projects were ranked on a basis of the level of project development, the cost per ton, total tons, and the NPV of each project with and without risk.
- Total Cost - Project implementation and management costs over 10 years.
- Total Project Savings - Projects are expected to provide some benefit in cost or energy savings; Total Project Savings is the total project income and energy savings over 10 years.
- Risk - Provides information on conditions related to each project. A higher risk value indicates a greater likelihood of success.
- NPV - The NPV is the present value of a project's future net cash flows minus the initial project investment. If the NPV value is positive, the investment should be considered, unless a better investment exists.
- IRR - Internal rate of return is the average annual return on an investment (project). The higher a project's IRR, the better the investment's return relative to its cost.
- Reduction (t CO_2e) - Estimated tons of CO_2 that can be reduced as a result of project implementation.
- Cost/Ton ($/t CO_2e) - Marginal cost of CO_2 abatement, calculated from Net Cost (Total Cost - Cost Savings)/tCO_2e.

Table 11: CU Carbon Mitigation- Administrative Projects, Financials, and Carbon Reduction

Sustainability Projects										
					NPV		IRR		Carbon	
Project Rank	**Projects**	**Total Cost ($)**	**Total Project Savings($)**	**Risk($)**	**No Risk($)**	**With Risk($)**	**No Risk(%)**	**With Risk($)**	**Reduction (tCO_{2e}) ($)**	**Cost/Ton ($\$/tCO_{2e}$) ($)**
Well-Defined Projects										
1	LEED Gold Plus - New Buildings & Renovations	(679,614)	1,047,420	0.90	264,941	175,075	15.3	12.0	43,948	8
2	Behavioral Conservation Program Fund	(550,000)	249,353	0.50	(55,545)	(245,816)	-15.2	——	6,194	(49)
TOTAL		**(1,229,614)**	**1,296,773**	**0.70**	**209,395**	**(174,364)**	**12.3**	**-2.3**	**50,142**	**-50**
Projects in Development										
3	Fleet Resizing	(18,574)	49,000	0.70	46,243	30,027	120.3	78.2	4,346	7
4	General Equipment Procurement Cost Share	(1,050,000)	240,741	0.70	(650,363)	(729,091)	——	——	0	0
5	Alternative Fuel Vehicle Revolving Loan Pool	(500,000)	420,000	0.70	(36,696)	(175,687)	3.5	-3.1	0	0
6	Implementation of *Diversion Potential Assessment* Recommendations	(1,380,000)	598,928	0.80	(546,739)	(662,358)	——	——	0	0

Table 11: CU Carbon Mitigation- Administrative Projects, Financials, and Carbon Reduction (continued)

					NPV		IRR		Carbon	
Project Rank	Projects	Total Cost ($)	Total Project Savings ($)	Risk	No Risk ($)	With Risk ($)	No Risk(%)	With Risk(%)	Reduction (tCO_{2e})	Cost/Ton ($\$/tCO_{2e}$)
Projects in Conceptualization										
7	Student Parking Ban	(25,200,000)	12,242,000	0.20	0	0	0.0	0.0	337	(38,451)
8	Telecommuting/Flex Scheduling	(1,045,000)	0	0.20	0	0	0.0	0.0	83	(12,667)
9	Purchase Carbon Offsets	0	0	0.20	0	0	0.0	0.0	0	0
10	Carbon Price Risk Factor (CPRF)	0	0	0.30	0	0	0.0	0.0	0	0
11	Conversion to Duplex/Quad Printers	(1,530,000)	133,268	0.40	0	0	0.0	0.0	0	0
12	Conversion to Online Forms and Processes	0	0	0.00	0	0	0.0	0.0	0	0
Long Term Projects Past Planning Horizon										
13	Continuous Review of Additional Renewable Opportunities									
14	Monitor Xcel Energy's Progress Toward 20 percent CO2 Reductions									

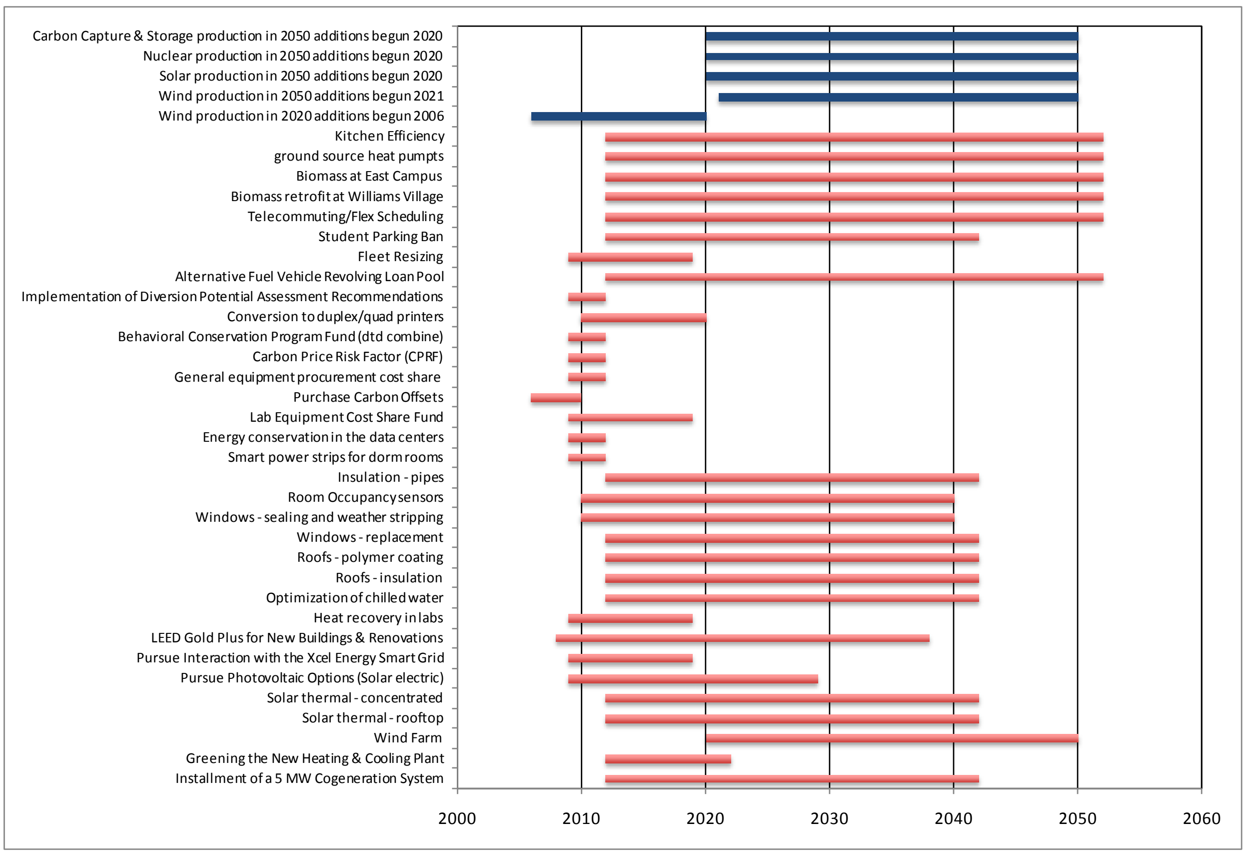
4.5.2 Overall Timeline

The timeline for project implementation is based upon project ranking (see Financials section for more information). Projects with the highest ranking will be implemented first. Additional projects will be implemented as funds become available.

Project time frames are based on a ten-year period, although the actual implementation time will vary from project to project. Projects such as the behavioral conservation program or the procurement cost share program are ongoing. Many of the energy conservation projects, such as kitchen efficiency or insulation, can be done in a much shorter time period.

The table below provides an illustration of how the sustainability projects will be implemented.

Figure 11: CU Carbon Mitigation Projects- Timeline



5 Financial Analysis

5.1 Financial Modeling

Targeted actions need to be taken in order to mitigate the amount of carbon generated by the campus. The Carbon Neutrality Task Force began a project list of possible activities and ideas for consideration. Working with the CNWG team leaders, the Fiscal Team then analyzed the possible activities.

Assessment of Opportunities

The campus has been engaged in carbon reduction activities with regular investments ranging from LEED certification in new construction, energy conservation projects for building mechanical systems to behavioral programs aimed at reducing the consumption of energy in campus buildings. Since the campus culture is already environmentally minded, existing infrastructure projects and initiatives that have been in place prior to this task force are expected to continue at normal rates. The task force focused on identifying new projects that are an enhancement of existing activities or are new opportunities. Only a few opportunities were chosen, and the projects below should be seen as a direction and initial point for discussion with campus leaders and the CU community, not a definitive or exhaustive list of options.

Project teams were organized by sector of opportunities for energy use management, including:

- Energy Supply
- Energy Conservation
- Policy
- Behavioral Programs
- Materials Management
- Transportation

Each project team developed project proposals that included information on cost, feasibility, and CO2 reduction. Appendix 5 provides a description of these projects. Tables 10 and 11 summarize the projects under consideration.

Project Evaluation

The opportunities identified range largely in terms of cost, feasibility, and CO2 reduction. Appendix 5 provides a synopsis of 35 projects. Projects were separated into either capital projects or administrative projects. This was done in order to differentiate specific projects, such as insulating pipes or roofs, from administrative actions or policies, such as requiring LEED Gold certification for new buildings and major renovations.

Net Present Value

The financial payback assessment was done by calculating the net present value (NPV) and internal rate (IRR). Projects with a positive NPV and relatively higher IRR than other projects indicate that there is favorable investment return. For the NPV calculation, most projects were assumed to have a timeline that begins between 2010 and 2013, then continuing for ten years, with a cost of capital at 5.0 percent. Cost inflators and implicit costs were not included, but three percent inflation in energy costs was included. The impact of potential carbon pricing was not included. The project description contains a discussion of whether the project is scalable, meaning that the project could be made larger or smaller depending on the cumulative number of "sub-projects" within that project.

The NPV is the present value of a project's future net cash flows minus the initial project investment. Internal rate of return is the average annual return on an investment (project). The higher a project's IRR, the better the investment's return relative to its cost.

The NPV approach assumes that the rate at which cash flows can be reinvested is at the cost of capital rate, which can be a more reliable indicator than IRR. The calculated IRR is not necessarily the rate at which a firm can reliably reinvest; however, both IRR and NPV should yield the same accept or reject decision.

Table 12: Top 10 Capital Projects by NPV

Project	NPV ($)
Roofs - Insulation	893,588
Smart Power Strips for Dormitories	776,077
Kitchen Efficiency	187,380
Windows - Sealing & Weather Stripping	147,110
Insulation - Pipes	112,428
Heat Recovery in Laboratories	46,725
Room Occupancy Sensors	28,035
Roofs – Polymer Coating	1,124
Photovoltaic	(74,870)
Solar Thermal - Rooftop	(560,457)

Table 13: Top 5 Administrative Projects by NPV

Project	NPV ($)
LEED Gold Plus - New Buildings & Renovations	264,941
Fleet Resizing	46,243
Alternative Fuel Vehicle Revolving Loan Pool	(36,696)
Behavioral Conservation Program Fund	(55,545)
Implementation of *Diversion Potential Assessment* Recommendations	(546,739)

The projects with the highest NPV are primarily those that focus on energy conservation, such as insulation projects or energy saving projects. Another area that arises is vehicle emissions. While it is easy to calculate the costs, savings, and reduced emissions of a single vehicle, for example, it becomes much more difficult to calculate the project benefits as they apply to a large and diversified fleet of vehicles.

An issue of note is that NPV does not distinguish between the overall project return. For example, a low cost project, such as a polymer coating on roof tops, is ranked on the same scale as a high cost project such as LEED construction projects. This ranking assumes that each project will be implemented as planned with no complications.

Risk

Risk was included to account for strategic and practical conditions unique to each project. The higher the risk value, the more likely a project could be successful and meet objectives relative to other projects on the list. However, the likelihood of carbon pricing (carbon risk, see page 6 for discussion) was not included in the risk values. This rating is subjective and influences the financial return values. Tables 14 and 15 demonstrate how projects can shift in rank based on the addition of risk.

Table 14: Top 10 Capital Projects by NPV with Risk

Project	Risk	NPV ($)
Roofs - Insulation	0.70	475,512
Smart Power Strips for Dormitories	0.60	393,646
Windows - Sealing & Weather Stripping	0.90	127,399
Insulation - Pipes	0.75	46,821
Kitchen Efficiency	0.60	12,428
Roofs - Polymer Coating	0.95	993
Heat Recovery in Laboratories	0.90	(7,948)
Room Occupancy Sensors	0.75	(53,974)
Photovoltaic	0.80	(130,964)
Solar Thermal - Rooftop	0.60	(588,274)

Table 15: Top 5 Administrative Projects by NPV with Risk

Project	Risk	NPV ($)
LEED Gold Plus - New Buildings & Renovations	0.90	175,075
Fleet Resizing	0.70	30,027
Alternative Fuel Vehicle Revolving Loan Pool	0.70	(175,687)
Behavioral Conservation Program Fund	0.50	(245,816)
Implementation of *Diversion Potential Assessment* Recommendations	0.80	(662,358)

Carbon Reduction

The carbon reduction from each project was assigned based on estimated energy savings. The carbon reduction reported for each project is the total carbon reduction over ten years. Reductions are primarily a result of energy savings, although other sources are a result of switching from purchased energy from Xcel Energy to cleaner energy generated by university projects.

Just as calculating financial costs and benefits was difficult for the administrative and policy projects, calculating the carbon reduction is problematic for the same reason. In some cases, as with LEED buildings, CU can extrapolate known savings for existing buildings and apply this to the expected campus growth. Other projects, such as equipment cost share programs, are much more difficult to calculate due to the broad scope of the project.

Table 16: Top 10 Capital Projects by Carbon Reduction

Project	Reduction (tCO_2e)
Wind Farm	546,662
Cogeneration System	173,644
Biomass at East Campus	17,359
Biomass Retrofit at Williams Village	11,820
Photovoltaic	7,551
Energy Conservation in the Data Centers	6,797
Roofs - Insulation	4,102
Room Occupancy Sensors	3,496
Solar Thermal - Central Ground Mount	2,987
Heat Recovery in Laboratories	1,690

Table 17: Top 5 Administrative Projects by Carbon Reduction

Project	Reduction (tCO_2e)
LEED Gold Plus - New Buildings & Renovations	43,948
Behavioral Conservation Program Fund	6,194
Fleet Resizing	4,346
Student Parking Ban	337
Telecommuting/Flex Scheduling	83

The projects with the greatest potential for reducing carbon are those that transfer energy production from Xcel Energy to the university. Energy savings projects, such as roofing and pipe insulation, are also important because reducing overall energy use on campus results in a reduction in the amount of energy generation needed to meet the university's overall energy demand. With policy projects, the focus is on reducing energy consumption, as well as reducing vehicle miles traveled that are associated with university business or commuting.

The projects are in various phases of the feasibility assessment, meaning that financial, risk and/or strategic direction are still being considered. As each project is further defined, the project list should be routinely sorted.

Strategic Opportunities

Overall, energy conservation provides the best strategic position based on financial return, low risk, and carbon savings. These types of projects are underway on campus and will continue to be implemented in the future.

In addition, projects can be clustered together to reduce costs. Roof insulation projects, for example, can easily be paired with painting a polymer coating on roof surfaces. Other projects, however, may have competing interests, such as the polymer coating and the addition of solar panels on building roofs. Taking advantage of market opportunities is crucial. Currently, many incentives and rebates for solar technology exist. There is also the possibility of funding from the federal stimulus package. By adding these factors to a simple cost/benefit analysis, the proper prioritization of projects can be achieved.

Next Steps and Critical Success Factors

A project's next steps are included in the financial analysis in order to see if there are other activities that must happen before the project can move forward—and if those other activities also incur a cost.

A project's critical success factors include whether a project's financial viability depends on external rebates or grants.

5.2 Aggregate Financial Impacts

Aggregating cash flows of all projects provides a projection of expected cash outflows and inflows in order to implement carbon reduction projects. Many of the recommended capital projects are short term having cash outflows up front with long-term benefits. With an expected increase in purchased energy costs these benefits are expected to increase slightly over time. Exceptions to this are the renewable energy projects such as wind and solar PV. Both of these projects are expected to utilize alternative financing, in which a third party provides the majority of the upfront cost. The university would ultimately purchase these projects after a designated period of time such as seven or ten years. This is reflected in the dip in cash flows in Figure 12.

Administrative projects tend to have higher on-going cost in addition to up front implementation costs. Projects such as the Behavioral Conservation Program Fund or a cost-sharing program will require an on-going source of funding. As a result, long-term cash flows will be lower than the cash flows of capital projects.

Figures 12 and 13 (below) depict the projected Tier 1 cash flows for both capital and administrative projects in Phase I (2010 – 2020). Tier 1 capital projects have a combined upfront cost of approximately $1.4 million with an annual positive cash flow of approximately $427,000 on average. This type of cash flow results in a simple payback period of about 3.5 years. The dip in year 2017 is a result of the university's buy-back of a solar PV project. For administrative projects, the upfront costs are lower ($520,000) but with annual expenses of approximately $71,000. Administrative projects have an average annual cash flow of $95,000, resulting in a simple payback period of about 5.5 years. However, it should be noted that there are only two administrative projects that fit into the Tier 1 category.

Figure 12: Combined Cash Flow of Capital Projects

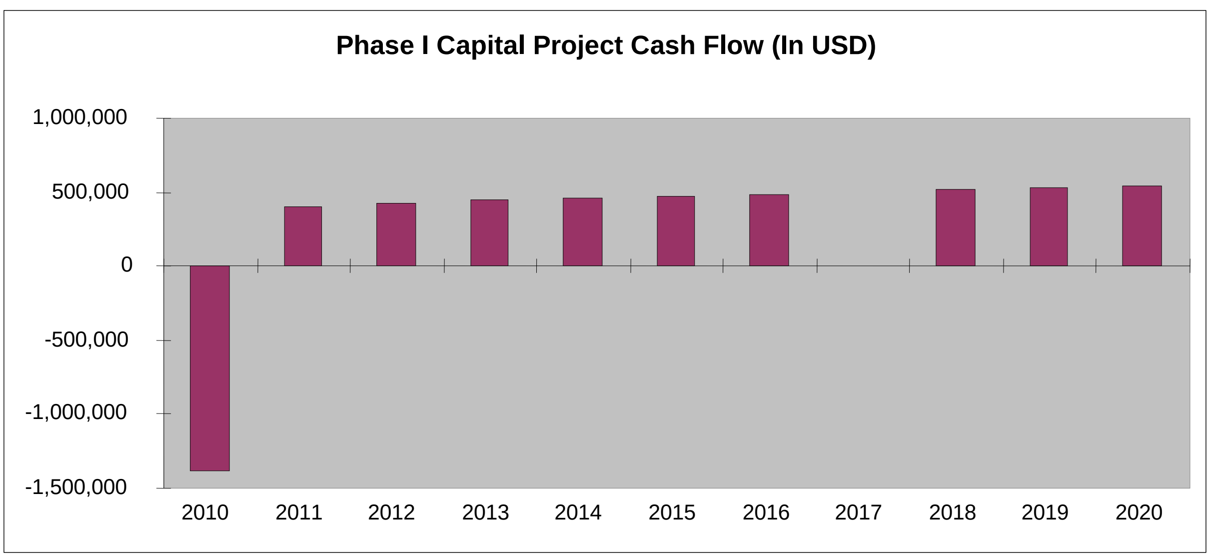
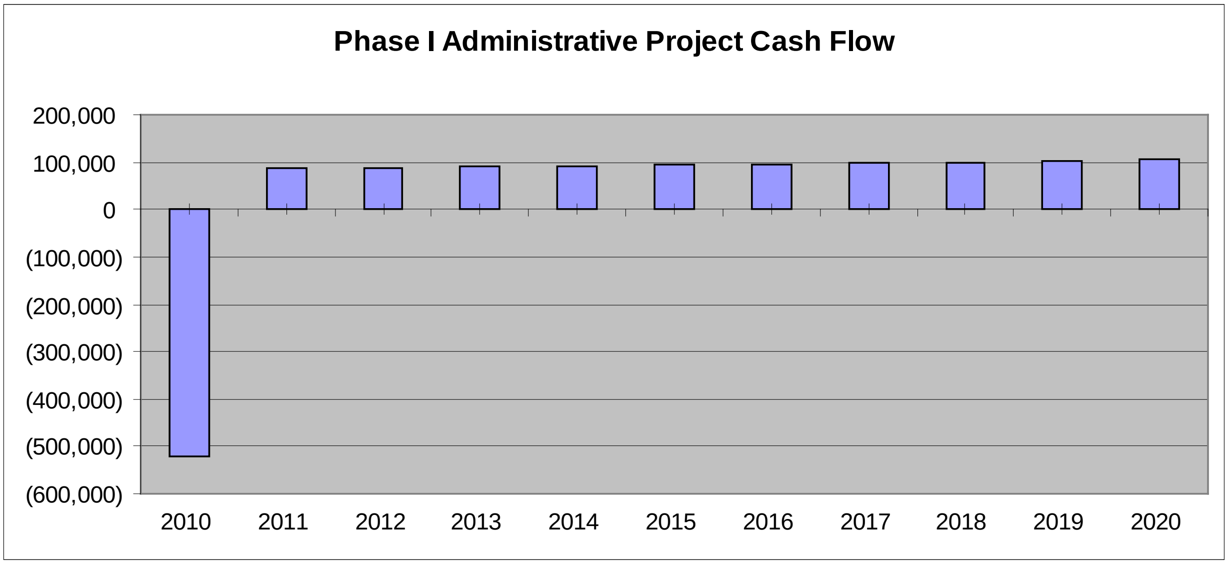


Figure 13: Combined Cash Flow of Administrative Projects



5.3 Funding Opportunities

Financing these projects can be achieved through many mechanisms ranging from internally and externally funded or a mix between the two. Cost sharing could involve internal only or internal-external funding agreements. Regardless of how a project is funded, all funding mechanisms can yield positive outcomes as well as pose challenges such that one method is not necessarily better than another.

The university follows traditional fund accounting and has restrictions on the co-mingling of and cross-subsidization with assets across fund types. All projects must have beneficiaries ~~and those paying identified,~~ which in turn can influence funding strategies.

Internal to the campus funding opportunities are direct contributions from campus units and/or the central campus which may require no payback of the original investment. Other examples of internal funding mechanisms are charge rates or loans from the University Treasury.

An example of an internal-external partnership is using third party venture capitalists. Another example is bond issues considered a common option for capital construction projects.

External opportunities include funding from the state, local and federal governments, and private contributions from gifts. The funding received from these entities may not require payback or return to the granting party; however, the funding may be contingent on meeting or executing certain requirements.

6 Carbon Mitigation Plans, Scope 3

Scope 3 emissions result from activities CU neither owns nor has direct control over. For instance, the emissions from a jet aircraft carrying a CU employee are proportionately attributed to CU's Scope 3 inventory. CU does not own the jet nor is capable of reducing the jet's emissions. However, CU can reduce the demand for the jet's use by electing to video conference. Likewise, CU's faculty and staff who commute to work via fossil fuel powered vehicles each day generate carbon emissions attributable to CU's Scope 3 inventory. CU has little control over where employees choose to live or how they commute; however, the university does provide a pre-paid bus pass to all faculty, staff, and students in an effort to reduce their commuting emissions.

Nonetheless, Scope 3 emissions are important as the university shares some responsibility and accountability for enabling upstream and downstream emissions. For instance, the university is not directly responsible for the emissions associated with producing paper. However, if the university chooses to buy less paper or purchase 100 percent recycled paper those upstream production emissions are reduced. Accordingly, CU monitors certain Scope 3 emissions and promotes their mitigation through a variety of means.

6.1 Commuting

Commuting to and from campus generates carbon emissions which end up in the atmosphere that all people in the community share. However, these emissions are difficult for CU to directly reduce.

Essentially, there are five approaches to mitigating the carbon emissions related to the commute to and from campus for the university's faculty, staff and students:

1. Address <u>residential choice</u> factors (with the objective of reducing person-miles traveled) by encouraging people to live closer to campus
2. Address <u>modal choice</u> factors (with the objective of accommodating a given number of person-miles) by encouraging higher vehicle occupancy through carpooling, vanpooling and transit use
3. Address <u>employment/study location and schedule choice</u> factors (with the objective of reducing vehicle-miles traveled) by reducing the number of trips made
4. Address <u>fuel/propulsion and modal choice</u> factors to reduce greenhouse gas (GHG) emissions per vehicle-mile traveled
5. Address commute-related GHG emissions by using <u>carbon offsets</u> such as sequestration and efficiency improvements

<u>Residential Choice</u>

The trend over the last decade has been for CU affiliates to live farther and farther away from campus increasing the average number of miles traveled per person in the daily commute between home and class and/or employment.[11] CU hopes to moderate if not reverse this trend by increasing the proportion of the student body living on campus and by increasing the amount of faculty and staff housing available on campus. Higher density housing has been added adjacent to campus in recent years; CU developers and the City of Boulder should work together to foster this trend where appropriate.

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[11] A 2007 estimate based on faculty, staff and student survey data suggested that all combined, CU-Boulder faculty, staff and students traveled a total of ~560,000 miles each day as they commuted to and from campus.

In addition, CU may provide support for or promote location-efficient mortgages for its affiliates. More broadly, CU may provide or promote services that assist affiliates in finding housing closer to campus. With the goal of sustainability in mind, CU should identify barriers and press for the creation of a mix of housing types, price levels and densities that will allow all faculty, staff and students to live within walking and biking[12] distance of campus or on a "one-seat" transit ride to campus.

Modal Choice

This commuting option focuses on moving the University population to and from campus in fewer vehicles. These strategies including a variety of approaches to encourage higher vehicle occupancy, i.e., filling empty seats. CU encourages more people to arrive at campus in fewer vehicles primarily through its Student Bus Pass program and Faculty/Staff Eco Pass program. Carpool parking permits are available and a new social marketing program (ZimRide) has recently been launched to encourage carpooling or vanpooling.

New initiatives are under consideration in this area that could lead to reduction in these Scope 3 emissions – particularly a program that integrates car and vanpooling with popular social networking systems. Increasing numbers of CU affiliates have been using public transit over the last 15 years. If RTD can find sources of additional funding to support improved and expanded transit service, there is potential for further increases in the transit mode share among campus commuters.

Additionally, four other factors support the reduction of the University-related carbon footprint via increased vehicle occupancy:

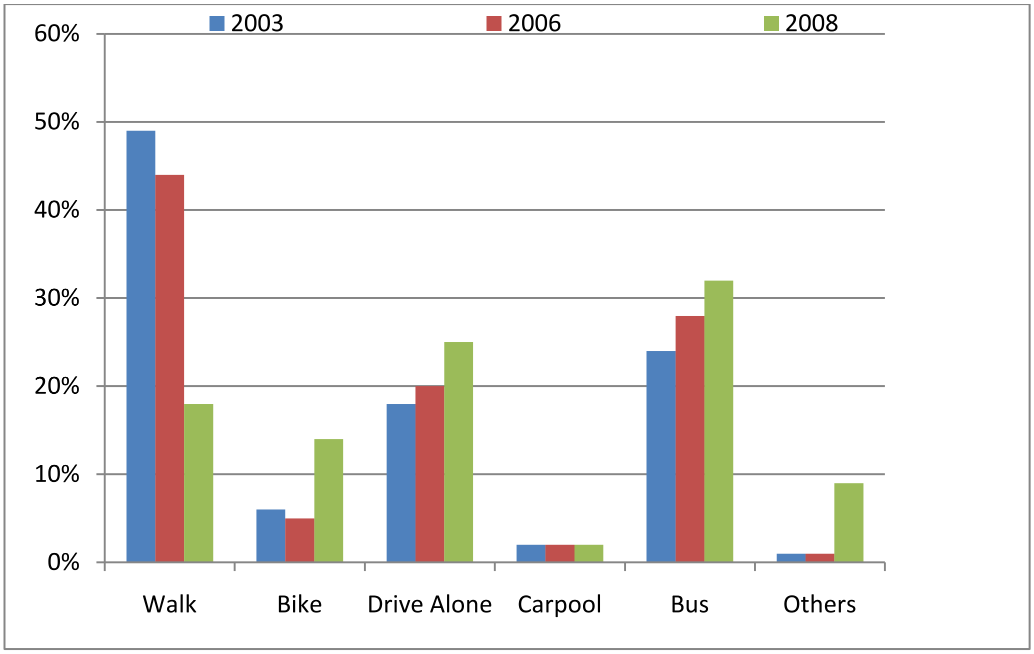
- Parking costs (pricing)
- Effective parking enforcement
- The guaranteed ride home (GRH) program
- Provision of car-share services on campus

Once people are asked to pay the cost of parking they are less likely to desire it. Modal choices are then made on a more level playing field. This is reinforced when drivers know that they will not be able to avoid parking fees. The GRH program provides a free taxi ride home for CU affiliates who traveled to campus by a mode other than driving alone and in the event that their planned alternative mode trip home becomes unavailable or impractical.

Finally, the most common reason given for driving alone instead of carpooling, biking or using transit is the perceived need to be free to do private or work-related errands before, during or after the work day. Access to car-share vehicles on campus and at home together with the GRH program can greatly reduce the perceived need to always have one's own vehicle on hand in case it *might* be needed.

[12] Walking and biking are the most sustainable modes of transportation and most frequently are seen as viable within two and five miles, respectively. Transit use tends to fall off in proportion to the number of transfers required; a "one-seat" ride gets you to your destination without a transfer.

Figure 14: Student Transportation Mode Split Trends



Work/Study Location and Schedule Choice

Telework, flextime and distance learning are other ways to reduce commuting (number of trips) as would otherwise be needed.

Telework includes doing suitable portions of a job at home or in a satellite office and/or working the same number of days and hours but eliminating the number of commuting days per week or month. Flex time might reduce the work commute from five 8-hour days a week to four 10-hour days, cutting work-related vehicle miles traveled (VMT) by 20 percent (one day per week). Distance learning can deliver a university course to any location with a computer and internet access. CU can do more to identify and overcome barriers and promote these approaches where may be appropriate.

Vehicle Fuel/Propulsion Choice

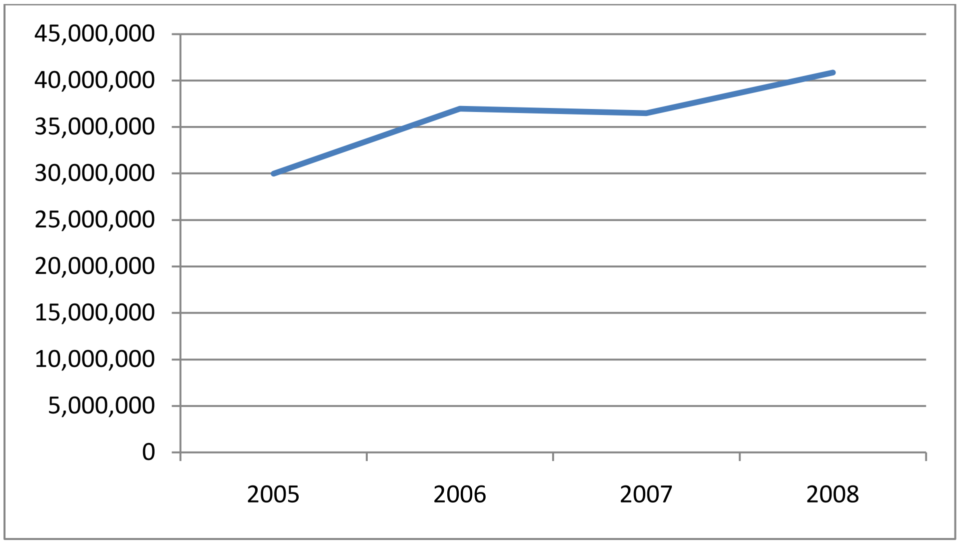
In addition to the above university-related commuting carbon footprint can be reduced by traveling in vehicles that emit fewer greenhouse gasses per mile of travel. When vehicles must be used the next best method is to employ vehicles that use more carbon-efficient fossil fuels (natural gas instead of gasoline, diesel or coal) or that use carbon-based fuels most efficiently (high mpg vehicles, such as gas, diesel, hybrid, plug-in hybrid, fuel cell, etc.). CU can support with this by making lower GHG producing vehicles more viable and convenient for commuting by providing fueling/charging stations and/or working with third parties to do so.

CU can also push for improvements within our own fleet of vehicles by emphasizing right-sizing of the vehicle, fuel efficiency, lower-carbon fuels, non-carbon fuels and non-fueled approaches and in making effective vehicle purchase and replacement choices.

6.2 *Air Travel*

Like commuting emissions discussed above, CU neither directly controls nor owns carbon emissions associated with air travel. Nonetheless, it is an important trend to monitor and reduce.

Figure 15: Air Travel Miles (Paid for by the University)



There are only two methods for mitigating travel-related GHG emissions:

- Offsets for the mileage
- Not taking the trip (attending remotely)

Offsets and their implementation can be achieved by more than one method. It is necessary to decide if travel offsets are considered as a normal expense and included in travel budgets. This would constrain overuse (of offsets) to justify trips.

In terms of reducing air travel miles by attending remotely, a range of policy options could be explored. A long term review of travel needs and options for remote delivery of content, dialogue in meetings and general criteria for authorizing travel should be explored. One option may be a state of the art Telecommunication Center funded in partnership with local government that would facilitate virtual attendance in remote meetings. The Center would have leading edge leading edge communications technologies, provide practical video/audio/data links at low cost and represent the University's leadership role within higher education.

6.3 Materials Management

Two directives in the Governor's Executive Order have driven considerable activity recently in the area of materials management:

- Adopt a goal of "Zero-Waste" from construction of new buildings and operation and renovation of existing facilities (current waste diversion rate for new construction is >75%) [13]
- Achieve a paper use reduction goal of 20 percent by fiscal year 2011-2012 using fiscal year 2005-2006 as a baseline

The CNWG believes progress on these goals will be achieved through a combination of actions, including:

Source Reduction

Reducing unnecessary waste at source allows the university to both mitigate the inefficient use of natural resources and economic benefit from decreased handling and disposal costs.

To date, waste reduction practices at CU have targeted simple activities. These include double-sided copying, interdepartmental mailing envelopes, and advanced voice-mail, e-memos, and Imaging Services print-on-demand capabilities. CU's student-led, pay for print initiative is now an accepted form of waste reduction and is cutting waste by over 30 tons per year.

Increasingly, a number of departments are showing leadership by tackling more ambitious and deeper reductions in the generation of materials. We are currently moving many of CU's processes online, a process that has thus far been successful. Property Services hopes to convert electronic processing of surplus property disposal from the initial request form through the final distribution of revenue and/or billing.

The Office of the Bursar has begun a transition to paperless billing of student tuition. Electronic billing and payment acceptance will reduce paper consumption by at least 400,000 pieces per year.

Telecommunications plans to further reduce telephone directories delivered to campus by approximately 25 percent (an estimated 25 tons of paper will be reduced). In addition, Web services such as the Personal Look Up System (PLUS) used for registration and grades could reduce the need for paper-based transactions.

Facilities Management Business Services is working to convert various forms to electronic format with electronic approvals. For example: key request forms, travel authorization forms, Official Function forms, BCA's, leave requests, etc.

CU Environmental Center and Facilities Management plans monitor excessive amounts of print overruns more actively. Bulk mailings, athletics schedules, Continuing Education catalogs are a few examples of large printing overruns.

[13] The term "zero waste" here refers to an aspiration similar to "zero defects" or "zero accidents"; that is, a goal that guides all planning, decisions, and actions.

Another recommendation for significantly reducing paper consumption is to convert all printers to duplex capable or quad capable and set default settings. This initiative will have a high impact, campus-wide (capital investment is estimated at $1.6 million).

Providing refillable mugs to CU employees is a practical and highly visible means of reducing drink container waste that can be practiced by almost everyone. A similar program, previously recognized by the EPA, has already reduced disposable cup usage by about 30 percent in the University Memorial Center. These and other activities that reduce consumption are increasingly practical examples of how CU can embed a Zero-Waste goal that directs everyday actions and decisions.

Landfill Diversion

The university currently diverts (recycles and composts) over 1,900 tons or approximately 35 percent of materials from area landfills annually.[14] Over 3,800 tons are landfilled annually. A Diversion Potential Assessment was completed in 2005 in which a consultant reported over 850 tons of commonly recycled materials continue to be discarded by CU-Boulder annually. Moreover, these tons that are currently thrown away can be diverted less expensively than landfill disposal.[15]

Specific activities identified to divert these additional tons recommended by the CNWG include:

- Expansion of corrugated cardboard collection in academic/administrative buildings
- Implementation of styrofoam collection
- Addition or consolidation of collection cabinets in academic, administrative, and residential buildings
- Continued placement of outdoor public containers for recycling

Additional activities include:

- Banning wood and scrap metal waste in dumpsters
- Expanding composting programs for food waste, food packaging, pallets/wood waste and campus grounds debris
- Designing in-house alternatives for handling organics such as food pulpers and food waste composting

There continues to be a need for additional space for recycling and solid waste management operations, to allow new materials to be collected, better space for class tours and training, and vital support for Facilities Management's collection operations.

Recycled Content Products

CU recognizes that recycled content products are essential to the continuing viability of CU's program and as feedstock for an environmentally sound production system globally. The Procurement Service Center has adopted a "Strategic Sourcing" model for the contracting of primary goods and services for the university. The RFP's currently published include sustainability language to test vendor competencies in this area. Consideration of these issues is a factor in award determinations. Sustainability-related checklists and questions help determine all the various methods bidders are using or considering in order

[14] At 35 percent, CU's diversion rate is about the same as the national average and half that of leading universities.
[15] SERA, Diversion Potential Assessment, 2005

to reduce packaging, minimizing distribution (material movement), reducing the transportation of the goods, and so forth. Another effective method is smarter buying of goods.

Table 18: Quarterly University Paper Purchases

CU A-Card Paper Purchases April – June 2009			
	Units	*Type*	*Expenditures (In USD)*
	4,607	Recycled	17,419.32
	4,923	Virgin	18,362.92
	9,530	**Total**	**35,782.24**

Office supplies are a perfect example of this. If orders are placed as items are needed, then the supplier is making multiple weekly deliveries. This means more packaging, more delivery mileage, more paperwork, and more carbon. Smart buying would simply entail keeping a master list of supplies used, setting a minimum and a maximum for each item, and when the minimum is reached, add it to the list. Ordering could then be done bi-monthly or even monthly, greatly reducing all the negative factors of a just-in-time method.

e-Procurement

An e-Procurement solution provides an efficient and user friendly process for faculty and staff to order commonly required products and specific services from University contracts and preferred suppliers.

Benefits include:

Automation/Process Improvement

- Streamlined, consistent ordering process
- System governed approval process that adheres to University policy
- Increased order accuracy
- Quicker delivery of goods
- Integrated billing process

Cost Savings

- CU-defined prioritization of search results (i.e. preferred suppliers, lowest cost, etc)
- Increased contract compliance by end users
- Detailed information to negotiate better contracts
- System directs end users to preferred vendors, which enables the PSC to negotiate better contracts
- Process automation (entire purchasing/payment cycle)
- Prompt payment discounts

6.4 Upstream Carbon Mitigation Leadership

While Scope 3 emissions are difficult to mitigate (since CU neither owns or directly controls their release) they also present an important economic and carbon reducing opportunity.

In short, it takes two to release carbon. A willing buyer and a willing seller create a product or service—and carbon is released. However, if CU focuses on reducing consumption, then CU saves money and lessens the upstream release of carbon. Likewise, if CU works with suppliers to research new ways of delivering needed products or services while minimizing or eliminating carbon, CU can push beyond carbon neutrality. Upstream emission reductions won't directly benefit CU's carbon inventory; however, as a leadership university CU has committed itself to the broader global community. This effort is consistent with that mission.

6.5 Reducing Upstream Carbon Emissions from Materials

The carbon that is emitted from CU's yearly 3,400 tons of trash is just the tip of the iceberg. For each ton of discarded products and materials landfilled, CU indirectly contributes to the production of about 71 tons of waste from manufacturing, mining, oil and gas exploration, agricultural, coal combustion, and other consumption expended to deliver our goods (241,400 tons in FY08). [16] When upstream impacts of extraction, transportation, manufacturing, and processing are included, the materials CU uses cast a much larger footprint than just the methane and CO2 emitted from landfilling in Weld County. Combined, these sectors produce more than 36 percent of all greenhouse gas emissions.[17]

Upstream Mitigation has many components, among them including reducing demand and transportation and constructing footprint models.

CU may reduce demand through various methods including education, reuse, and product-specific technological breakthroughs. Coordinated manufacture and shipping of goods with strategic suppliers, smart ordering patterns from the departments, and ordering of small dollar items from local manufacturers are examples of methods the university could use to reduce transportation.

Construction of models to determine the actual footprint of a manufactured item is commodity-specific at the moment. Office paper impact can be determined with a model such as papercalulator.org; but many others have no models to use as a benchmark. Strategic suppliers could be asked to work with their various manufacturers to begin calculating the footprint and real total cost of the items they sell. These total cost models will need to include raw material, impact for removing the raw material, the cost of the electricity needed to produce the item, the origins (renewable, fossil fuel) of the electricity, the amount of and quality of packaging needed and used for the product, and the method of transportation used to get the goods to the marketplace, etc. Some industries are already working on these issues, but many are not. Leasing and renting versus buying is a model that works with some commodities.

Increasingly, there is a need to understand the interconnectedness between CU as a consumer and the many companies that produce the materials used. In other words, CU can demonstrate leadership by lowering and mitigating emissions in our supply chain to go "beyond carbon neutrality" (See page 48).

Accurate accounting is challenging. It's difficult to obtain accurate reports from companies doing business directly with CU, much less getting their supplier's reports. Hopefully, this issue will become more practical with new Scope 3 emissions accounting protocols coming from World Resource Institute (WRI) next year.

[16] Stop Trashing the Climate, June, 2008. Institute for Local Self Reliance
[17] US EPA Inventory of Greenhouse Gas Emissions and Sinks, 1990-2005, US EPA , Washington, DC

In the meantime, CU can:

- Remain current with emerging measurement protocols, sharing them with our suppliers, and jointly testing them with academic rigor (sponsored technology transfer)
- Where practical; leverage our purchasing decisions through competitive bidding and negotiated extensions
- Reward a "waste-not, want-not" culture throughout the campus community

Two measurement tools have been developed to assist CU in this effort. The EPA's Waste and Reduction Model (WARM) calculates and compares greenhouse gas emissions for 26 categories of materials landfilled, incinerated, recycled, or composted. The model takes into account upstream benefits of recycling as well as the carbon sequestration benefits from composting. Additionally, the Recycled Content Calculator (RECON) can help estimate upstream benefits of increasing recycled content in one of CU's most consumed commodities: paper.

Some practical, common sense activities that CU can use to leverage action from its suppliers and excite the campus community include:

- Limiting the amount of low-value, non-recyclable packaging waste (polystyrene, foam pack, etc.) imported to the campus through purchases. This may include take-back agreements as well as reusable packaging agreements with large volume vendors for computers, food service, and concessions. This could include reusable pallets, toner cartridges, CRTs, etc. This initiative will have a high impact campus-wide. No funding would likely be needed.
- Providing clear information to prospective vendors who give preference to environmentally friendly products whose quality, function, and cost are equal or superior to more traditional products. Include such language in all "boilerplate" documents for RFPs
- Focusing on price preferences for certain "closed-loop" commodities such as fine paper made from CU's recyclables or finished compost made from CU's organics
- Creating special environmental terms and conditions sections in the most common RFBs that produce the most waste or most toxic emissions. Consider awarding 5-10 percent of total bid in contracts for the "greenest" bid from a menu of options provided equally to all bidders
- Tapping research classes within appropriate CU departments (Engineering, ENVS, Biology, Business, etc) to help evaluate products and share information with existing or prospective suppliers
- Extending the good work begun with Centerplate to other concessions and soft drink vendors and contracts
- Establishing acceptable locations for vendors to deliver recyclable packaging after delivering products to campus
- Prohibiting the use of deep-dyed, neon paper campus-wide through Imaging Services and the Distribution Center (as UCSU has already done) because of its contamination of paper recycling and potential health effects from heavy metals used in their production.
- Increasing the switch to Ecolab and other companies who offer more environmentally friendly packaging and access to more Green Seal or equivalent products
- Specifying the use of low-VOC paints and carpet with recycled content
- Investigating the use of carpets that can be reclaimed by manufactures at the end of useful life
- Accelerating efforts in integrated pest management to minimize the use of chemicals and pesticides

- Reducing the use of pesticides and herbicides, and amending soils with compost through CU's turf management program
- Facilitating faculty and staff names removal from unnecessary commercial mailing lists.
- Working with the Registrars office and HDS to purge obsolete contacts and addresses from large, direct-marketing companies.
- Launching a "waste line" for the campus community to easily report waste and suggest improvements.

6.6 Reducing Upstream Carbon Emissions from Food

Food procurement is a critical component of any climate plan. The decisions made by dining service procurement officers have a significant range of health, social, economic, and environmental impacts. CU has already taken several tangible actions to reduce its ecological footprint related to food management, and is beginning to make significant plans for the future.

This section of the CU Climate Action Plan is dedicated to:

- Describing the impacts of the current U.S. and global food system in which CU is linked
- Highlighting sustainable actions already taken by dining service staff and food management services
- Providing strong goals to significantly reduce the University's food-related impacts
- Offering realistic opportunities to achieve the goals detailed above
- Listing the additional benefits of a sustainable food policy

Impacts of Current Industrial Food System

Food systems are the networks of activities, individuals, companies and resultant food products involved in the production, transportation, consumption, and disposal of food, as well as the complex relationship between food production and the natural environment (Johns Hopkins, 2008).

The following categories provide specific examples of the impacts generated by the current U.S. food system - a structure in which CU is explicitly linked.

Food and Climate Change

According to the PEW Center on Climate Change (2006), agriculture and land use change account for one-third of the total greenhouse gases linked to anthropogenic warming.

The U.S. food production system, including agricultural processes, accounts for 17 percent of national fossil fuel use (Horrigan et al., 2002; Johns Hopkins, 2008)[18]. In addition to carbon dioxide emissions (CO_2), agricultural production also results in significant outputs of methane (CH_4) and nitrous oxide ($_{N2O}$); compounds that carry 25 and 298 times more global warming potential (GWP), respectively, than CO_2 (IPCC, 2007). According to a report released by the U.S. Geologic Study (1999)[19], roughly 19 million tons

[18] "Literature Review of Methods and Tools for Quantifying the Indirect Environmental Impacts of Food Procurement". A study conducted by the Johns Hopkins University Center for a Livable Future. Available: http://blogs.csun.edu/sustainability/files/2008/11/jhu-foodprint_report.pdf

[19] Statistics from the US Geological Study (USGS) (1999) are available at: www.usgs.gov, accessed June 3, 2009.

of nitrogen are applied annually in the form of fertilizers and manure – a statistic that represents an estimated 72 percent of all U.S. nitrous oxide emissions (EPA, 2008).

Other Environmental Implications

In addition to GHGs, the current global and U.S. agricultural systems have numerous direct and indirect ecological consequences. The heavy application of nitrogen fertilizers, for example, has led to algae overgrowth, subsequent decay, and low oxygen concentrations (hypoxia), followed by massive die-offs of aquatic life (U.S. Geological Survey, 1999, Johns Hopkins Study).

The increasing amount of pesticide and herbicide use has also demonstrated severe environmental impacts. The escalating presence of pesticides in agricultural application, run-off, and surrounding ecosystems has been attributed to the massive die-off of honeybees in the United States and around the world (Johns Hopkins Study). In 2005, nearly 1.8 million pounds of pesticides and 126.2 million pounds of fertilizers were applied to corn crops in the state of Colorado alone.

Health and Safety

The significant application of nitrogen, and the resulting large quantities of nitrate present in drinking resources, has also led to “blue baby syndrome” in states with high percentages of agricultural production (Johns Hopkins, 2008). Additionally, overexposure to pesticides in humans has been implicated in the development of cancer, acute toxicity, immunosuppression, disorders of reproductive, endocrine, and nervous systems, and respiratory and dermatological effects (U.S. Geological Survey, 1999; Johns Hopkins, 2008). Furthermore, the heavy reliance on antibiotics within the U.S. meat industry may promote the development of resistant bacteria, contributing to resistances in humans and compromising antibiotic use in medical settings (Horrigan et al., 2002)[20].

Additionally, the complex nature of the current global food system increases the overall amount of food handling and potential contamination. The trend toward increasing chemical additives and preservative use also raises the likelihood of health-related problems and preventable diseases.

Current Actions to Reduce Food’s Carbon Footprint

There are several food service providers within the CU campus, including: Housing & Dining Services (HDS), the University Memorial Center (UMC), Folsom Field Stadium Concessions, and other private contractors. This plan has only concentrated on the largest two food providers: the UMC and Dining Services.

- *University Memorial Center (UMC)*

  Purchasing: The UMC currently purchases produce such as potatoes, carrots, corn, onions, and melons all grown in different areas of the state of Colorado when available. The buffalo meat used in the grill is sourced in Denver, CO.

[20] Horrigan, L., Lawrence, R. S., & Walker, P. (2002). How Sustainable Agriculture Can Address the Environmental and Human Health Harms of Industrial Agriculture. *Environmental Health Perspective, 110*, 445-456.

Waste management: In order to comply with student government (UCSU), university, and the Governor's mandates for decreases in waste and resource use, the UMC currently diverts roughly 80 percent of its pre-consumer food waste to compost. The organization has also eliminated the use of Styrofoam and has selected to utilize sugarcane-based compostable containers instead. Additionally, all catering events funded by student fees must be Zero-Waste.

Education: The UMC has placed signs throughout its food service area (and at all catering events) that promote recycling, composting, and reuse of materials.

- *Housing & Dining Services (HDS)*

Purchasing: HDS has committed to purchasing: fair trade, organic coffee; providing organic greens in salad bars; ordering natural ground beef; and purchasing local and organic produce when available.

Waste management: In order to reduce the amount of waste generated in the procurement, production, and disposal of food, HDS has installed pre and postconsumer composting in all dining halls (including pulpers that reduce an estimated 183 tons of potential landfill waste); provides recyclable containers to its customers; collects used cooking oil for biodiesel generated on campus; and has engaged in Zero-Waste catering events (e.g. Global Jam).

Education: In order to effectively compost and recycle resources used in the dining areas, HDS provides regular trainings for all staff members. Additionally, the organization: provides students and staff with posters highlighting sustainable practices and continually updates its web site with ways to "reduce your footprint"; offers fall harvest diners to highlight local and seasonal produce; and holds "scrape-your-plate" events to encourage students and customers to compost.

Sustainable Food Policy Plan

The complexity of the current food system has also led to fractured information among the various producers, distributors, retailers, and consumers. As a result, there is limited data available to accurately analyze the GHG emissions associated with current procurement practices. However, the combination of stricter food regulations and improved communication between distributors and consumers is continually creating opportunities for data-gathering and analysis.

Based on the emerging trend, CU plans to create a campus master food plan within two years of the release of this plan. The plan will include a full life-cycle analysis of the GHG emissions associated with the current food procurement and management processes; as well as, a strategic plan for improving university procurement standards, reducing resource use and waste, and expanding curriculum and educational opportunities around the food and agricultural systems. Examples of potential actions under each sub-section of the proposed plan are detailed below.

Full Life-Cycle GHG Analysis

It is important that the university engage in a full cradle-to-grave analysis of its current food procurement strategies. The chart below depicts a calculation of the food miles for meat purchases made by the UMC over the course of a school semester. Food miles account for at most 11 percent of total GHG emissions for the life-cycle of a product.

Table 19: Total Distance and Carbon Emissions[21] from UMC Meat Procurement (five month time period)[22]

Food Type	Location[1]	Distance[2] (miles)	Fuel Use[3] (gallons)	CO_2 Emissions[4] (lbs)	CO_2 Emissions (metric tons)
Chicken	Westfield, WI	1044.9	204.9	4671.7	2.3
	Springdale, AR	820.3	160.8	3666.2	1.8
	Chattanooga, TN	1307.5	256.4	5849.9	2.9
	Moselle, MS	1343.7	263.5	6007.8	3.0
	Chicago, IL	1018.7	199.7	4553.2	2.2
	Denver, CO	*26.3*	*3.2*	*73.0*	*.03*
	Total	**5561.5**	**1088.5**	**24,817.8**	**12.2**
Beef	Enid, OK	596.4	117.0	2667.6	1.3
	Long Beach, CA	1043.1	204.5	4662.6	2.3
	Kansas, NE	400.0	78.4	1787.5	0.8
	Rochester, MN	896.4	175.8	4008.2	2.0
	Winom, MN	936.5	183.6	4186.1	2.0
	Total	**3824.3**	**819.3**	**17312.0**	**8.4**
Pork	Oscola, IA	674.0	132.2	3014.6	1.5
	Shawnee Mission, KS	623.1	122.2	2786.2	2.3
	Denver, CO	*26.3*	*3.2*	*73.0*	*.03*
	Total	**1323.5**	**257.6**	**5873.8**	**3.8**
Lamb	Hawarden, IA	701.8	137.6	3137.5	1.5
	Total	**701.8**	**137.6**	**3137.5**	**1.5**
Turkey	Downers Grover, IL	996.6	195.4	4455.3	2.2
	Total	**996.6**	**195.4**	**4455.3**	**2.2**
Buffalo	*Denver, CO*	*26.3*	*3.2*	*73.0*	*.03*
	Total	**26.3**	**3.2**	**73.0**	**.03**
Shrimp	Ecuador - Long Beach, CA	1021.9	200.4	n/a 4568.9	n/a 2.2
Tuna	Vietnam – Segundo, CA	1021.9	200.4	n/a 4568.9	n/a 2.2
Salmon	Valparaiso, Chile – Long Beach, CA	1043.1	204.5	n/a 4663.3	n/a 2.3
TOTAL		**15,494**	**3,104**	**66,961**	**33.5**

21 Source of food miles tracking data: http://www.leopold.iastate.edu/pubs/staff/ppp/food_mil.pdf

22 1. The location of the packaging warehouse before the final product is shipped to the UMC.
2. Total distance between packaging location and University (mapquest.com).
3. Total gallons of diesel fuel required in transportation of product; distances over 300 miles were assumed to have used large semi-trailers (5.1 mpg) and distances under 300 miles were assumed to have used mid-size semi-trailers (8.1 mpg) (Bureau of Transportation Statistics).
4. Total CO2 emissions were calculated based on the ratio: 1 gallon of diesel fuel = 22.8 pounds of carbon dioxide (Environmental Protection Agency).
5. Time period: 12/28/08 – 5/9/09

Comprehensive Food Asset Analysis

In order to fully involve the local and regional food production community in a responsible and inclusive way, a comprehensive asset analysis should be pursued in conjunction with the UMC/Dining Services "foodprint" analysis. The expected outcome of such an analysis would be the production of a database of local and regional food producers, distributors and agricultural organizations that CU could partner with upon implementation of new purchasing policies. A working knowledge of local and regional allies will be essential as CU continues towards a more sustainable, less carbon intensive food system.

Institutional Purchasing Policies

After calculating the full life-cycle emissions associated with the university's current method of food procurement, the institution should begin working with all contractors and providers to entertain more environmentally responsible purchases in the future. A potential set of guidelines for institutional purchasing is available in Table 20.

Table 20: Potential CU Food Purchasing Guidelines[23]

	First Tier (ranked in order of preference)	*Second Tier (ranked in order of preference)*
Vegetable Guidelines	Colorado organic Colorado ecologically-grown Regional organic Regional ecologically-grown Colorado conventional (small-scale operation) Regional conventional (small-scale operation)	Colorado conventional (medium-scale operation) Regional conventional (medium-scale operation) U.S. organic (small-scale operation) Colorado conventional (large-scale operation) Regional conventional (large-scale operation) U.S. ecologically-grown (small-scale operation)
Fruit Guidelines	Colorado organic Colorado IPM Regional Organic Regional IPM Colorado conventional (small-scale operation) Regional conventional (small scale operation) Colorado conventional (medium scale operation	Regional conventional (medium scale operation) U.S. organic (small/medium scale operation) U.S. IMP (small/medium scale operation) Colorado conventional (large-scale operation) U.S. organic (large-scale operation) U.S. IPM (large-scale operation) International organic U.S. Conventional
Meat and Poultry Guidelines	Colorado free-range/pasture-fed Colorado organic Regional free-range/pasture-fed Regional organic Regional conventional (small-scale operation)	U.S. free-range/pasture fed U.S. organic (small/medium scale operation) Conventional (small/medium-scale operation) U.S. organic (large-scale operation) U.S. conventional (large-scale operation)

A co-op between the university and local farms in the area would effectively reduce the GHG emissions associated with food transportation and distribution. This relationship would bolster the local economy and fortify strong bonds between the university and the local community. The potential to create partnerships with local farms can be found from analysis of the detailed "food asset analysis" described above. In addition to forming independent co-ops with local farmers, the university should encourage its larger food providers to provide more options for organic, local purchases.

[23] - Adapted from Yale University purchasing guidelines available at: http://www.yale.edu/sustainablefood/food_purchasing.html

Resource Management

All food service operations within the university will coordinate actions to reduce waste, energy, water, and steam use with Facilities Management and the related parties labeled under this climate plan. The immediate installation of energy monitors in kitchens and dining areas is necessary to the completion of a baseline energy use assessment. This analysis will help track progress in subsequent years and ensure the effective use of resource investment.

Education outreach / curriculum opportunities

The development of informed consumers is a crucial first step in the process of alleviating the various ecological and health impacts of the current global food network. For this reason, dining services should continually engage in campaigns and events that increase customer awareness of important food realities and options.

Additionally, CU can support a new food paradigm through the identification of faculty members interested in guiding internships and service/experiential learning models that incorporate agriculture and sustainable food education. One opportunity for educational advancement beyond campus is the "Farm-to-College" program. Overseen by the Community Food Security Coalition, the program offers workshops and conferences that facilitate constructive and collaborative exchange among stakeholders in institutional food systems. Participation in the Farm-to-College program would offer the university a way to reach out into the community and bridge the gap between the farm and the plate. There is also substantial opportunity to extend agricultural and food system knowledge across disciplines.

Additional Benefits of Sustainable Food Policy

As a major stakeholder in the Boulder community, CU has an unprecedented opportunity to influence the local food system in a positive way. Whether through institutional purchasing policies that support local and regional farmers directly or through a conscious effort to increase demand for local agricultural products, CU has the potential to encourage an increase in the availability of fresh, nutritious, sustainable food for all. Additionally, the amount of energy stored in food that is lost during processing, packaging, and transportation can be counteracted through increases in local and organic purchasing.

The community is inherently interconnected and CU must therefore be conscious of the ways in which the university has the potential to affect others. An effective way for CU to build a stronger community would be engage in more direct purchasing from local farmers and businesses. Through revised institutional purchasing policies and increased awareness of alternative consumption opportunities CU can encourage local exchange between the university and food producers. While these connections can aid in the on going process of community building, the local economy is also strengthened by inflows of revenues that would normally be delivered to multi-regional corporations. Additionally, a university commitment to purchase from the local food supply will potentially allow local farmers to engage in more sustainable production practices, as well as, be able to support themselves and their families.

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7 Synergies

7.1 Synergies between Carbon Action and Existing Campus Planning

Synergy is the interaction of two or more elements so that their combined effect is greater than the sum of their individual power or potential.[24] *It is also about the connections between seemingly different plans or approaches and the geometric clout that occurs once they are combined.*

American Heritage College Dictionary, Third Edition, 1993.

Three planning elements have come together to create synergy and connection on campus – adoption of the Presidents Climate Commitment, Flagship 2030, and a campus-wide update to the campus master plan. The Presidents Climate Commitment initiated the process to create a conceptual plan for carbon neutrality. The process brought together a diverse group of participants to develop a plan with specific goals and projects to reach those goals. Many of these goals are closely aligned with Colorado Governor Ritter's executive orders to reduce energy intensity, paper, water consumption, petroleum fuels and to create Zero-Waste construction projects and operations for all facilities.

The University of Colorado at Boulder completed Flagship 2030, the strategic plan that serves as a turning point in planning for the future of the university. This plan creates partnerships "with the public that would reshape the university and better serve the state, the nation and the world." In Flagship 2030 core initiatives require investment in essential service areas that assist the university in remaining competitive in the short-term. Flagship initiatives encourage the university to create innovative programs, ideas and solutions.

Updating the 2000 Campus Master Plan is the third element that completes the synergy and connects the university's current efforts with its creative and innovative future. Building on recent efforts to focus on sustainable construction and renovation of facilities using LEED™ standards, the updated master plan will include a document to address sustainability in an unprecedented way.

Additional documents will serve as the basis for campus-wide changes necessary to accomplish the goals laid out in this carbon neutrality plan. These guiding documents include the ACUPCC goals, waste minimization as a component of the national RecycleMania competition, LEED™ building certification of renovations and new construction, the Energy Star offerings for higher education, Governor Ritter's Greening of the State Government executive orders and the Campus Master Plan.

Using the flagship initiatives as the basis for a decision matrix, this decision matrix will integrate master planning guidelines for future physical development of the campus and overlay the goals, timelines and recommendations from this carbon neutrality plan. These documents will be interwoven using an innovative approach to decision making. The matrix and documents then become extremely powerful tools to lead the campus in the direction of achieving carbon neutrality, focusing decision making on future impacts and benefits, and weaving sustainability into every nook and cranny of campus.

[24] Reinterpretation of "synergy" from *The American Heritage College Dictionary*, Third Edition, 1993.

Currently, the Residential Academic Program (RAP) offers undergraduates a one year residential academic experience with focused and intensive opportunities to explore specific areas of study. Flagship 2030 recommends an expansion of the RAPs to offer the lifelong benefits for a multi-year residential college experience to all undergraduate students. The synergy between Flagship 2030 and the sustainability and carbon neutrality benefits for the campus include:

- Decreasing energy use and costs
- Increasing water efficiencies
- Increasing student sustainability literacy and faculty curriculum connections
- Creating opportunities for a culture of conservation that encourages students to integrate their college experiences and carry them beyond the campus setting
- Creating incentives for public/university transportation solutions with lower carbon footprints
- Enhancing community and neighborhood partnerships
- Assisting in the shift away from parking space management to commuter traveling options

These RAPs can focus on natural sciences, global leadership, community development, conservation and sustainability, and green energy. By using residence hall operations as the real world model for teaching these issues, the university will be able to build upon the extensive conservation outreach programs already underway. Conservation minded RAP students will use less energy and go on to subsequent years on campus with a greater conservation mindset and enhanced mastery of this curriculum.

The opportunity for these students to develop and enhance behavioral conservation measures will cut costs and carbon emissions at the same time as CU grows and graduates more effective leaders for tomorrow. Research and analysis of the efficacy of these synergies will illuminate leading edge behavioral, programmatic, and pedagogical pathways. These are clearly quality outcomes born of synergies across historic campus silos.

Table 19 identifies the Flagship 2030 flagship initiatives, goals from the Presidents Climate Commitment, the update to the campus master plan and the Greening of the State Government and connects them with specific sustainability benefits to the campus.

Table 19: University Resources to Support Strategic Initiatives

Flagship 2030 Initiatives	ACUPCC	Campus Master Plan	Greening of the State Govt	Sustainability benefits to campus
1. Residential Colleges	1.c.ii. interim goals	Building classroom and office space, student housing, capital improvements	20% reduction in energy use	decreased energy use and costs, and increased water efficiencies and reductions
	1.c.iii. curriculum and ed. exp.	Transportation	10% reduc. water consumption	increased sustainability literacy and curriculum connections
	2.d. public transportation	Utilities Infrastructure	25% reduc. vehicle petroleum	creates a culture of conservation students carry forward through college and beyond
		Capital Expenditures		provides incentives for public/university transportation solutions with lower carbon footprint
		Re-inventing Parking and Transportation		enhances community partnerships
				assist in shift from parking space management to creating solutions for moving faculty, staff and students
2. Customized Learning	1.c.iii. curriculum and ed. exp.	Building classroom and instrutional space, academic capital improvements	20% reduction in energy use	opportunity to further enhance CU's reputational assets as carbon action leader
			25% reduc. vehicle petroleum	opportunities to increase sustainability leadership within campus and reaching out to local community
			10% reduc. water consumption	innovative use of space and technology
3. Experiential Learning	1.c.iii. curriculum and ed. exp.	Building classroom and instrutional space, academic capital improvements, and multi-purpose facilities	20% reduction in energy use	broadly based experiential learning creates marketable offsets, enhances community partnerships, fosters economic development
	1.c.iv. expanded research			innovative use of space and technology
				decrease in energy, water and paper use
4. Colorado's Research Diamond	1.c.iv. expanded research	Micro-Master Plans	10% reduc. water consumption	increased efficiencies in energy use, water consumption
	2.d. public transportation	Environmental Management Plan	25% reduc. vehicle petroleum	innovation in technology, use of space and transportation solutions
		Transportation Plan	20% reduction in energy use	foster economic development
		Utilities Infrastructure Plan		opportunity to further enhance CU's reputational assets as carbon action leader
		Reinventing Parking and Transportation		enhance community partnerships
		Building research laboratories and other academic capital improvements		
5. Transcending Traditional Academic Boundaries	1.c.iv. expanded research		25% reduc. vehicle petroleum	interdisciplinary research and creative work including bridges between disciplines
			20% reduction in energy use	opportunities for increased public transportation
			10% reduc. water consumption	
6. Building a Global Crossroads	1.c.iii. curriculum and ed. exp.			opportunities for sustainability literacy and connections with sustainability curriculum
	1.c.iv. expanded research			innovation of technology solutions
				foster economic development
7. Creating University Villages	1.c.iii. curriculum and ed. exp.	Re-inventing Parking and Transportation	10% reduc. water consumption	"University Villages" mixed use plan, reducing carbon footprints and increasing community benefits and partnerships
	2.d. public transportation		25% reduc. vehicle petroleum	Reinventing Parking and Transportation Service
			20% reduction in energy use	opportunities for increased public transportation
				innovation in space and technology solutions
				opportunities for sustainability literacy and connections with sustainability curriculum
8. Alternative Degree Tracks	1.c.iii. curriculum and ed. exp.			options provide opportunities for integrating sustainability
	1.c.iv. expanded research			
9. Year-round Learning	1.c.iii. curriculum and ed. exp.		10% reduc. water consumption	opportunities for sustainability literacy and connections with sustainability curriculum
	1.c.iv. expanded research		20% reduction in energy use	
	2.d. public transportation			
10. Making Enterprise Work	1.c.iii. curriculum and ed. exp.	Reinventing Parking and Transportation	25% reduc. vehicle petroleum	encourage innovation in materials management
	1.c.iv. expanded research		10% reduc. water consumption	opportunities for sustainability literacy and connections with sustainability curriculum
			20% reduction in paper use	foster economic development
			20% reduction in energy use	

7.2 Flagship 2030

Flagship 2030[25] is a twenty-five year strategic plan that focuses on the university's role as a national comprehensive university. The plan provides guidance and direction to the campus as it strives to become the "new flagship university" of the 21st century. A 54-member steering committee guided the planning process, and included faculty, staff, students, parents, alumni, business leaders, community members, government officials and other university stakeholders. Collectively, they created a vision to transform the university. Using a 25 year horizon allows the university's stakeholders to remain unencumbered by current issues and concerns, and focuses the group on future aspirations.

The plan includes both a short and long-term vision. A focus on the short-term resulted in the development of "core initiatives" and the necessity of maintaining core service areas. These initiatives include sustaining quality in research, creative work, teaching, and service by investing in areas ranging from enhancing research and graduate education to improving campus infrastructure and increasing access.

From the long-term perspective, flagship initiatives create a support structure for transforming the university beyond traditional thinking to create a world class educational experience. The flagship initiatives include the 10 items below.

Flagship Initiatives

1. **Residential Colleges.** We will offer a multi-year residential academic experience for every entering student.
2. **Customized Learning.** We will establish the Colorado Undergraduate Academy as a new education model featuring mentored, self-directed, and customized learning tracks.
3. **Experiential Learning.** We will incorporate experiential learning opportunities more broadly into every student's education.
4. **Colorado's Research Diamond.** We will initiate a "research diamond" enterprise, in collaboration with other regional universities, businesses, government, and federal laboratories, helping to advance the university's research mission as well as the state's economic future.
5. **Transcending Traditional Academic Boundaries.** We will build high-level advocacy and incentives for promoting interdisciplinary teaching, learning, research, creative work, and scholarship.
6. **Building a Global Crossroads.** We will bring the world to CU and CU to the world—through a new center for global studies and the expansion of student and faculty exchanges around the world.
7. **Creating University Villages.** We will develop a new concept for the build-out of university properties, emphasizing an education-related, mixed-use approach.
8. **Alternative Degree Tracks.** We will provide a range of options for earning CU-Boulder degrees, with greater emphasis on the master's degree as the primary degree track within 10 years.
9. **Year-round Learning.** We will examine the creation of a year-round campus with an academic calendar of three semesters.
10. **Making Enterprise Work.** We will seek greater operating flexibility and expanded resources for meeting CU-Boulder's role and mission.

[25] Additional information: http://www.colorado.edu/flagship2030/downloads/CUFlagship.pdf.

Flagship 2030 and the core and flagship initiatives were adopted by the Board of Regents in 2007. Following adoption, nine task forces made up of faculty and staff developed initiative recommendations and presented them to the Chancellor's Executive Committee and the Council of Deans. These recommendations now serve as the basis for campus-wide decision making from both the budgetary and programmatic perspectives.

7.3 Campus Master Plan

The campus architect and design staff have begun updating the 2000 Campus Master Plan. Much like the Flagship 2030 strategic plan, campus stakeholders and decision makers will form a steering committee, and subject matter task forces will determine facilities' needs, create a land and facilities plan and develop an implementation plan. This process is expected to be completed by spring of 2011.

Over the past five years, the campus has focused on sustainable construction and renovation of facilities using LEED™ standards. These efforts, combined with an internal shift in focus to one more inclusive of external constituencies, will produce a document addressing sustainability in an unprecedented way. Several of these issues include parking and transportation, gold and platinum LEED™ building and campus infrastructure, and development that will create opportunities fostering ongoing community-wide sustainable development.

As the past five years have resulted in the construction of LEED™ certified buildings, relationships have begun to shift and evolve. The City of Boulder Planning Office and the university's Planning, Design and Construction office have been sometimes caught in adversarial relationships. These relationships have begun evolving into partnerships focused on best results for users.

Parking and Transportation

Ongoing campus construction continues to reduce the availability of on-campus parking and the resulting revenue stream. Additionally, the purchase of student parking permits has declined over the past six years. These two realities will force the re-evaluation of constructing additional parking spaces, the methods used to transport faculty, staff and students between campuses and the impact of campus parking on the carbon footprint for the region, the county, the city and the campus.

Progressive transportation planning can be effective in reducing the campus carbon footprint through continued promotion of alternative modes of transportation. This will become particularly critical as development is considered in locations such as the East Campus, the area north of Boulder Creek, Williams Village and the South Campus. Transportation planning will need to consider and integrate local and regional networks to leverage infrastructure and resources. Related to the issue of vehicular travel is the location of faculty and staff housing. Planning for a greater array of housing options on or adjacent to campus will also have a positive impact on reducing the university's carbon footprint.

LEED™ Building and Campus Infrastructure

Over 80 percent of the campus carbon footprint is attributable to the energy used in or around campus buildings. Because the strategic plan, Flagship 2030, envisions growth based on past growth rates, emphasis needs to be placed on improving energy conservation in existing buildings and energy efficiency in new buildings. This is especially important because many of the growth areas are anticipated to be in the sciences, applied sciences and engineering, whose facilities typically use more energy. Planning efforts will also consider utility infrastructure issues that will impact issues of energy source, efficiency and costs.

Sustainable Development

The master planning process offers an opportunity to explore sustainable development. The university may then serve as a regional model for innovative, efficient and cost effective development driven by the need for sustainability. Issues of density, land use, parking and transportation, environmental sensitivity, water conservation, renewable energy and education will be considered.

7.4 Academic Plans

7.4.1 Curriculum and Other Educational Experiences

The University of Colorado at Boulder is recognized as a national and international leader in the areas of climate and energy science, engineering, policy, law, business, and sustainability. The campus has a cultural legacy of environmental awareness and conservation, and of using new and innovative approaches to demonstrate a less carbon-intensive, more sustainable future. All of this has been grounded in sound research and enlivened through academic discourse. Many existing interdisciplinary centers and institutes, academic programs, conferences, internship opportunities, student groups, peer-to-peer educational programs, service opportunities in the community, faculty forums and workshops, residence life programs as well as the visible campus culture (e.g. operations standards, LEED™ buildings, xeriscaped grounds, and Zero-Waste events) have maintained and furthered these university, faculty, staff and student values. The university's legacy and considerable resources create an obligation to continue but also to excel in research and the preparation of our students for leadership roles essential to facing the climate, energy and societal challenges of the 21st century.

Existing Institutes, Centers, and Initiatives

The University has over 16 existing Institutes, Centers, and Initiatives engaged in energy, environment, and sustainability research, and outreach and education. These include,

the Cooperative Institute for Research in Environmental Sciences (CIRES), the Institute for Arctic and Alpine Research (INSTAAR), the Institute for Behavioral Sciences Environment and Society Program, the Institute for Ethical and Civic Engagement, the Colorado Renewable Energy Collaboratory and the Center for Energy and Environmental Security (CEES), both under the auspices of the Renewable and Sustainable Energy Initiative, the Center for Environmental Journalism, the Deming Center for Entrepreneurship Sustainable Venturing Initiative, the Natural Resources Law Center, the Conflict Information Consortium, and the Center of the American West. These centers demonstrate the breadth of faculty engagement in these most pressing issues of the 21st century, and also the wisdom of CU's history of enabling collaboration among departmental disciplines, research and teaching faculty, and different schools and colleges on the Boulder campus. Indeed, many faculty are members of both a Research Institute or Center and a disciplinary department. This dual-home approach has encouraged faculty to be freely interdisciplinary, and has positioned CU to lead the way in innovative, cross-disciplinary research.

Existing Courses and Academic Programs

Over 24 degree-granting programs exist at the University of Colorado at Boulder that include a focus on energy, climate, the environment, or sustainability. These programs are found in the College of Arts and Sciences, College of Engineering, Leeds School of Business, the College of Architecture and Planning, the School of Journalism, and the School of Law. A few examples include Natural Resources Law, Environmental Journalism, Environmental Studies, Ecology and Evolutionary Biology, Geological Sciences, Graduate Program in Environmental Sociology, Leeds School of Business Curriculum Emphasis on Social Responsibility, Land Use and Environmental Planning and Design, Environmental Engineering, Building Systems Program, and Engineering for Developing Countries. See Appendix 6 for a full listing. In addition, the University offers approximately 10 pertinent Certificate Programs, including: Certificates in Energy (Undergraduate and Graduate); Engineering, Science and Society; Environment, Policy and Society; Western American Studies; Peace and Conflict Studies; Interdisciplinary Graduate Program in Environmental Policy.

Existing Programs for Undergraduates

The University offers a variety of programs that are designed to foster educated and engaged leaders among the undergraduate population. These programs include: the Chancellor's Leadership Residential Academic Program; the Presidents Leadership Class; the Puksta Scholars Program; INVST Community Studies; Baker Residential Academic Program for the Natural Sciences and Environmental Studies; and the Farrand Residential Academic Program in the Humanities integrated with service learning. All of these programs allow students to learn from and collaborate with faculty in small class and small group settings. Many of these programs require student-led projects that focus on issues facing modern society. In addition, there are many opportunities for engagement in research or applied sustainability open to motivated individual undergraduates. These include opportunities to work in research laboratories through undergraduate research programs such as UROP, URAP, and REUs; internships and work-study opportunities with Facilities Management; CU Recycling; and Housing and Dining Services' Sustainability initiatives. Teams of undergraduate students are also involved with furthering CU Boulder's carbon reduction and sustainability goals through faculty/operations staff/student partnerships in courses such as ENVS 4100, Carbon Neutral CU, and ENVS 3001, Sustainable Solutions Consulting.

Existing Student Organizations and Groups

The University of Colorado at Boulder is renowned for its actively engaged student body. There are myriad extra-curricular opportunities that students have created for themselves with an emphasis on the environment, alternative energy and sustainability. First and foremost is the CU Environmental Center, (E-Center), which is the nation's oldest, largest, and most accomplished student-run environmental center. The E-Center has been at the heart of student-led initiatives for environmental responsibility and sustainability since its inception, and has a reputation as a training ground for young leaders in fields of the Environment and Sustainability. The E-Center is overseen by the Environmental Board of the University of Colorado Student Union. Other student-fueled or student run groups that work in the community on environmental energy, and sustainability issues include: Earth Education; Green Teams; CU Wild; CU Community Energy Connections; and Ralphie's Green Stampede. On-campus outreach efforts include CU Going Local, EcoReps, and CU Recycling.

Campus Events

At CU, multiple Centers, Programs, Initiatives, and Departments sponsor a wide range of public events that pertain to energy, the environment, and sustainability. Events just within the last year include: *"Meeting the Global Climate and Energy Challenge,"* the *Renewable and Sustainable Energy Initiative Research Symposium*; conferences such as the *Rocky Mountain Sustainability Summit* and the *Conference on World Affairs* with a keynote by James Hansen; CEES and IBI presented the first *North American Biochar* conference on the science of biochar with a strong focus on the policy and economic dimensions of biochar; and *"ELEVATE! The Future of Development*, *Climate Change and the New Frontiers of Urban Development,"* a jointly sponsored symposium offered by the LEEDS School of Business and the Law School.

Climate Literacy

CU has through CIRES Education and Outreach played a leadership role in developing the Essential Principles of Climate Literacy, which has been reviewed and endorsed by the principals of over a dozen federal agencies involved with the U.S. Climate Change Science Program as a central document in education and communication around the basics of climate science. This effort has also helped inform the "Climate Solutions" curriculum development efforts of the Council of Environmental Deans and Directors (CEDD). An online Climate Literacy course will be offered during the summer of 2009 through CU Continuing Education. Educational experiences relating to environmental and sustainability topics are available to all faculty and students through on-line presentations on Climate Literacy, sponsored by CIRES Education and Outreach, and on Climate Change basics, sponsored by the Environmental Center.

In addition, "*Making Climate Hot: Effectively Communicating Climate Change"* workshops, developed by CIRES Education and Outreach, which focus on the challenges of communicating climate change and the importance of emphasizing climate solutions through energy efficiency and renewable energy technologies. Individual faculty are also developing model units that can be expanded throughout the campus community and beyond. For example, numerous undergraduate courses in ATOC and Environmental Sciences require students to calculate their personal carbon footprint; a course in Writing and Rhetoric on sustainability is currently being tested as a possible model for other writing and rhetoric courses and as a method for reaching all undergraduates; and courses in the Baker and Farrand Residential Academic Programs infuse energy awareness and sustainability into the living and learning community.

Faculty Workshops - Sustainability

In the Spring of 2009, Dr. Geoff Chase of AASHE and San Diego State University, was invited to lead two workshops on Integrating Sustainability Into the Curriculum. The first was open to all participants at the *Rocky Mountain Sustainability Summit*; the second was exclusively for CU faculty. Approximately 24 CU faculty members attended the workshop, representing Environmental Studies, Geography, E-Biology, Political Science, Philosophy, Economics, Communication, Education, Western American Studies, ATOC, Mathematics, Baker RAP, Sewall RAP, Farrand RAP, Program in Writing and Rhetoric, and CIRES. The representation of different disciplines and outlooks was inspiring, especially the attendance of faculty who had not joined previous conversations. Participants showed interest in gathering together on a regular basis to network, provide support and help each other develop grass roots approaches for forwarding sustainability curricula, as well as moving the topic forward among the faculty. One meeting has been held since the workshop, and more are expected. More on the possibility of a Sustainability Initiative at CU follows later in the report.

Next Steps

The University of Colorado recognizes the importance of reinforcing sound science, outreach, and education with programs that encourage behavioral change. Some of these programs target the entire student, faculty and staff population of the university, while others focus specifically on undergraduates or staff. In the spring of 2009, the CU Buffs Live Green Pledge campaign challenged students, faculty and staff to commit to three personal lifestyle changes from a list of actions geared toward reducing their carbon footprint. Pledge signatories agreed to increase their understanding of environmental consequences of personal behavior and to seek sustainable options. The university matched each signed pledge with $5 towards campus sustainability projects that reduce CU's carbon footprint. Other campus-wide behavioral change initiatives include the "*Turn Off Climate Change*" campaign, focusing on energy conservation in lighting; the annual Campus Environmental Awards; and the CU Bike Station which offers free bike maintenance and repairs as well as free loaner bikes to members of the CU community.

Several sustainability programs are targeted specifically for first year students in CU Residence Halls. These extra-curricular opportunities for education and behavioral change are fostered by Housing and Dining Services and Residence Life Departments of Student Affairs some in collaboration with Environmental Center. These programs include: the Zero-Waste post-convocation welcome picnic (Global Jam) for all new students; the *EcoStar* Challenge Hall competition for energy, water, and steam conservation and recycling; the *ChicoBag* program for the elimination of plastic bag use in carry-out meal venues and campus convenience stores; the filtered water station program for reduction of single-use bottled water purchases; implementation of a growing array of natural, organic, and local foods in all dining halls; and a Residence Hall Room Energy Virtual Tour promoting energy saving tips.

The University of Colorado at Boulder's strengths clearly lie in the number of students, research and teaching faculty, administrators, and staff who are actively engaged in energy, climate change, and sustainability throughout the campus. These efforts have grown largely from the interests, visions, and efforts of individuals in the campus community, demonstrating that the people of the University of Colorado remain one of our greatest strengths.

Given this rich historical background, the reality of reaching the point of campus carbon neutrality, and preparing students for the challenges of climate change and past unsustainable practices, requires the university and its faculty to stretch further than in the past to develop innovative approaches for integrating sustainability into the curriculum and working with students, faculty, staff, and the broader community to build more cohesive curricular and extracurricular activities.

Energy and climate change research and initiatives are well developed at the University of Colorado, and can be better integrated into the teaching mission of the university. One main issue for the university on the way forward is that there is little coordination among all existing programs. This is problematic for faculty, who may or may not be aware of potential colleagues in other departments or schools, and for students and staff, and for future reporting, as no one-stop, on-line or office resource for "all things sustainable" currently exists. A university-wide office or coordinator for academic and extra-curricular opportunities would help address this issue, as well as help track the progress of the University in the future.

A second issue is that the university has no program in place for assessing the effectiveness of educational efforts for students. Establishing graduate competency requirements could provide measurable outcomes of our efforts. Such metrics could not only inform the university on its efforts, but also provide critical assessment information for accreditation bodies interested in measurable outcomes. Academic strength in sustainability is less developed, and attention to this area is a goal of the university.

Chancellor's Exploratory Committee on Curriculum

To further the goal of strengthening sustainability in the curriculum, Chancellor DiStefano has approved the establishment of an exploratory committee of faculty members to develop the tenets and plan for a possible sustainability initiative. This committee will be comprised of teaching and research faculty from nearly all the colleges at the university. The chancellor called for this committee based on the following rationale:

1. **A growing need** from society (local, statewide, nationally and globally) to fully explore sustainability, not only the sciences, technology and engineering aspects, but also behavior, ethics, business and other professional schools, policy, expressive arts, and philosophy. Research on campus in the sciences and humanities is strongly related to this topic. There is also a business case that can be made relative to attracting new students to the university. Both traditional and non-traditional students will be involved, creating an opportunity for diversity in the involved student group.
2. **Availability of excellent resources** on campus with over 45 faculty members incorporating "sustainability" into their roles at the university.
3. **A campus-wide initiative** embracing several colleges and forging closer relationships between them. This initiative could truly be a campus-wide initiative.
4. **Opportunities to leverage campus resources**. The City of Boulder and CU-Boulder are "brands" readily identifiable as sustainability leaders. This would provide opportunities to leverage resources on campus beyond faculty, including a strong commitment to facilities, and by the students. Also, the availability of community partners such as NREL and USGS, and NGO's such as the Rocky Mountain Institute, Natural Capital, Inc. and others as well as those in the private sector, create a combination of players and resources not available anywhere else.
5. **Build on Flagship 2030**. This sustainability initiative has the possibility of blending with initiatives identified in the university's strategic plan "*Flagship 2030"* – visions, concepts, linkages and strategies related to international programs, building upon our strengths, unique outreach opportunities, and cross-cutting programs.

Specific charges for the committee include:

- Complete an inventory of campus resources, especially research resources and funding sources, but also including teaching, classes, etc.
- Complete an inventory of leadership programs nationally and internationally, helping to identify and define CU niche/role.
- Develop curriculum options and alternatives related to Sustainability at CU, building upon (not instead of) current strengths (undergraduate certificates, minors, majors, graduate program(s), Program in Writing and Rhetoric, and Residential Academic Programs) and possible funding sources.
- Form faculty working groups: Research and Funding; Undergraduate Certificate; Graduate Collaboration; PWR curriculum; Residential Academic Program/Department of Housing and Dining Living and Learning collaborative efforts; and Outreach and Colorado Engagement options.
- Identify strategic gaps and synergies worthy of investment for multiplier effects.

- Develop an understanding of the economics, and what success looks like for evaluation purposes.

The committee will be formed and convene during the summer of 2009. A kick-off workshop will be offered early during the fall semester. A report including recommendations and next steps will be delivered to the Provost and Chancellor by November 30, 2009. Additionally, faculty have identified the following methods to accomplish infusion of climate change into the curriculum -

- **Assess the current curriculum** as it relates to climate by conducting an inventory and gap analysis of all existing course and other educational experiences available to all students, as well as courses that require prerequisites that relate to climate change and sustainability.
- **Establish a baseline of existing attitudes and awareness of students, faculty and staff** about climate change and sustainability topics in order to develop metrics and strategies to measure student gains.
- **Establish an academic coordinator** whose primary responsibility is to inventory, coordinate, and integrate existing programs across campus, and **to support professional development for faculty for the integration of** CU Boulder energy and climate **research into the classroom**. This could possibly be addressed through the Faculty Teaching Excellence Program (FTEP).
- **Develop campus wide incentives and programs to encourage faculty** across the institution to address sustainability in their courses, such as the addition of sustainability categories on the Faculty Report of Professional Activities (FRPA), support for course development, cross-disciplinary course development, and recognition of such activities on annual evaluations
- **Incorporate measurable graduate competency standards** for undergraduates that relate to climate and energy science (addressed through the science course required for graduation) as well as the social, environmental, and economic challenges that current students and future generations will face in this century and beyond.
- **Accelerate the implementation of student life educational initiatives** related to climate change and sustainability, beginning with new student orientation and continuing through Residential Academic Programs/Flagship 2030, and post-residence campus life.
- **Engage students in city and community activities** that support on-campus, city, county, and state efforts in carbon neutrality and sustainability.

7.5 Research Plans

New technological breakthroughs will be critical to the success of CU's Climate Action Plan and transformation of our global energy future. More than 120 researchers and faculty from the University of Colorado at Boulder work to discover, develop, and deploy cost-competitive and environmentally acceptable energy alternatives and strategies. This work will increase in the coming decades.

Building Systems Program

Recent studies show that one of the most immediate and cost effective strategies for reducing energy consumption and greenhouse gas emissions is improving energy efficiency in commercial and residential buildings. For several decades, CU-Boulder's Building Systems Program (BSP) has been a leader in research on energy efficiency in buildings and in training students to design or renovate buildings to take advantage of this research.

Center for Energy and Environmental Security

The Center for Energy and Environmental Security (CEES) is an interdisciplinary research and policy center within the University of Colorado Law School that focuses on developing practical strategies and solutions for moving society toward a global sustainable energy future. CEES addresses issues of energy security and climate change by anticipating emerging concerns, establishing new lines of inquiry, developing and deploying strategic programs and projects, and charting the territory for responses by government, business, and society.

Center for Research and Education in Wind

Producing electricity from wind energy is a proven technology and deployment of wind turbines is growing rapidly around the world. The Center for Research and Education in Wind (CREW), in collaboration with federal NOAA and NCAR laboratories, conduct research on the production and utilization of electricity from wind. In particular, CREW researchers focus on turbine modeling and testing, power grid modeling, and numerical atmospheric wind models. CREW is a catalyst for research on wind energy production and in bringing this energy to the public.

Center for Revolutionary Solar Photoconversion

The Center for Revolutionary Solar Photoconversion (CRSP) explores a range of new concepts for improving the efficiency and cost of solar conversion. In particular, research through this center focuses on direct, one-step photoconversion into liquid and gaseous fuels and the application of nano-science to solar photoconversion. The center is moving beyond current technologies to make solar energy cost competitive with energy produced from traditional fossil fuel sources. The CRSP was recently funded by the US Department of Energy as part of a joint Energy Frontier Research Center (EFRC) to explore the role of nano-technology in photoconversion.

Colorado Center for Biorefining and Biofuels

In 2007, CU-Boulder joined Colorado State University (CSU), Colorado School of Mines, and the National Renewable Energy Laboratory (NREL) to form the Colorado Center for Biorefining and Biofuels (C2B2). This collaborative center serves as a central point for research on the development of commercially viable, sustainable biorefining and biofuel applications. The center supports a wide range of research, ranging from increased biomass production, to the thermochemical conversion of biomass into fuels and chemicals.

Deming Center for Entrepreneurship

The Deming Center for Entrepreneurship within the University of Colorado Leeds School of Business promotes cutting edge research and development in entrepreneurship, with a particular focus on sustainable ventures. The center supports the Sustainable Venturing Initiative (SVI) which provides educational and research opportunities in renewable and sustainable energy technologies. Research within this center has lead to the development of businesses like Sky Energy and Rocky Mountain Sustainable Enterprises.

Renewable and Sustainable Energy Initiative

The University of Colorado's Renewable and Sustainable Energy Initiative was launched in 2006 to provide a central point for the wide-ranging energy and climate related research occurring at the university. The initiative is a strongly interdisciplinary program that integrates university research on renewable energy with climate and environmental science, behavioral studies, policy analysis, and entrepreneurship. The three-pronged approach of discovery, transformation and entrepreneurship helps innovative research become commercially viable leading public benefit.

To encourage the rapid growth of interdisciplinary and collaborative research, the Renewable and Sustainable Energy Initiative, in cooperation with National Renewable Energy Laboratory (NREL) sponsors an annual seed grant competition. Seed grant funds are committed to innovative partnerships in novel energy research areas with the goal of developing new research thrusts for the campus.

Solar Decathlon Team

The CU Solar Decathlon Team participates in the US Department of Energy's Solar Decathlon competition to design and build a solar powered, energy efficient house. The purpose of this competition is to promote the development of energy efficiency and solar energy technology while providing an educational opportunity to engineering and architectural students. The CU team won the competition in 2002 and 2005 and placed 7th in 2007.

7.6 Existing Programs and Policies

The University of Colorado at Boulder has an extensive and successful history of sustainability initiatives and leadership. Students on the CU-Boulder campus were the first in the country to establish an Environmental Center (1970), a campus recycling program (1973), a bus pass program (1991), and purchase renewable energy credits from wind power (2000). CU became the first major athletic program to implement a Zero-Waste goal in a NCCA Division One sports stadium (2008). Many entities, campus community organizations and administrators have been at the forefront of CU's sustainability initiatives and the dedication to greening the institution has become more established and customary in recent years.

Energy Supply

A variety of renewable energy sources are currently being explored for both small scale and utility scale direct applications. Solar photovoltaic arrays are currently being finalized for installation on Coors Event Center, the Law School, Housing Maintenance, and the Mountain Research Station. Additionally, feasibility studies are underway to assess the application of ground source geothermal systems and biomass systems for the expansion of Williams Village and the build out of east campus. CU has also allied with several other Colorado institutions of higher education to explore the provision of wind energy from a potential future wind farm at Walker Ranch, an extension facility managed by Colorado State University. Additional opportunities are also being evaluated for possible installation in south campus, as appropriate.

Energy Conservation

Efforts to reduce campus energy consumption and increase the use of renewable energy are the core mission of the university's Energy and Water program, managed through a partnership between the Environmental Center and Facilities Management. In 2001, the CU administration set a goal to reduce campus energy use by 5 percent annually. Since the onset of the program, CU has realized a significant shift in energy use and has saved the campus well over $2 million in energy cost over the subsequent four years.

In 2002, the Office of Energy Conservation was established, and energy efficiency was identified as a top priority in reducing campus greenhouse gas emissions. University administrators and policy makers recognize the role that the campus community plays in achieving an energy efficient campus. The Energy Program harnesses the energy of Environmental Center student staff and volunteers to educate the campus community on simple ways to conserve energy and reduce GHG emissions. "*Turn off the Juice When Not in Use" c*ampaign and a "*Turn Off Climate Change*" have been launched around the campus in order to make the campus energy conservation movement visible and information accessible to the community.

Efforts that have resulted in increased energy conservation and reduced electrical energy use include:

- The re-commissioning of all campus building's HVAC systems to optimize performance
- Weather stripping windows in older buildings
- The addition of insulation to campus steam and chilled water distribution networks
- New high pressure steam traps
- The installation of smart master steam valves to regulate steam flow to several building based on outdoor temperature
- Campus lighting upgrades and lighting occupancy sensors in large labs and classrooms
- The update and expansion of the Building Automation System (BAS) software for temperature set back after hours, weekends and holidays (the campus wide number of BAS points has increased from 10,000-12,000 in FY05-06 to approximately 55,000 points)
- Desktop computer power management/sleep mode
- Vending machine power management
- A 95 percent campus wide conversion to compact florescent lighting (the remaining 5 percent is special purpose lighting for museum and theater needs)
- Ice/snow melt control system altered to more precisely monitor and correlate operation to outdoor conditions
- The introduction of Rational Combi ovens to Dining Services to increase efficiency and energy savings due to reduced cooking time
- Instituted a program for family housing turnovers to caulk and seal all units as well as provide energy conservation tips to new occupants
- All campus design standards require LEED Silver certification or higher for all new building and major restoration construction projects

The *EcoStar Challenge* fielded by Housing and Dining Services is a conservation competition between halls to reduce consumption of electricity, water, steam and trash (through increased recycling) from the same period from the previous year.

The *EcoStar Challenge* promotes sustainability within the residence halls and is part of CU's culture of progressive action when it comes to the environment and climate change. The program encourages students and staff to use what they need, not waste resources and reuse/recycle everything. Results from this program are represented in Table 20.

Table 20: EcoStar Challenge Results on HDS Utility Costs and Emissions

HDS Utility Cost and Emission Summary FY09									
	Consumption FY08	Consumption FY09	Difference	% Change	Emissions FY08 Lbs	Emissions FY09 Lbs	Difference	CO2 Ton Reduction	Cost Change
Electricity (kWh)	20596919	20168941	-427978	-2%	38928177	38119299	-808878	-404	$ (4,644.84)
Water (Kgals)	116610	108416	-8193	-7%	186575	173466	-13109	-7	$ (69,478.93)
Steam (kLbs)	116580	116110	-470	0%	13290119	13236558	-53561	-27	$ (10,481.93)
Natural Gas (Therms)	441460	413260	-28200	-6%	5120936	4793816	-327120	-164	$ (20,586.00)
Chilled Water (Ton Hrs)	879259	782293	-96966	-11%	1230963	1095210	-135752	-68	$ (35,755.31)
						28709		-669	$ (140,947.01)

Policy

In 2007, Chancellor Bud Peterson signed the American College and University Presidents Climate Commitment (ACUPCC). By becoming an ACUPCC signatory, Chancellor Peterson committed CU to the development and implementation of a comprehensive plan to reduce its carbon emissions that include:

- An annual greenhouse gas audit for the university
- Two or more short term 'tangible actions' that demonstrate CU's commitment to results and begin addressing the issue
- Specific targets and timelines to achieve climate neutrality at a pace and manner that maximizes the opportunities for CU
- Sharing CU's commitment plans and progress reports to facilitate and accelerate progress for its fellow institutions and society (ACUPCC 2008 Annual Report)

In 2007, CU opted to support Governor Bill Ritter's *Greening of the State Executive Order*. Per its voluntary compliance with the Executive Order, CU has instituted policy and programs to achieve the following goals:

- By FY2011-2012: to achieve a 20 percent reduction in energy consumption based on FY2005-2006 levels
- As of January 2008: to develop or update an energy management plan and ensure development of a study determining feasibility of energy performance for all state-owned facilities
- On an ongoing basis, assess and implement, where effective, the development of state renewable energy projects with the support of the Governor's Energy Office
- By FY2008-2009: develop a purchasing policy to reduce the state's environmental impact as a consumer of products and services
- Adopt a goal of Zero-Waste from construction of new buildings and operation, and renovation of existing facilities
- Achieve a paper use reduction goal of 20 percent by FY2011-2012, using FY2005-2006 as a baseline
- The development of purchasing policies for the selection and usage of environmentally preferable products by the Department of Personnel, in cooperation with the Department of Public Health and Environment

- By June 30, 2012: achieve a 25 percent volumetric reduction in petroleum consumption by state vehicles, based on FY2005-2006 baseline numbers, while increasing energy efficiency of the fleet (excluding vehicles used for law enforcement, emergency response, road maintenance, and highway construction)

In the interest of applying dedicated student funds toward programs with the greatest environmental and social benefit, CU's Environmental Center has allocated a portion of student funds to go toward buying credits from Colorado-based emission reduction projects in Governor Ritter's recently created Colorado Carbon Fund (CCF). These credits will enable CU to create not only environmental benefits but also local, social benefits by stimulating capital projects in Colorado.

In 2005, based on the student capital construction fee and mandate, campus leadership decided to use Leadership in Energy and Environmental Design (LEED) as green and sustainable design and construction standards for student-funded buildings. Campus Design and Construction standards were upgraded to meet LEED-Gold and LEED certification became CU's focus for the design and construction of new capital construction projects. Designing and constructing a building to a LEED Gold level signifies 20-30 percent higher water and energy efficiency with comparison to a building that meets current building codes and common design and construction standards. LEED certified construction projects divert significant portions of waste from landfills, taking an important step toward the Zero-Waste construction goal.

Since adopting LEED standards, CU has achieved a LEED Gold rating for the new Wolf Law building, ATLAS buildings and the Koelbel School of Business addition and renovation. CU is currently working on sustainable design and LEED Gold level certification for the future Visual Arts complex as well as for the renovation of Arnett Hall.

CU has and will continue to adopt Green Purchasing initiatives and policies that fall under the Environmentally Preferable Purchasing (EPP) Guidelines. Through these guidelines, the university gives preference to environmentally friendly products whose quality, function, and cost are equal or superior to traditional products. Considerations such as raw material acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, and disposal of the product are considered when selecting a product. Green Purchasing standards include:

- In support of a recently enacted campus policy of purchasing Energy Star appliances, the campus energy conservation office will be announcing support for the above policy by considering budgetary support for validated monetary premiums for Energy Star purchases.
- CU purchased Green Seal certified foaming hand soap, and jumbo toilet paper containing no less than 80 percent post-consumer paper content.
- The university will add a resource conservation section to "*Ralphie's Guide to Student Life*" to include recommendations to buy green products and Energy Star devices.
- Housing and Dining Services will optimize their purchasing system to prioritize the purchase of the most energy efficient products possible.
- Facilities Operations and Housing and Dining Services will specify the use of low-VOC paints, and carpet with recycled content.
- A vendor change to Ecolab, in order to provide more environmentally-friendly packaging for dining operations.
- A continuation of the Environmentally Friendly Turf Management plan to reduce the use of pesticides and herbicides on campus property.

- A continued effort in Integrated Pest Management to minimize the use of chemicals and pesticides.

The Energy and Climate Revolving Fund (ECRF) was established in 2007 for use in UCSU facilities. This (one time) $500,000 fund supports projects that will save energy and energy costs—and repay the entire ECRF in less than five years. Audits of the buildings were completed in January 2009. The audit findings will prioritize additional projects with projected good paybacks.

CU's Environmental Center administers *Sustainable CU: The Environment Improvement Initiative*. In the spring of 2005, students voted on the Sustainable CU Referendum, which dedicates $2.80/student/semester to implement on-campus projects incorporating renewable energy, energy efficiency, recycling and waste reduction, and other innovative projects that reduce the campus' impact on climate and environment. Sustainable CU funds are specifically for the following: capital investment for the purchase of infrastructure necessary for the initiatives, installation of capital projects, educational displays related to the capital projects, and any other non-staff operating costs associated with the initiatives.

In the spring of 2004, the University of Colorado Student Union voted to create a new fund for energy and renewable energy projects in the three student-owned buildings on campus—the Wardenburg Health Center, the University Memorial Center and the Recreational Center. The Energy Efficiency Fund allocates approximately $108,000 a year plus 35 percent of projected energy savings for projects from the previous year to go toward capital improvements for a minimum of five years.

Materials Management

CU's Environmental Center started a campus-wide recycling program in 1973. It has since, in partnership with Facilities Management and Housing and Dining Services, grown to become one of the nation's largest and most successful recycling programs, earning awards from the Governor's Office of Energy Conservation, the Environmental Protection Agency, Renew America, and other organizations. The majority of the CU community participates, and the recycling program diverts 1,900 tons or approximately 35 percent of the campus waste stream from landfills annually. The amount of material landfilled has trended downward for the last three years. In 2006, a Diversion Potential Assessment reported that over 850 tons of recyclable paper continues to be landfilled by CU-Boulder and that CU could effectively double its recycling rates.

Some of the existing projects that continue to reduce campus waste and increase diversion of reusable, recyclable and compostable materials include:

- The commitment to Zero-Waste Events (Zero-Waste is defined by CU as an attainable end goal, which currently results in far less waste than if an event was planned without any waste reduction strategy). UMC Food Service catering, the *Global Jam* (an event welcoming first year students), and many other campus events implement Zero-Waste.
- *Ralphie's Green Stampede*: Zero-Waste Program for Athletics was a notable achievement of the 2008 football season. A combination of CU's internal commitment, strong vendor involvement, and effective outreach and external relations set a new standard in "sustainable stadiums" as CU rolled out its Zero-Waste program for home football games. Some of the 2008 highlights included:

- Over 40 tons of recycles and compostable materials were collected (188 percent more than the previous year)
- New materials were diverted for the first time from Folsom Stadium, including over 14 tons of compostable food and biodegradable packaging. A portion of the finished compost will be used at CU
- Fry oil from the prep was re-refined for the first time. Over 300 gallons (2,500 pounds) were converted to biodiesel to be used in CU's recycling trucks
- Inside the stadium, public trash cans were replaced with recycling and composting containers
- Approximately 80 percent of all materials generated inside the stadium were diverted from landfills

- Paper use reduction:

  - Mailing Services recycles all undeliverable standard class bulk mail, and has pioneered paperless mail at CU by developing and implementing the campus E-memo and Buff Bulletin systems. Mailing Services hopes to remain at the forefront of the campus move to paperless communications.
  - Waste reduction practices promoted to CU office users include double-sided copying and the use of interdepartmental mailing envelopes, advanced voicemail, e-memos, and Imaging Services print-on-demand capabilities.
  - CU's Environmental Center and Facilities Management monitor excessive amounts of print overruns that enter the Integrated Processing Facility (IPF) for recycling. Departments are provided with information about waste reduction options on campus.
  - A continued effort to seek an alternative to "astrobright" paper and enforce campus guidelines to avoid use.
  - Materials Management recently implemented a new software system to reduce the amount of paper used for purchasing/material requests on both the ordering and billing sides of the process.
  - The Distribution Center recently converted to electronic time-off requesting and approval.
  - Property Services recently automated the billing process for their moving and hauling function.
  - In 1992, the Office of the Registrar accomplished paperless course registration for almost all students when a telephone service replaced paper. In 1998, online registration replaced the telephone process. In 2003, electronic student address change was employed, reducing annual paper consumption by at least 500,000 pieces (100 cases). In the fall of 2007, additional paperless innovations were implemented, resulting in further reductions of approximately 13,200 pieces per year.
  - Payroll and Benefit Services (PBS) converted to electronic distribution of employee pay advices in April 2008, reducing paper consumption by approximately 485,000 pieces (97 cases) per year.
  - The Office of the Bursar is transitioning to paperless billing of student tuition that will be fully in place by Summer Session 2009. Electronic billing and payment acceptance is projected to reduce paper consumption by at least 400,000 pieces (80+ cases) per year.
  - The campus initiated a very successful pay-for-printing at public computer labs

- Property Services receives thousands of surplus items from campus departments annually, including electronics, furniture, office equipment and various educational, athletic and laboratory items. In an average year, Property Services facilitates the return of more than 3,100 items to useful life in a new place on campus
- Property Services processes over 230,000 pounds (per year) of surplus electronics and metal considered to be “trash.” 99 percent of these items are recycled rather than sent to landfills
- Property Services facilitates the donation of hundreds of computers, computer-related equipment, shoes and furniture to non-profit organizations and schools
- In 2007, Property Services initiated the use of ExpandOS as a substitute for Styrofoam for packing peanuts. The new product is as lightweight as Styrofoam and roughly the same price, but it is made from recycled paper and can be recycled again after use
- 8,665 cases of 100 percent recycled content paper are distributed to various departments annually
- Scrap wood from shops and work areas is transported to the composting area grinder to be used as mulch or compost
- Renewing feasibility of recovery and recycling discarded items from student residence hall move-out
- A continued promotion of the use of reusable cups by students, staff and faculty

Transportation

A sustainable transportation partnership between Parking and Transportation Services and the Environmental Center manages the transportation demand of the campus to achieve goals set forth pertaining to carbon neutrality, congestion mitigation and social justice. This program facilitates car-pooling, marketing alternatives, right-sizing and greening fleets, idling reductions and more. The student bus pass, faculty/ ECO pass and the bicycle programs are a few of the cornerstones of the university’s sustainable transportation initiatives. Currently, over 90 percent of CU students arrive at campus by using alternative transportation options.

In 1991, CU became one of the first campuses in the country to vote on and pass a referendum for pre-paid full service bus passes, allowing CU students, faculty and staff to ride campus, local and regional bus transit supplied by the university and Regional-Transit Denver. The buses owned and operated by CU burn biodiesel fuel.

The bicycle program was created in 2002, and is funded by self-generated revenues within the student bus pass program and by Parking and Transit Services. Key areas of the program include: upgrading and expanding campus bicycle parking; providing interest-free loans for bicycle purchases; providing free bicycle checkout services for students, faculty and staff; managing the bike station; and the construction of safe, legal bicycle corridors throughout the campus. On a typical day, 26 percent of student commuters arrive at campus by bicycle.

A second bike station will soon be under construction. A temporary, working location is projected to be completed in the spring of 2010. The final location is projected for completion the spring of 2011. If plans are approved the building will be explicitly zero-energy, drawing only from what it can generate from its roof through solar panels. The building will conform to campus building standards and contribute to a more comprehensive, sustainable transportation network for the campus community.

Special Transit, a private, non-profit organization in Boulder, is an important partner of the Sustainable Transportation Program. The organization operates a late night/early morning bus service for CU students throughout the school year.

A SkiBus runs regularly throughout the ski season.

Behavioral Conservation

CU, in partnership with the student government's Environmental Center and other campus and community organizations, sponsors a variety of successful environmentally educational events and programs on campus and beyond.

2008-2009 **events i**ncluded:

- BikeBash
- Bioneers Conference
- CU's representation at AASHE
- Earth Day events and Film Festival
- Energy Awareness Day
- National Teach-In on Climate Change
- Recycled Products Expo
- RecycleMania
- Rocky Mountain Sustainability Summit
- Scrape Your Plate Day
- Sustainable Transportation Festival
- The Impacts of Global Warming on Women and Poverty, a Series on Climate Justice

2008-2009 **programs** included:

- A Live Green Pledge
- Buff Energy Star Program
- CFL swap
- Community Energy Connections
- Student Orientation Programs on Conservation
- Earth Education
- EcoLeaders
- Environmental Justice
- Green Office Certification and Pledge Program
- Ralphie's Green Stampede and Zero-Waste Events (i.e., Global Jam)
- Residence EcoStar Challenge

7.7 Reaching a Carbon Neutrality Date

*"What we do in the next two to three years
will determine our future."*

Rajendra Pachauri, IPCC Chairman, November 2007

The concept of carbon neutrality is best thought of as a powerful incentive for aggressive short term action. The university's plan sets out challenging but achievable short term goals that will alter CU's carbon emissions trajectory towards a tangible neutrality point as soon as possible. As CU implements these short term actions, long term carbon projections will be revisited. The goal for each review will be to forecast a credible and technically feasible carbon neutrality date.

While the purchase of carbon offsets would close the gap to neutrality at any point, diverting investment into offsets would eliminate funding for infrastructure and programming that can deliver sustainable emissions reductions for the short and long term. Accordingly, the university decided that offsets will not be considered as a viable mitigation tool.

The lessons of the Kyoto Protocol teach a more focused and performance-based approach to attaining carbon neutrality. Instead of setting long term deadlines that may inspire procrastination, an emphasis on short term action and transparent performance monitoring underpins this plan. The university will be judged not by the distant date declared as the neutrality point our successors must fulfill, but by the achievements made in the short term. In doing so, excuses for inaction are eliminated. Deferring to a distant date is not possible when deadlines loom even as this report is written.

Yet, in focusing on robust short term action, we are embracing and accelerating our ultimate neutrality date, not eschewing it. Indeed, all of higher education and the society the university serves is moving from this age of promises into a new age of performance. This plan is a performance plan, not a promise. This plan seeks to inspire the best within us now to effect aggressive action today. And those actions have already begun.

8. Conclusion

"When a storm rolls in from the west on the Great Plains you can see it coming for miles. My people have noticed that when domesticated animals see the storm coming they turn sideways to it. By doing so they turn their gaze away from the threat and can resume grazing without being anxious. The Buffalo, on the other hand, knows that the Creator has blessed him with wide shoulders and sturdiness. So the Buffalo turn to face the storm."

Native American parable[26]

The pledge to meet the President's Climate Commitment has led the University of Colorado at Boulder through a complex and exhaustive process. Originally, efforts focused on the need to determine a date by which the campus would reach carbon neutrality. However, as the process evolved the focus integrated the longer view of establishing a set carbon neutrality date with shorter timelines (2012, 2030) and immediate tangibles that will set the stage for meeting this goal.

Specifically, the shift in focus has created opportunities for synergy between Flagship 2030, the Campus Master Plan, the Governor's Greening Government Goals and the Conceptual Plan for Carbon Neutrality. Using Flagship 2030 "flagship initiatives" as the basis for decision-making, these other plans and goals integrate more easily. A decision matrix demonstrates the relationships between different planning documents and creates a framework to take advantage of synergies.

For instance, the Flagship 2030 recommendation for expansion of the Residential Academic Programs (RAPs) highlights opportunities for synergy between the academic benefits for students and the gains made by the entire university. The goals of an updated master plan and implementation of projects to meet carbon neutrality mesh easily with this RAP flagship initiative. Instead of creating three long lists of goals and projects that exist in isolation and could potentially be at cross purposes, the plans have been combined to create a result that is greater than the sum of its parts.

However, the mechanisms and pathways that create efficiencies between this plan, Flagship 2030 and the update to the campus master plan have not been well established. Success of all three plans may depend on the wise development, careful fine-tuning, and wise implementation of such strategies. Further efforts to focus on those points of leverage should follow this work.

The university's ability to harness these synergies will define this campus and differentiate it from its peer institutions. Rankings and comparisons between institutions have begun to incorporate measures of sustainability and climate action that include carbon neutrality work as a baseline. The campus should focus on implementing crucial climate sustainability practices in order to maintain the university's student recruiting edge.

The university's unique scientific and intellectual assets coupled with Colorado's robust New Energy Economy further CU's mandate to provide advanced leadership, which has proven to be an extremely effective tool for faculty and staff recruitment. Mindful of the legacy of leadership provided by this

[26] From "Ethical Leadership: In Pursuit of the Common Good," by Bill Grace, Center for Ethical Leadership, Seattle, WA, 1999, ISBN 1-892042-01-0

institution, successful implementation of this plan's recommendations is extremely critical. Placing an emphasis on short-term action horizons, pursuit of utility-scale renewable energy and mitigation of supply-chain carbon emissions fuels a whole host of unexplored opportunities.

The plan also outlines multiple pathways to mitigate all forms of carbon risk faced by this university, our state, and the broader global community. Following these pathways delivers benefits on every level. As global climate change progresses, inquiries into CU's efforts will also increase. If CU executes the elements of this plan, it will hedge direct financial risk while contributing directly to mitigating the symptoms of climate change. Thus, CU furthers its public service mission on every level.

Work called for by the plan is underway even before this report is fully drafted or published. The campus community has essentially called itself to action. Knowledge that the subjects covered here are significant is the catalyst for immediate action and continued leadership.

In conclusion, the Conceptual Plan for Carbon Neutrality and its recommendations offer a strategy and specific tasks for the university to employ to pursue campus carbon neutrality. The plan identifies several goals to be achieved in the long-term and divides those long-term deadlines into three year plans, all aimed toward achieving carbon neutrality as soon as feasibly possible. Both the short and long-term goals are integrated into the flagship initiatives as the basis and all of the additional campus planning documents become components of and aligned with objectives. This is a rare opportunity for people across the campus, community and region.

Ultimately though, this plan documents a living, breathing process, carried out by students, faculty and staff. That coalition has led this university to the leadership position we enjoy today. That coalition must now raise its standards of effectiveness and execution to match the new challenge before us.

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9 Appendices

9.1 Appendix 1 – CU GHG Emissions Worksheet

2007/2008

SCOPES 1 AND 2

ENERGY USE IN BUILDINGS	Collected units	Quantity	Converted Units	Quantity	CO2 factor (lbs/unit)	Total CO2 (lbs)	Total CO2 (tons)	Total CO2 (Metric tons)		
Steam (heat, hot water, chilled water)			Dth	980,069	116.41	114,089,832	57,045	51,751		
Non-steam Natural gas	therms	895,486	MMBtu	89,549	116.41	10,424,353	5,212	4,728		
Electricity			kWh	93,623,046	1.88	176,292,196	88,146	79,966	%	
Total CO2						**300,806,380**	**150,403**	**136,446**		98%
Building sf						**9,685,160**	**9,685,160**	**9,685,160**		
Total CO2/sf						**31.0585**	**0.0155**	**0.0141**		

ENERGY USE IN TRANSPORTATION	Collected units	Quantity	CO2 factor (lbs/unit)	Total CO2 (lbs)	Total CO2 (tons)			
B20 biodiesel	gallons	52,570	17.9	941,003	471			
Unleaded gasoline	gallons	103,455	19.38	2,004,958	1,002			
Diesel	gallons	8,519	22.38	190,655	95		Metric tons	
Total CO2					**1,568**	**1,568**	**1,423**	1%

EMISSIONS FROM REFRIGERANTS - HFCs	Collected units	Quantity	CO2e factor (tons/sf)	Total CO2e (tons)			
Cooled building space (s	sf estimate	1,500,000	0.00092	1,380		Metric tons	
Total CO2				**1,380**	**1,380**	**1,252**	1%

			CH4		N2O				
ENERGY USE IN BUILDINGS - DE MINIMIS GASES	Units	Quantity	CO2e factor (lbs/unit)	Total CO2e (tons)	CO2e factor (lbs/unit)	Total CO2e (tons)			
Total natural gas	MMBtu	1,069,618	0.24	128	0.06	33			
Total electricity	MWh	93,623	0.55	26	8.88	416		Metric tons	
Total CO2				**154**		**449**	**603**	**547**	0%

Totals	**153,955**	**139,668**	100%

SCOPE 3

AIR TRAVEL	Units	Quantity	CO2e factor (lbs/unit)	Total CO2e (tons)	Total CO2 (Metric tons)	Total CO2e (tons)	Total CO2 (Metric tons)
Total miles travelled (FY	miles	36,469,430	1.71	31,181	28,288		
Total CO2				**31,181**	**28,288**	**31,181**	**28,288**

STAFF FACULTY COMMUTING	Units	Quantity	CO2e factor (lbs/unit)	Total CO2e (tons)	Total CO2 (Metric tons)		
Car	miles	23,408,604	0.89	10,417	9,450		
Bus	miles	554,836	0.56	155	141		
Total CO2				**10,572**	**9,591**	**10,572**	**9,591**

STUDENT COMMUTING	Units	Quantity	CO2e factor (lbs/unit)	Total CO2e (tons)	Total CO2 (Metric tons)		
Car	miles	11,333,940	0.89	5,044	4,576		
Bus	miles	1,882,878	0.56	527	478		
Total CO2				**5,571**	**5,054**	**5,571**	**5,054**

SOLID WASTE	Units	Quantity	CO2e factor (tons/unit)	Total CO2e (tons)	Total CO2 (Metric tons)		
Tons waste to landfill (with methane capture	tons	4,215	0.31	1,307	1,185	Total CO2e (tons)	Total CO2 (Metric
Total CO2				**1,307**	**1,185**	**1,307**	**1,185**
Total Scope 3						**48,631**	**44,118**
Total all sources						**202,586**	**183,786**

Changes to original inventory

- 12/1/2008 Updated air travel factor for converting travel dollars to miles ($.25/mi updated to $.13/mile)
- 4/23/2009 Added new natural gas numbers from Bryan Birosak (PP); replaced engineered steam number with total NG used at plant
- 4/23/2009 Subtracted electricity produced in cogen (31m. kWh) from total campus consumption; production data from Doug Ryan at Xcel
- 5/18/2009 Update to electricity carbon intensity factor using 2005 (2008 release) eGRID factor.
- 5/18/2009 Update to Car commuting factor, compliant with version 6.3 of CACP Campus Calculator
- 5/18/2009 Update to solid waste factor, compliant with version 6.3 of CACP Campus Calculator

Factor sources

Air travel emissions $/mil http://www.airlines.org/economics/finance/PaPricesYield.htm

9.2 Appendix 2 – NREL Letter and CU's Response

NREL
National Renewable Energy Laboratory
Innovation for Our Energy Future

March 30, 2009

Ann Livingston
Sustainability Coordinator
Boulder County
PO Box 471
Boulder, Colorado 80306

Dave Newport, Director
Environmental Center
University of Colorado at Boulder
University Memorial Center 355
Boulder, CO 80309-0207

Dear Ms. Livingston and Mr. Newport:

Per your request under the Technical Assistance Project approved March 21, 2008, NREL has conducted a review of CU_Carbon_Model_V1.8, as received on March 5, 2009. The review was conducted by the NREL review team, comprised of Otto Van Geet, PE, Dan Bilello, and Shannon Cowlin.

Overall, we found the model logic to be straight forward, transparent and algebraically accurate. The model's architecture is well crafted, and base assumptions, excluding a few points cited in the attached Appendix, were found to be reasonable and reflective of industry practices. We have discussed our initial findings with the CU modeling team and believe they are responding appropriately.

We would be pleased to answer any further questions or provide additional input or recommendations upon request.

On behalf of the NREL review team, we appreciate the opportunity to provide technical assistance to Boulder and CU during the past year, and also appreciate the opportunity to review and comment on this carbon mitigation planning tool.

Sincerely,

Douglas Arent
Director
Strategic Energy Analysis Center

Cc: Misty Conrad, NREL
Julie Riel; DOE

1617 Cole Blvd. • Golden, CO 80401-3393 • (303) 275-3000 • NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC

CNWG RESPONSE TO NREL'S COMMENTS

April, 2009

NREL's comments and recommendations and CU's responses are listed below:

Model Description & Color Codes page:

1. NREL: We would suggest considering reductions in metric tons of CO2e to be consistent with current and emerging protocols. This is particularly relevant if the U.S. moves toward development of domestic and international market harmonization.
    a. *CU: All carbon values will be reported in metric tons of CO2e.*

***Parameters and assumptions page**:*

2. NREL: Biomass boilers are given an emissions rate of 0, which seems a bit optimistic and will depend on if CU secures the GHG reductions from the use of this resource. Also, net emissions from a biomass powered source may be argued to be non-zero, as the transportation of the biomass is a specific additionality for this application. We suggest at least adding transportation energy. To obtain a reasonable estimate for this value, the wood chip heating plant in Boulder should be able to provide transportation information for woodchips. NREL can provide transportation information for of our wood chip heating plant upon request.
    a. *CU: Consistent with the intent of the model, Scope 3 emissions are not being projected. As such, we do not have the capacity to include third party transportation emissions associated with transporting biomass fuel. We are mindful of and will continue to monitor Boulder County's plan with respect to potentially developing the biomass as a carbon offset in the future. In that case, we would be unable to claim it as a carbon neutral fuel.*
3. NREL: Starting at row150, there are values associated with the Governor's Executive Order. These values are then used on the Building Energy Use page to compute the estimated electricity and steam use in buildings, but the details of reaching these reductions are not apparent in the documentation nor specified in the model.
    a. *CU: These project write-ups are being completed and modeling techniques are being developed.*
4. NREL: It would be helpful to explain the discrepancy between lines 12 and 13, the 2005 emissions rate (lbs CO2/kWhr) and if material to the results.
    a. *CU: Line 12 is actual eGRID data. Line 13 is an estimation of the same emission rate given the generation portfolio summarized in eGRID (rounding discrepancy). The estimation approach is propagated through the model as a forecast where the anticipated portfolio changes can be used to forecast lower future emission rates.*
5. NREL: Line: 71: fixed tilt PV at 20 deg requires 6 Acres per MW, not 10, as used in the model.
    a. *CU: This estimate was thought to be a conservative selection based on the attached DOE poster tabulating existing flat panel PV projects. The one that stands out as a fixed array (in Portugal, similar latitude to Colorado) uses 13.6 acres per MW. The Alamosa, CO*

plant, which employs a combination of 1-axis and 2-axis tracking uses 82 acres for 8.2 MW (http://www.renewableenergyworld.com/rea/news/article/2007/04/ground-broken-on-sunedisons-8-22-mw-pv-solar-plant-in-colorado-48245).

6. NREL: Using PV Watts, the annual PV output is at 20 deg = 1400 kWh/kW. This is the same as a capacity factor (CF) of 16 percent . 16.6 percent CF is assumed on line 69 (minor).
    a. *CU: This PV Watts run was at the recommended value of 40 deg (per 40 deg latitude).*
7. NREL: We recommend reducing off site RE (wind) production by T&D losses - approx 9 percent (starting on Line 56).
    a. *CU: The projected wind supply is projected as delivered.*

Projects page:

8. NREL: line 36: Transportation: The items listed as possible transportation reduction measures appear to combine Scope 1 and 3 measures. Further clarification of the Scope 1 measures and their impacts on reductions would be beneficial.
    a. *CU: Telecommuting projects are contemplated but not integrated in forward projections. We will strike them from mention as they are Scope 3.*

NREL: Additional Comments based on our discussions:

9. NREL: We recommend you look at new options for A/C load reduction which would shift some of your peak power to base load. The GHG reduction benefits of this are more subtle than your model captures, but overall impact on the Xcel system would be beneficial. Examples of approaches would include “ice energy” cooling systems.
    a. *CU: Future modeling may include these options as model sensitivity increases sufficiently.*
10. NREL: For the residual natural gas emissions, your team might consider sourcing alternative sources such as landfill methane or biogasification.
    a. *CU: As those contingencies become available they will be evaluated.*
11. NREL: Additionally, we recommend, as a next step, that you complete a sensitivity analysis of key parameters and assumptions in the model. Doing so will provide you input to understand which parameters should be more carefully assessed as you move forward in time and implementation.
    a. *CU: Sensitivity analysis will be combined with financial modeling.*

9.3 Appendix 3 – ACUPCC Letter

University of Colorado at Boulder

Office of the Chancellor

914 Broadway
17 UCB
Boulder, Colorado 80309-0017
303-492-8908
Fax: 303-492-8866
www.colorado.edu/Chancellor

LETTER OF INTENT

February 16, 2007

Anthony D. Cortese, Sc. D.
Co-Director, Presidents Climate Commitment
Second Nature
18 Tremont Street, Suite 1120
Boston, MA 02108

Dear Dr. Cortese,

I agree with the goals of the *American College & University Presidents Climate Commitment.* Addressing climate change in our curriculum as well as campus operations is an urgent and integral part of our mission as educators and our social obligation to society. Higher education plays a critical role in preparing the new workforce and creating the knowledge that will help society create the strategies, technologies, policies and economic opportunities that will allow humanity to thrive while protecting our life-supporting environment.

I will work to get broad involvement and support in my institution for achieving the goals of the *Presidents Climate Commitment* and will be a charter signatory to it. I also plan to attend the June 2007 summit of my colleagues from other colleges and universities in a joint effort to implement and publicize the *Presidents Climate Commitment.*

In recognition of the need to build support for this effort among college and university administrations across America, I will do whatever I can to promote this initiative to my colleagues at other institutions.

Sincerely,

G.P. "Bud" Peterson
Chancellor
University of Colorado at Boulder

9.4 *Appendix 4 – ACUPCC Background*

Background

University of Colorado at Boulder Chancellor Bud Peterson on February 16, 2007 signed the American College and University Presidents Climate Commitment (ACUPCC) that pledges CU to:

1. Initiate the development of a comprehensive plan to achieve climate neutrality as soon as possible.

a. Within two months of signing this document, create institutional structures to guide the development and implementation of the plan.

b. Within one year of signing this document, complete a comprehensive inventory of all greenhouse gas emissions (including emissions from electricity, heating, commuting, and air travel) and update the inventory every other year thereafter.

c. Within two years of signing this document, develop an institutional action plan for becoming climate neutral, which will include:

i. A target date for achieving climate neutrality as soon as possible.

ii. Interim targets for goals and actions that will lead to climate neutrality.

iii. Actions to make climate neutrality and sustainability a part of the curriculum and other educational experience for all students.

iv. Actions to expand research or other efforts necessary to achieve climate neutrality.

v. Mechanisms for tracking progress on goals and actions.

2. Initiate two or more of the following tangible actions to reduce greenhouse gases while the more comprehensive plan is being developed.

a. Establish a policy that all new campus construction will be built to at least the U.S. Green Building Council's LEED Silver standard or equivalent.

b. Adopt an energy-efficient appliance purchasing policy requiring purchase of ENERGY STAR certified products in all areas for which such ratings exist.

c. Establish a policy of offsetting all greenhouse gas emissions generated by air travel paid for by our institution.

d. Encourage use of and provide access to public transportation for all faculty, staff, students and visitors at our institution

e. Within one year of signing this document, begin purchasing or producing at least 15 percent of our institution's electricity consumption from renewable sources.

f. Establish a policy or a committee that supports climate and sustainability shareholder proposals at companies where our institution's endowment is invested.

g. Participate in the Waste Minimization component of the national RecycleMania competition, and adopt 3 or more associated measures to reduce waste.

3. Make the action plan, inventory, and periodic progress reports publicly available by providing them to the Association for the Advancement of Sustainability in Higher Education (AASHE) for posting and dissemination.

Colorado's response to the ACUPCC commitment

CU has responded to this commitment by:

1. Appointing the *Chancellor's Committee for Energy, Environment, and Sustainability* (CCEES, June 2007), an executive-level steering committee to guide plan development and implementation;
2. Compiling and publishing a comprehensive Greenhouse Gas Inventory (September 2008) quantifying campus carbon emissions;
3. Appointing the *CU Carbon Neutrality Working Group* (CNWG, October 2007), a faculty, staff, student, and community-based group to research and compile a "Comprehensive Plan for Climate Neutrality," also known as a Climate Action Plan.
4. Initiating four "Tangible Actions" to immediately advance GHG emission reductions (September 2007). These include:
    a. Minimum LEED Silver building code standards for all campus construction;
    b. Energy Star purchasing policy
    c. Enhance public transportation (bus pass)
    d. Participate in Waste Minimization competition of RecycleMania.

All these actions have been developed and implemented within the prescribed ACUPCC timeline.

The CNWG was charged to:

1. Determine "a target date of [UCB] climate neutrality as soon as possible."
2. Identify "interim targets for goals and actions that will lead to climate neutrality," and,
3. Design "mechanisms for tracking progress on goals and actions."
4. Conduct (with CCEES) public stakeholder meeting on campus to solicit input on UCB's ACUPCC process,
5. Review the UCB GHG Emissions Inventory,
6. Develop a rigorous fiscal model by which carbon-reducing options are analyzed and prioritized,
7. Develop implementation scenarios if necessary, and
8. Write a draft final report for submission to the CCEES.

The CNWG work plan and timeline:

- Fall 2007
    - CCEES forms CNWG
- Spring 2008
    - CNWG teams research/compile options
        - Finalize GHG inventory, create reference trend projection
    - CNWG public stakeholder involvement process
- Summer 20'08 – Spring 2009
    - Financial analysis of mitigation options
- Winter 2008 – 2009
    - Draft integrated plan
    - Present draft findings to stakeholders, integrate comments
- Summer 2009
    - Present final draft to CCEES/Chancellor

9.5 Appendix 5 — Project Descriptions

Cogeneration

Description

This project includes the installation of a 5 megawatt base load natural gas-powered cogeneration system. It would reduce the amount of electricity purchased from Xcel Energy by about 40.15 gigawatt hours per year. The base load approach balances the demand for electricity and steam, which is a byproduct of the cogeneration process. When the system is not balanced and the steam production exceeds demand, the excess steam must be released into the atmosphere, wasting energy.

Financial Analysis

Assumptions

Project Cost: $9,000,000 (initial capital investment)
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: $354,000 to $2,277,000
Cost Avoidance: No
Revenue Generated: No
NPV: no risk ($6,266,506); with risk ($6,266,506)
IRR: no risk -14.1 percent ; with risk -14.1 percent

Due the numerous variables that could impact this project, including the price of electricity, price of natural gas, carbon tax and carbon offsets, the cost-benefit between cogeneration and purchasing electricity from Xcel Energy is difficult to determine. A sensitivity analysis was prepared using various assumptions for these variables. Twelve scenarios were evaluated and are summarized in the attached table.

The results of the analysis include a range of annual cost per ton of carbon from $16 to $104. The most likely scenarios had an annual increase in utility costs of $354,000 to $2,277,000. However, certain scenarios, such as a combination of a major increase in the cost of electricity (40 percent or more than current costs), sustained low cost natural gas prices (lower than current prices), and a carbon tax $26/ton indicate lower annual utility costs compared to today's annual budget by as much as $400,000.

Risk Value: .33

The risk factor for this project ranges from a high to a moderate due to the significant uncertainties associated with the financial and operating assumptions. Carbon markets and the carbon emissions regulatory environment are immature and changing rapidly. Technologies are also rapidly developing and may provide carbon reduction options that do not exist today. It is important to note that Xcel Energy's goal of a 20 percent reduction in emissions by 2020 will impact the University's carbon savings for this option, reducing it to about 14,100 tons per year.

Carbon Estimate

See the assumption on the attached sensitivity analysis summary.

$/ton: $16 to $104
Tons reduced: 21,997

Strategic Considerations

This project potentially has a significant impact on the campus' utility operation. The campus has transitioned from a cogeneration model to a purchased electricity model during the last several years. A change back to cogeneration will require infrastructure that must be considered as improvements to the utility systems are planned.

Next Steps

A determination needs to be made as to whether this project should be incorporated into plans that are underway for renewal of the campus' utility infrastructure.

Critical Success Factors

Success will require the commitment of campus and University leadership to incur potentially significant additional costs for utilities.

Wind Farm

Description

This project seeks to connect the campus to a large off-campus wind energy farm and directly receive that electricity transmitted through Xcel/other grid in order to power the campus.

Under the so-called "Strategic Investor Flip" approach, CU and the wind farm developer would form a joint venture but the project would be majority funded by a third party (CU could put more or less equity into the project in year one; a minimum of 1 percent appears normal). The joint venture (CU and the developer) would contract to buy power at a predetermined price for up to ten years. At the end of that period, CU would have the option (or obligation) to become a majority owner in the project at a predetermined fair market value. CU would then own and operate some or all the entire wind farm.

CU has entered into a Consortium Agreement with several other Colorado campuses to aggregate interests and resources in pursuit of this goal.

Under another approach, CU might co-mingle capital with the other universities and establish an equity position in a large wind farm from the outset. This normal Corporate Structure arrangement features all the capital coming from the universities, working with a developer to fund, build and operate the wind farm. No third party funding would be contemplated. However, this approach may inevitably cost more if no method of reaping the tax benefits by public entities is identified.

Assumptions

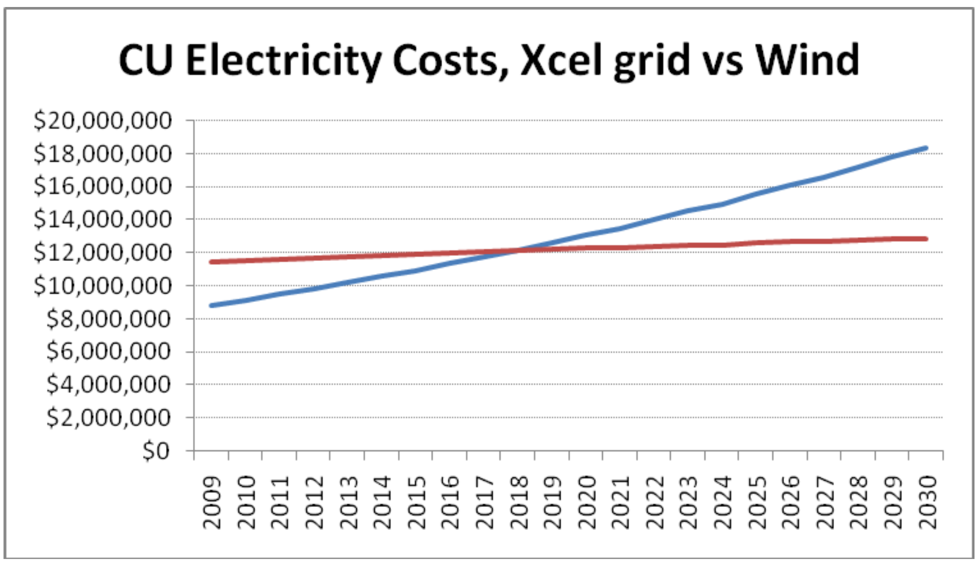
Project Cost: Under the flip scenario, up front capital costs are negotiated, and then in ten years a fair market value buy out cost is negotiated. (For the 1/3 load, flip scenario):

1/3 load in kWh	43,137,245
1/3 load in mWh	43,137
# of 1 MW turbines	15
capital needed @ 1800/kw	$26,867,488
1% capital up front	$268,675

*Assumed @33 percent capacity factor, a 1MW turbine will produce 2,890 mWh/yr
Lad calculated from 2008 actuals. Load expected to increase over time.

Additional equity would be required in the tenth year to purchase CU's proportionate share of the project at the fair market value of the equipment at the time of the purchase. If we assume the facilities are at 1/3 of their service life (30 years) after ten years, then perhaps a fair market value is 2/3 of $27-million = $18 million in year ten.

Rate of capital: 5 percent
Terms: 30 years
On-going costs: ~$550,000/year for O&M, admin, insurance etc.
Cost Avoidance: (difference between Xcel electricity cost and wind electricity cost)



Wind @ 8 cents fixed, Xcel at 6.9 cents in 2009 increasing at 3 percent /yr. Growth in total load as projected in CNWG model.

In terms of electrical costs, for the first ten years the project may result in a higher—but fixed—rate for delivered electricity. At 1/3 of load and 8 cents/ kWh for wind, that could mean a first year additional cost of $1.4 million versus CU's 2008 annual average Xcel rate of 6.9 cents/kWh[27]. However, that cost would become a cost savings as Xcel Energy costs increase over time (see graph/table).

[27] Data obtained from Doug Ryan, CU's Xcel account representative, 1/28/09

Year	Xcel	Wind	Difference	Cash Flow
2009	$8,769,443	$10,167,470	($1,398,027)	($1,398,027)
2010	$9,100,034	$10,243,460	($1,143,426)	($2,541,453)
2011	$9,444,405	$10,321,458	($877,053)	($3,418,506)
2012	$9,783,663	$10,380,797	($597,134)	($4,015,641)
2013	$10,151,646	$10,457,514	($305,868)	($4,321,509)
2014	$10,534,896	$10,536,225	($1,329)	($4,322,837)
2015	$10,897,558	$10,581,488	$316,070	($4,006,767)
2016	$11,306,606	$10,658,905	$647,701	($3,359,066)
2017	$11,732,554	$10,738,304	$994,251	($2,364,815)
2018	$12,120,315	$10,770,102	$1,350,214	($1,014,601)
2019	$12,574,445	$10,848,195	$1,726,250	$711,649
2020	$13,047,264	$10,928,257	$2,119,008	$2,830,657

Revenue Generated: n/a for ten years. However after the flip, CU would receive 99 percent of revenues for its proportionate share of the project for energy sales above that used by CU. Likewise, as seen above, CU could go cash positive on electrical budgets in less than ten years; thus, retaining those funds for other purposes.

NPV: no risk n/a; with risk n/a

IRR: no risk n/a; with risk n/a

Risk Value: .20

Carbon Estimate

Assumptions: If we presume we could buy an equity stake in a wind farm sufficient to produce 1/3 of our load for $18-million with a 30 year bond plus our share of the operating costs ($550,000/yr), then total annual costs would be $18 million / 30 + $550,000 = $1.15 million/year (plus interest).

Therefore: $1,150,000 / 38,000 = $30/ton CO2 reduced.

- $/ton: $30/ton per year
- Tons reduced: 38,000 tons*
  *carbon reduction calculated from CNWG model

Strategic Considerations

This is a very daunting project. With respect to securing direct wind power to campus at a stable price inclusive of the carbon reductions, there is a high level of uncertainty and a currently low probability of success. Navigating the regulatory, fiscal, and logistical challenges that this project face will take time, resources, and sustained interest. Accordingly, the main strategic consideration is how to develop and maintain the staff and leadership focus that this project requires.

Another major strategic consideration is the potential onset of carbon regulation and the attendant increase in Xcel electrical costs. Carbon regulation is considered highly likely at this time. A conservative estimate of 3 percent additional cost/yr is commonly projected in the literature—and is not reflected in the projections above. This would significantly improve the project's pro forma.

Overall, the potential upside of the project—carbon free constant price electricity at significant savings—is a huge carrot. However, significant barriers exist to successful completion.

Next Steps

This project needs to be clearly identified as a major goal for the campus and a project team tasked with prosecuting it. Outside expertise is a must. We need an attorney, a wind development expert, and a sound fiscal analyst with knowledge of wind deals, for starters.

Critical Success Factors

Ultimately, we will need some regulatory or legislative changes. If all the money and logistical factors can be made to work, it is ultimately illegal under present law/regulations to do what we need done. Therefore, we must change that if we are to be successful.

Solar Thermal Installations – Rooftop & Concentrated Systems

Description

Solar thermal systems utilize solar power to heat water for domestic uses, such as showers and laundry. A typical solar thermal system is guaranteed for 25 years, but can continue to provide service for 50 years with minimal maintenance. A typical solar thermal panel can off-set natural gas use by approximately 65 therms/year[28] for the life of the system.

This project focuses on providing hot water in the residence halls, which is provided either by hot water tanks in the buildings or by steam. Solar thermal systems can be used either by installing systems directly on the dormitories to supplement hot water tanks, or by installing a ground-mounted solar system to supplement the central steam system. The size of the solar systems will depend on the type of project.

This type of project is particularly appropriate for the campus dormitories, but could be scaled to include other university-owned residences or could be used to heat the pools.

[28] Savings rate of 65 therms/year obtained from the Colorado Solar Energy Industries Association.

Financial Analysis

Assumptions

Solar Thermal – Rooftop
Project Cost: $630,000
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: $4,770 (increases by 3 percent annually)
Revenue Generated: n/a
NPV: no risk = -$181,367;
with risk = -$360,820
IRR: no risk = -1.45 percent ;
with risk = -9.53 percent

Solar Thermal – Ground-mount
Project Cost: $2,352,000
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: $470,400 over five years
Cost Avoidance: $58,100 – $290,500 (incremental increase over 5 years)
Revenue Generated: n/a
NPV: no risk = -$422,857;
with risk = -$1,109,080
IRR: no risk = -0.27 percent ;
with risk = -10.73

All project costs occur during the installation process, although there may be minor repair costs after 10 years in order to maintain the systems. The financial analysis for rooftop installations assumes that solar thermal panels provide 10 percent of the hot water for the residence halls, given the limited rooftop space. The number of panels required and installation costs are based on assumption provided by AquaCare Solar: a) 10SF of panels are needed for each person, b) a panel is 4'x10', and c) each panel costs $4,000 to purchase and install. The analysis also includes an assumption that it will not be possible to install panels that would satisfy the total hot water demand for each residence hall due to limited roof space. For the purpose of this analysis, it is assumed that roof space will limit the number of solar panels to the number needed to offset the hot water needs of 10 percent of the residents, for a total of 157 panels. Residence hall capacities were obtained from the Housing & Dining Services website.[29]

The cost avoidance is a result of a reduction in natural gas purchased to heat the domestic water supply of each residence hall. This estimate is based on a cost of $7.80/mmBtu of natural gas, and an estimation of the savings from each installed panel (65 therms/panel annually). This results in an annual savings of $50.70 for each panel installed, or $7,950 per year for the rooftop installation (based on a 10 percent provision rate). This rate increases by 3 percent annually to reflect increasing prices for natural gas.

The assumptions for the ground-mounted solar installation are that a) 10SF of panels are needed for each person, b) a panel is 4'x10', c)a ground-mounted solar system can provide 50 percent of the hot water needs of the residence halls, c) each panel costs $3,000 to purchase and install[30], and d) the installation is spread out over five years.

The cost avoidance, as with the rooftop installations, is a result of savings from natural gas purchases. The first year of installation will result in a savings of $7,950. This will increase as more panels are

[29] http://housing.colorado.edu/index.cfm

[30] The assumption is that a ground-mounted system will have lower installation costs due to the concentrated vs. distributed layout of the system.

added. Calculated savings also include an increase in natural gas pricing of 3 percent a year. Cost savings per year are reflected in the table below.

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$7,950	$16,138	$24,572	$33,259	$42,206	43,473	$44,777	$46,120	$47,504	$48,929

It may also be possible to obtain third party financing. A solar PV project currently being undertaken on campus provides the full cost of a 100 kW system. The university purchases the system after seven years for a third of the original price. With a similar financing arrangement, the rooftop project could have an NPV of $300,882 with no risk and $121,429 with risk. The concentrated solar thermal project could have an NPV of $1,163,956 with no risk, and $820,844.

Risk Value: Rooftops - 0.60; Ground-mounted – 0.8

Solar installations have a large up-front cost and a long payback period. The rooftop installation project also faces limitations of available roof space that is suitable for a solar installation. Not all buildings may have sufficient roof space with the proper orientation for a solar installation, which further limit the ability of solar thermal installations to meet the domestic hot water requirements of the residence halls.

The cost savings are dependent on the cost of natural gas. Savings are calculated based on the current price of natural gas. Savings could increase or decrease based on future gas prices. As the cost of natural gas generally increases over time, the cost savings should increase.

Carbon Estimate

$/ton
Tons reduced over 10 year term

Strategic Considerations

The carbon footprint of the University of Colorado includes the emissions of natural gas purchased for cooking and domestic hot water purposes. While many projects suggested for the campus climate action plan include efficiency and energy reduction outcomes, none of them address this input of natural gas.

Next Steps

Instituting water savings projects should be initiated in all the residence halls, as well as behavioral campaigns to reduce individual water consumption. It will also be necessary to consider the lifespan of a solar installation (10–15 years) to ensure service and replacement when necessary.

Critical Success Factors

Regular assessment of water efficiency measures will be necessary, as well as making sure that systems are maintained appropriately. Finding and utilizing rebate programs can reduce the cost of installation significantly.

Solar PV

Description
Solar PV provides electricity using the sun as a renewable resource.

Financial Analysis

Assumptions

Project Cost: $400,000 (assumes third party financing; payment is in year 7)
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: $50,088 (annual, includes 11.5 cents/kwh rebate up to year 20)
Revenue Generated: n/a
NPV: no risk = $171,217; with risk = -$80,119
IRR: no risk = N/A ; with risk = N/A

Project costs include the purchase and installation of solar panels. The estimations are based on a current project to install 210 kW of solar panels divided between the Wolf Law building, the Coors Event Center, and the housing maintenance center[31]. The cost is estimated to be $1.5 million, which will be covered through third party financing. The university's cost comes after seven years, at which time the university will purchase the system for an estimated $400,000.

The cost savings are based on a reduction of purchased energy. The 210 kW panels will result in 305,373 kWh of electricity per year. This results in an annual savings of $50,088 after all the panels have been installed. The calculations are based on the electricity off-set, and uses $0.069/kWh as the rate and includes 11.5 cents/kWh rebate up to year 20.

Risk Value: .8

The cost savings are based on the cost of electricity, which fluctuate. As the cost of energy generally increases over time, the cost savings should increase.

Carbon Estimate

$10/ton
7,551 Tons reduced over 10 year term

Strategic Considerations

In order to reduce the university's carbon footprint, it must find ways to offset energy produced from fossil fuels with energy produced from renewable energy. As more LEED-rated buildings are built on campus, it should be possible to add more solar to the campus, as with the Wolf Law building. In order to meet the university's goal of carbon neutrality, projects such as this are necessary.

[31] Moe Tabrizi estimations.

Next Steps

Identify campus buildings that have the rooftop capacity for solar panels. These may be given more immediate priority. When constructing new buildings, consideration should be given to the design of these buildings in order to take advantage of solar orientation and providing sufficient rooftop space.

Critical Success Factors

Financing solar installations is necessary to make them cost effective. This can be through third party financing, rebates, or a combination of the two. Third party financing will delay the availability of energy offsets, but can significantly decrease the cost of the installation.

LEED Gold Plus for New Buildings and Major Capital Renovations

Description

LEED is a third-party certification program and the nationally accepted benchmark for the design, construction and operation of high performance green buildings. It gives building owners and operators the tools necessary to have an immediate and measurable impact on their buildings' performance. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

According to the U.S. Green Building Council, which oversees the LEED program, LEED gold-certified buildings are considered to be 25 percent to 30 percent more water and energy efficient than buildings compliant with current buildings codes and ASHRAE 90.1, which establishes energy standards and guidelines for heating, ventilation, air conditioning and refrigeration systems. LEED gold plus would achieve additional savings by designing buildings that are 30 percent -45 percent more efficient than the baseline. Energy modeling will point us to design choices that achieve this level of efficiency and additional credits in the LEED category of Energy and Atmosphere.

Financial Analysis

Assumptions

Project Cost: 1.0 percent to 1.5 percent of total project cost for LEED Gold and LEED Gold Plus, respectively.

Example: The cost of LEED Gold certification for the Wolf Law building was about $470,000 for a project consisting of 184,000 GSF, or about $2.55 per GSF. The cost of LEED Gold Plus would have been about $705,000, or $3.83 per GSF.

Rate of capital: 5.0 percent

Terms: 10 years

On-going costs: n/a

Cost Avoidance: Costs associated with increased electric and civil utilities rates, as well as the price of natural gas.
Revenue Generated: n/a
NPV: no risk $264,911 with risk $175,075 (assuming 25 percent reduction in consumption)
IRR: no risk 15.3 percent with risk 12.0 percent

All project costs occur at the time of construction or renovation, whereas there is a long-term benefit associated with reduced energy and water consumption. The benefit will oftentimes represent cost avoidance, as opposed to actual cost savings, since many of the LEED projects will represent new construction and require additional operating and maintenance funding.

The actual cost achieving LEED certification and related benefits are determined by the level of certification (i.e. Gold, Gold Plus or Platinum), Design and Construction standards, the location of the project and the type and use of facility. The parameters outlined above are generally accepted estimates.

Risk Value: .90

The cost of building facilities has been rising at unprecedented rates, which can deter investment in LEED compliance. It has been proven that these buildings are more energy efficient and have a good payback in the long term. As more buildings become LEED certified, suppliers and funding models will likely adapt to the concept, thereby reducing risk.

Carbon Estimate

$/ton
Tons reduced over 10 year term

Strategic Considerations

Recent capital projects have had a provision requiring them to be LEED certified. Increasing construction costs have created challenges with project budgets. However, the campus' commitment to environmental stewardship and the long-term payback suggest that this is a viable initiative.

Next Steps

Adopt a campus policy to establish conservation standards for all new construction and major capital renovations; establish current standards (i.e. LEED Gold or LEED Gold Plus) as well procedures for monitoring and updating standards; and provide campus education on the benefits of LEED or other conservation standards.

Critical Success Factors

This initiative requires buy-in from the building stakeholders and campus administration to increase the project budget by 1 percent to 1.5 percent . In addition, the adequacy of the 1 percent to 1.5 percent allowance will need to be evaluated and monitored.

Heat Recovery in University Laboratories

Description

Heat recovery projects are meant to capture exhaust heat generated from laboratory processes and use it to supplement the building heat. In many similar examples, recovered heat is used to warm incoming air in order to reduce total heating needs for the building.

Financial Analysis

Assumptions

Project Cost: $250,000 - $500,000 for three labs
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: $21,371/year (based on an estimated 6 – 8 year payback schedule)
Revenue Generated: n/a
NPV: no risk = $6,739; with risk = -$43,935
IRR: no risk = 5.3 percent ; with risk = 3.1 percent

All project costs occur at the time of construction or renovation and will vary from project to project. The three labs currently under consideration are in the Molecular, Cellular, & Developmental Biology building, Chemical Engineering, and Ekeley. The cost for each project is dependent upon existing infrastructure. The cost savings are a result of the reduced energy needs for the building as a result of the heat recovery. This amount is based on estimated 8-year payback schedule (range is 6–8 years, but chose to use the more conservative figure). For example, the CIRES building cost $90,000 to install a heat recovery system, and had an IRR of 15.8 percent , an NPV of $11,000, and a payback period of 10 years.

Risk Value: .90

The cost for installing a heat recover system involves precise engineering of the existing HVAC system in order to maximize the benefits of the project. In addition, each project is dependent on the existing infrastructure, some of which may need to be replaced for a heat recovery system to be installed. However, laboratories are much more energy intensive than other uses of campus buildings, and improving energy efficiency in these spaces will have a significant contribution to the efficiency of the university as a whole.

Carbon Estimate

$169/ton
1,690 Tons reduced over 10 year term

Strategic Considerations

The Governor's Executive Order contains a goal for an improvement in energy intensity (energy used per square foot) by 2012. Specifically, the order calls for a 20 percent reduction in energy use based on

2005 levels. Because laboratories are very energy intense (5 – 10 times more intense than office space), focusing on these spaces can make a significant contribution in the university's energy consumption levels as a whole.

Next Steps

This project is one of a series of projects that have been identified to meet the Governor's Executive Order. In order to meet these goals within the allotted time frame, additional funds are needed. Some engineering studies are needed to determine the exact scope of each project.

Critical Success Factors

Funding is critical to the successful completion of this project within the time frame outlined by the Governor's Executive Order. In addition, support is needed from laboratory stakeholders, whose work could be disrupted while the new systems are installed.

Chilled Water Optimization

Description

The objective of the Chilled Water Optimization project is to improve the efficiency of the Central Plant chilled water system and increase its available capacity both on the generation side (chillers) and its associated distribution (piping). The project will add pressure independent control valves in front of the chilled water coils in all of the buildings served by the Central Plant, as well as some piping modifications at the coils and in the tunnels. This will enable the Central Plant to deliver chilled water effectively and efficiently to each building, saving energy and potentially freeing up valuable chiller and piping capacity.

Currently, the chilled water plant experiences a 4 to 5 degree temperature difference between the supply and return of the chilled water system. This project is expected to increase the temperature difference between the supply and return to 10 to 12 degrees, resulting in energy savings from reduced pumping and increased performance of the chillers. There is also a potential that this project could delay the purchase of new infrastructure, such as a chiller or additional piping, by freeing up plant and distribution capacity. These improvements would result in energy savings regardless of whether a new central cooling plant is constructed.

Financial Analysis

Assumptions

Project Cost: $2 million (placeholder only)
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: Yes
Revenue Generated: n/a
NPV: no risk TBD ; with risk TBD

IRR: no risk TBD ; with risk TBD

RMH, an engineering consulting firm, is in the process of evaluating this project and is expected to have an initial proposal completed in March. At that time, the cost-benefit can be determined and the project scoped appropriately.

Risk Value: TBD

RMH's proposal will provide information to support a thorough assessment of project risk. Adequate information is not currently available.

Carbon Estimate

$/ton
Tons reduced over 10 year term

Strategic Considerations

This project supports the goal of providing cost-effective production and delivery of utilities to campus facilities. It may also assist the Central Plant with meeting peak cooling demand as plans to expand capacity are developed and the solution implemented.

Next Steps

RMH Consulting is expected to complete an initial proposal, including estimated project costs for a limited number of buildings by mid-March.

Critical Success Factors

Proper cost and energy modeling will be critical to determine the cost/benefit of the project. General fund resources will determine the scope of work.

Roofing Insulation and Painting

Description

The university has undertaken a systematic review of roofing insulation in campus buildings. This has involved an aerial survey to obtain infrared pictures of the roofs to determine where roofs need to be repaired and insulation replaced or installed. In addition, applying a coat of reflective paint on flat roof surfaces has helped to reduce cooling loads in the summer.

Financial Analysis

Assumptions

Roofing – Insulation:

Project Cost: $500,000
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: $51,880 annually
Revenue Generated: n/a
NPV: no risk = $893,588;
with risk = $754,229
IRR: no risk = 32.24 percent ;
with risk = 28.5 percent

Roofing – Polymer Coating

Project Cost: $1,500
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: $98 annually
Revenue Generated: n/a
NPV: no risk = $1,124;
with risk = $993
IRR: no risk = 17.76 percent ;
with risk = 16.4 percent

These projects can be implemented simultaneously. After the insulation has been placed and any leaks on the roof repaired, the white polymer coating can be painted onto the flat surfaces of the roof. Costs involve material and labor costs, and by combining these projects, there can be significant savings on the labor.

The cost avoidance is a result of energy savings. For roofing insulation, this results in approximately 2 percent savings in electricity costs, 5 percent savings in steam, and 3 percent in chilled water costs. Cost savings were determined by calculating the energy use of 11 campus buildings targeted for roofing projects and include an inflation rate of 3 percent to reflect rising energy costs. Energy savings for the polymer coating are based on a payback period of five years.[32]

All project costs occur at the time of construction or renovation. The cost savings is a result of reduced heating and cooling needs for the building.

Risk Value: .9 for roof insulation, 0.95 for polymer coating

These projects are very low-risk, as similar projects have demonstrated high financial returns. The total cost is relatively low, and is included in existing budgets for efficiency measures being undertaken on campus. Further, the projected cost will cover the remaining buildings on the Boulder campus that require insulation upgrades.

Carbon Estimate for Roofing – Insulation:

-$5/ton (a savings)
4,102 Tons reduced over 10 year term

Carbon Estimate for Roofing – Polymer Coating:

$68/ton
8 Tons reduced over 10 year term

[32] Estimates provided by Moe Tabrizi.

Strategic Considerations

This program falls into a category of projects already being implemented on campus. It is generally recommended that projects of this nature be initiated prior to larger-scale projects focused on building heating and cooling as insulation and sealing can result in a significant reduction in load.

Next Steps

While this project should address all the rooftops on campus, it would be prudent to implement a policy for regular inspections to ensure that roofs remain in good condition in order to maintain efficiency ratings.

Critical Success Factors

Funding for the program must be maintained at current levels in order to achieve maximum efficiency.

Windows – Replacement, Sealing, and Weather-Stripping

Description

The window installations on campus can account for significant heat loss and gain, particularly with older windows. This project aims to address this issue by initiating a pilot project to replace windows in three buildings (Museum Collections, Old Main, and 924 Broadway), as well as sealing, caulking, and weather stripping additional windows. The latter option is not as effective at saving energy, but is much cheaper.

Financial Analysis

Assumptions

Windows – Replacement:
Project Cost: $500,000
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: $528 annually
Revenue Generated: n/a
NPV: no risk = -$485,282;
with risk = -$492,626
IRR: no risk = -36.01 percent ;
with risk = -41.0 percent

Windows – Sealing
Project Cost: $50,000
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: $7,338 annually
Revenue Generated: n/a
NPV: no risk = $147,110;
with risk = $127,399
IRR: no risk = 46.76 percent ;
with risk = 41.9 percent

All project costs occur at the time of construction or renovation. Replacement costs are much higher due in part to the cost of new windows, which must meet university design codes. In addition, because of the age of some of the buildings, asbestos removal may be an issue. The majority of the cost for sealing and weather stripping windows is labor, which makes up approximately 90 percent of the total cost.

The cost savings is a result of the reduced energy needs for the building. For window replacement, this is estimated to be 5 percent of the energy costs of the building. For buildings that use steam heat, there may be an additional 10 percent of steam cost savings. Calculations were based on the energy use of the three buildings in the pilot project (Museum Collections, Old Main, and 924 Broadway). The efficiency of sealed windows is not as high – approximately 1 percent of the cost of steam and chilled water for the building. Calculations are based on 11 buildings being considered for similar projects. A 3 percent inflation rate for increasing energy costs is included in both calculations.

Risk Value: Replacement: .90; Maintenance: 0.90

The risk value of replacing existing windows is relatively low. The risk for maintaining the sealing and weather-stripping is fairly low due to the low cost of the project.

Carbon Estimate for Windows – Replacement:

$11,847/ton
42 Tons reduced over 10 year term

Carbon Estimate for Windows – Sealing:

-$40/ton (a savings)
580 Tons reduced over 10 year term

Strategic Considerations

Window replacement has a high strategic value in terms of the effect on building efficiency – efficient windows can result in a 5 percent reduction in electrical use and an additional 10 percent reduction in steam used for heating and cooling. It is important to address building efficiency in order to reduce total energy use on campus.

Next Steps

In order to understand the fiscal impacts of replacing windows on campus, it will be necessary to gain a better understanding of the number of windows that require replacement. It may also be necessary to establish a fund to deal with asbestos removal. Those buildings that are on the waiting list for new windows should have their windows sealed and weather-stripped to obtain what efficiencies are possible.

Critical Success Factors

Obtaining support from building stakeholders to undertake window replacements (which may be very disruptive to work flow) will be important.

Installing Room Occupancy Sensors

Description

The purpose of room occupancy sensors is to reduce lighting needs – lights come on when a person enters a room and turn off after a period of no movement within the room. These are ideal for offices, bathrooms, and smaller classrooms.

Financial Analysis

Assumptions

Project Cost: $300,000
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: $42,857
Revenue Generated: n/a
NPV: no risk: = $74,896; with risk: = -$18,828
IRR: no risk: = 9.63 percent ; with risk: = 3.7 percent

Project costs are estimated to be approximately $5,000 – $7,000 for a medium-sized room and $8,000 – $12,000 for a large room. It is estimated that $300,000 should cover remaining classrooms.

The cost savings are the reduced energy from lighting requirements for the building. These savings are based on a payback period of 7 years.

Risk Value: .75

Occupancy sensors can reduce lighting in used rooms. Large room applications are more efficient than small spaces. Current campus strategy is priority implementation in large public spaces.

Carbon Estimate

$/ton
Tons reduced over 10 year term

Strategic Considerations

The university is already undertaking lighting retrofits across campus. Installing room occupancy sensors could easily be incorporated as part of this process.

Next Steps

It will be necessary to identify the rooms in which occupancy sensors are appropriate, and incorporate this into the lighting retrofit projects. A program should also be implemented that measures the effectiveness of the light sensors and the resulting energy savings.

Critical Success Factors

Adjusting occupancy sensors for the room type, as well as monitoring their use, will be necessary to ensure that lights are turned on/off appropriately. There may also be some educational needs for certain users.

Pipe Insulation

Description

Insulating pipes reduces the loss of energy as hot water, chilled water or steam is transported through the system. While it may be difficult to gain access to all the pipes, insulation can result in significant energy savings over time. This project particularly addresses the steam and chilled water pipes on campus. The major systems have already been insulated – this project is to address the residual pipes that have not yet been insulated.

Financial Analysis

Assumptions

Project Cost: $150,000
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: $9,770 annually
Revenue Generated: n/a
NPV: no risk = $112,428; with risk = $46,821
IRR: no risk = 17.76 percent; with risk = 10.7 percent

The estimated cost of insulating the remaining steam and chilled water pipes on campus is $150,000[33].

The cost savings are a result of steam and chilled water conservation, and is based on a payback period of 5 years. A 3 percent inflation rate for increasing energy costs has been incorporated into the calculated savings. There will likely be diminishing returns in the future as the systems age.

Risk Value: .75

While the cost of insulation is relatively low, gaining access to the pipes can be difficult. Further, the insulation can make it difficult to determine whether there are other problems in the pipes that may also reduce transportation efficiency.

[33] Estimates from Moe Tabrizi

Carbon Estimate

$68/ton
772 Tons reduced over 10 year term

Strategic Considerations

This would be an ideal project to undertake during building renovations. In addition, properly insulated pipes can reduce overall heating and cooling loads on campus (steam) and/or reduce energy needs for water heating.

Next Steps

There will need to be an audit to determine exactly how much piping needs to be insulated. In some buildings, this could be done in conjunction with other renovation projects.

Critical Success Factors

Securing funding to initiate this project will be critical to the success of the project.

"Smart" Power Strips for the Dormitories

Description

This project would distribute "smart" power strips to students living in the residence halls as a means of reducing energy use. "Smart" power strips can reduce energy use by powering down electronics that are not being used. Many electronics – such as TVs, stereos, computers, and charging stations – continue to draw power even when they are turned off. The "smart" power strips can sense when an item has been turned off and shuts off current to that item. The strips also have "normal" outlets for items that might need to have electricity available at all times. This project addresses the increased use of electronics being used by students, and provides an easy, low-cost means of reducing energy use.[34]

Financial Analysis

Assumptions

Project Cost: $180,000 ($30 per strip, 6,000 students in on-campus housing)
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: none
Cost Avoidance: $109,296 per year
Revenue Generated: n/a
NPV: no risk = $776,077; with risk = $579,599
IRR: no risk = 63.11 percent ; with risk = 53.9 percent

[34] SmartHomeUSA: http://www.smarthomeusa.com/ShopByManufacturer/Bits-Ltd./Item/LCG5/
Bits Limited: http://catalog.bitsltd.us/power_strips/
Alter, L. (2007). Smart Strip Controls Phantom Loads. Treehugger.com. http://www.treehugger.com/files/2007/05/smart_strip_con.php.

Students who take the strips home at the end of the year would be charged a replacement fee, so after the initial investment in the strips, there would be no additional costs. The strips can save between $0.15 and $20 per day, depending on plug load, existing behavior, and setting. This analysis is based on a savings estimate of 1.10 kWh/day and assumes that distribution would be to the 6,000 students living on campus.

Current costs for the strips are $35-$45 based on individual resale value. Cost estimates for this project assumes some savings for bulk purchasing resulting in a per unit cost of $30, which could be even lower given the size of the initial order.

This project could easily be scaled up to include academic and administrative offices.

Risk Value: .9

This project is very low risk, as it reduces the cost of behavior changes in the students. Students living in the dorms are likely to be using power strips already to accommodate the number of electronics they bring to campus, as well as to provide surge protection for their electronics. The major risk involved is that people may not use the strips correctly in terms of distributing the plug load appropriately (plugging a monitor into an outlet that is always on as opposed to plugging it into an outlet that allows it to be powered down). Students who take the strips at the end of the year can be charged a replacement fee, but even having to pay for some replacements (up to 80 percent in the risk scenario) would result in a positive IRR and NPV.

Carbon Estimate

$/ton
Tons reduced over 10 year term

Strategic Considerations

This project addresses behavioral change, and provides a low-cost, low-risk means of reducing individual energy consumption in the dormitories. The project could also be scaled up to include office spaces and computer labs.

Next Steps

Adopt a policy and practice to provide smart power strips in the dormitories. There would need to be an inspection at the end of the semester or year to determine the replacement rate. There may need to be some initial education for incoming students regarding the importance of using the smart strips rather than regular power strips.

Critical Success Factors

Actual use by the students would be the determining factor.

Energy Conservation in the Data Centers

Description

Data centers such as server rooms and computer labs are extremely energy intensive due to the electricity needed to run the machines, as well as the temperature control systems. As a result, there has been a great deal of effort expended in recent years to make data centers more efficient. These measures include modeling the air flows, proper orientation of the equipment, re-engineering the exhaust systems, consolidating and upgrading equipment, and virtualization. This project focuses on the structural elements rather than issues related to equipment.

Financial Analysis

Assumptions

Project Cost: $250,000 (will fund the renovations of three data centers)
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs:
Cost Avoidance: $49,826 annually
Revenue Generated: n/a
NPV: no risk = $478,963; with risk = $260,274
IRR: no risk = 33.92 percent ; with risk = 22.1 percent

The project costs include the modeling of airflow through the data centers, which will help to determine the proper orientation of equipment. Engineering modeling will also be needed to adjust the exhaust systems to increase efficiency and improve heat recovery, as well as take advantage of passive cooling and heating by using ambient outdoor temperatures.

The cost savings for this project are based on estimated payback period of three years.

Risk Value: .70

The true costs and benefits of this project will not be known until it is undertaken and measures can be made of the savings from energy use and from heating and cooling. Existing studies have shown that the leaders in data center efficiency have achieved savings of 30 percent or more.

Carbon Estimate

-$37/ton (a savings)
6,797 Tons reduced over 10 year term

Strategic Considerations

Because of the energy-intensive nature of data centers, any attempt to reduce the university's overall energy intensity needs to address those areas with the largest contribution. The Governor's Executive Order calls for a 20 percent improvement in energy intensity by 2013. This project can make a significant impact both in electrical use, as well as steam used for heating and cooling the buildings.

Next Steps

An engineering study of data center efficiency is currently being undertaken to assess the best course of action regarding the data centers. The pilot phase of the project can cover three data centers, which will provide an improved understanding of the costs involved and the energy savings that can be achieved. Additional projects should be scheduled and budgeted once this information has been obtained.

Critical Success Factors

Funding for the pilot phase is critical to the success of the program. Buy-in from stakeholders will also be needed.

General Equipment Cost Sharing Program

Description

This program would create a fund that would reimburse purchasers who spend more on electronic equipment that helps lower the campus carbon footprint. Often, the "green" choice in office equipment or supply options is more expensive than other products, making it difficult for departmental purchasing agents to justify the purchase. This fund would be used to off-set the higher costs of these items.

Financial Analysis

Assumptions

Project Cost: $250,000 to initiate the fund, may require additional funding in later years
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: unknown
Cost Avoidance: $30,000 annually
Revenue Generated: n/a
NPV: no risk = -$699.16; with risk = -$768.66
IRR: no risk = -22.08 percent ; with risk = -26.8 percent

The rebate program will need money to replenish the fund on an annual basis, but will depend on the number of applications to the fund. Currently, the cost projections call for $250,000 over the first four years of the program for a total of $1 million. Carbon savings due directly to these programs may be hard to quantify other than on a case-by-case basis.

Risk Value: .7

While providing incentives is relatively risk free, it can be hard to measure the savings of such a program. There is an issue of educating purchasers about the availability and accessibility of the fund, as well as in helping them to understand which options will help lower the campus' carbon footprint. Some equipment, such as copiers, are leased from distributors, which may make it more difficult to apply the rebate. Another issue is university purchasing agreements with companies that do not provide "greener" options.

On the plus side, incentives can be adjusted and scaled over time to reflect the success of the program. Incentives are popular, and should not receive much push back from employees.

Carbon Estimate

$/ton
Tons reduced over 10 year term

Strategic Considerations

This project would demonstrate CU's commitment and leadership to the goal of climate neutrality. Providing incentives generally does not conflict with other efforts. Determining the level of demand for such a project would be beneficial, as it could result in a lower cost project. This would involve identifying the volume of equipment purchased annually, as well as determining the cost difference between the average purchase cost and the purchase price of an energy efficient model. This would also help to determine the amount of the rebate.

Next Steps

Adopt a policy to promote greener purchasing and provide education and training on what constitutes green purchasing. This could be done as part of annual purchasing card training sessions. Access to the fund and a list of criteria for qualifying purchases would also need to be determined.

Critical Success Factors

In order to set up a rebate program, staff running the program will have to develop a means to effectively evaluate what type of purchase qualifies and have the ability to manage the rebates and make sure the rebates are being used properly. Staff may also choose to award rebates only for purchases that would not have happened with the rebate, thus ensuring a change in behavior, however, this can be hard to deduce. Staff could evaluate Xcel Energy's rebate program for ideas.

Carbon Price Risk Factor

Description

A Carbon Price Risk Factor (CPRF) is a policy initiative that will essentially provide a green bias for purchasing and contracting decisions. It is expected that carbon emissions will be regulated at some point in the near future in some sort of cap-and-trade system. While the costs associated with such an initiative are not yet known, Xcel Energy has estimated a value of $20.00 per ton of CO2. As Xcel Energy will likely pass these additional costs to customers through energy price increases, this is the value being proposed for the CPRF.

A CPRF should first be instituted for major capital construction projects, and ultimately move toward purchasing decisions at all levels. The CPRF may be instituted through purchasing policies rather than individual purchasing actions. By assuming a price risk factor of, for example, $20/ton or 2 cents/kWh on top of the purchase cost, a purchaser may choose the more energy efficient option because the CPRF will lead to shortened payback periods. The CPRF factor also helps integrate long-term operating costs into the initial purchasing decision, two areas that have been previously disconnected. In this way, the CPRF represents long-term energy savings opportunities. While the CPRF doesn't actually represent real dollars (e.g. it is not a tax), and is rather an assumption one makes in doing a financial analysis of energy savings opportunities, there may be an increase in up-front costs associated with its use.

The CPRF could be implemented in four main categories:

1) New construction and renovations
2) Large energy systems (i.e., new HVAC systems)
3) Transportation
4) Everyday purchasing decisions

This initiative should be implemented over time in the order listed above. This may include some changes to purchasing policies, and may supplement some existing policies, such as LEED standards for construction and the purchase of Energy Star equipment.

Financial Analysis

Assumptions

Project Cost: unknown
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: unknown
Cost Avoidance: n/a
Revenue Generated: n/a
NPV: no risk = n/a; with risk = n/a
IRR: no risk = n/a; with risk = n/a

It is not possible to determine actual costs or returns for this project as these will vary considerably based on the type of project. In addition, the project depends considerably on a future cost of carbon. It is likely that there would be some up-front costs to implement this project (set-up, implementation, and education), but could easily be paid back in carbon savings.

Risk Value: .5

The success of the CPRF initiative is highly dependent on a cost being assigned to carbon emissions and to a strong implementation strategy. A carbon cost is highly anticipated, but the implementation timeline is unknown. Instituting such a strategy now based on estimations of the cost of carbon would serve as an incentive to lower the university's emissions and reduce future costs.

The initiative also depends on people with purchasing power to understand the CPRF and implement it appropriately. It will be easier to implement this initiative in stages, starting with larger projects that involve a few number of key stakeholders and gradually expand to a larger number of participants.

Carbon Estimate

$/ton
Tons reduced

Strategic Considerations

This policy initiative will provide support to a large number of projects aimed at reducing the university's carbon footprint. By placing a value on carbon emissions, it skews purchasing decisions in favor of more energy efficient equipment. This project should be considered in conjunction with the equipment, vehicle, and laboratory cost share programs that are designed to support energy-efficient purchasing.

Next Steps

A university policy regarding the CPRF needs to be adopted, including a timeline for each stage of adoption. The first stage should be for large capital projects, such as new construction or major renovations. This would be followed by large systems purchases (such as HVAC equipment), transportation purchases, and finally by general purposes. Each step will require input from the major stakeholders, administrators, and the purchasing department. Some purchasing agreements may need to be re-negotiated to include the CPRF.

Critical Success Factors

This project requires the support of major purchasers, as well as the purchasing department. Education on how to apply the CPRF will be needed for each level of implementation, as well as purchasing policies designed to include the CPRF.

Behavior Conservation Program Fund

Description

The Behavior Conservation Program Fund would provide funding for incentives and competition to motivate individuals and groups to focus on conservation goals and adapt new behaviors. Providing individuals with information is a conventional conservation strategy. While communication alone does not change behavior, it can provide necessary tools in order to promote behavioral change. Another aspect of this program is the use of prompts to remind people of better behaviors, such as turning off lights and closing windows. The program would also be able to target specific individuals or groups of individuals for specific conservation behaviors. This would allow programs to be designed to meet specific needs, responsibilities, and potential actions of specific groups.

Financial Analysis

Assumptions

Project Cost: $550,000 total ($50,000 annually)
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: $50,000 annually

Cost Avoidance: $43,502
Revenue Generated: n/a
NPV: no risk = -$55,545; with risk = -$169,708
IRR: no risk = -15.23 percent ; with risk = -n/a percent

An annual budget of $50,000 and would provide additional funding for conservation programs, for educational and awareness materials and events, financial incentives, and student staffing. This funding is increase of an existing $10,000 fund that would allow existing programs to expand. Various existing departmental budgets are already used for conservation programs, but this effort would provide dedicated funds to continue and grow these efforts. It is estimated that the behavioral program will result in a net reduction of 0.5 percent annually in energy use, resulting in approximately $43,502 in savings, based on an electric rate of $0.069 (a 3 percent inflation rate has been included in these calculations to factor in increasing energy costs).

Risk Value: .7

The risk associated with this program relates to the difficulty in measuring results and in ensuring that behaviors continue after the initial contact. For the program to be effective, the educational and incentive campaigns must result in permanent shifts in behavior. Previous educational campaigns have been quite successful, and relatively low-cost.

Carbon Estimate

$/ton
Tons reduced

Strategic Considerations

This program is in-line with commitments made by the University through the President's Climate Commitment, the Colorado state government, and the city and county of Boulder. There is a strong commitment to education through these programs. In relation to the campus climate plan, this program is critical to the reduction of energy use on campus.

Next Steps

A staff dedicated to this project to maintain the consistency of the message and quality of the program will be needed. This is currently in place through the Environmental Center.

Critical Success Factors

Beyond a dedicated funding source, the program needs to be well-managed to maintain consistency in the message being disseminated, well-designed to ensure that incentives and messages match the end-user's needs, and have management support.

Conversion to Duplex/Quad Printers

Description

Convert all campus printers to duplex capability or quad capability within 24 months.

Financial Analysis

Assumptions

Project Cost: Sinking fund of $1.53M for an estimated 1,275 printers on campus converted at an average cost of $1,200. Two years to complete a full renewal replacement cycle at $40,000 annual operating costs
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: $0
Cost Avoidance: $23,250 annually
Revenue Generated: n/a
NPV: no risk ($1,381,000); with risk ($1,433,000)
IRR: no risk -26.9 percent ; with risk -30.4 percent

It is assumed that 60 percent of all print jobs involve more than one page and can be printed in a duplex format. The cost savings is the reduced paper needed. This project is estimated to yield a reduction of 20 percent paper costs. This project is scalable. For example, a $1.02M replacement cost for 850 printers on average with $40,000 annual operating costs over two years has an expected 13 percent paper reduction, a $15,113 savings. The financial returns (NPV and IRR) are similar to the larger project. There is a high negative financial return.

Risk Value: .70

Units already are responsible for replacing their own office equipment. There is incentive to "upgrade" when someone else pays for it regardless of intended outcome. Printers could be replaced that still have a useful life that outweighs the savings from the new capabilities or printers already have the ability to print two-sided. Also, there is no guarantee that once the capability is available that it would be chosen to be used.

Carbon Estimate

$/ton
Tons reduced

Strategic Considerations

This project as proposed is campus-wide, meaning that it co-mingles General Fund and non-General Fund funded activity. Typically, non-General Fund units cover the cost of operations within their own operations. Many units likely already have printers that have duplex capability since there is an inherent incentive to two-sided printing. Units also have to pay for their own paper supply.

Next Steps

Provide printer models in procurement information that include a function for duplex printing. Communicate at least twice yearly how to set (or check for) printer defaults for duplex capability. The focus of this project should not be based on paying for the replacement of equipment, rather influencing behavior for the procurement and use of this equipment. This would have a substantially reduced project cost with likely positive financial returns.

Critical Success Factors

This project is not feasible from a financial perspective and yields little carbon savings. The focus of this project should be switched from equipment replacement to perhaps behavior to both yield positive financial results and still contribute to carbon reduction.

Implementation of Diversion Potential Assessment Recommendations

Description

The purpose of this project is to support the implementation of applicable recommendations from the *Diversion Potential Assessment* as part of the effort to assess the costs and benefits of a comprehensive review and overhaul of the campus solid waste management system to be more in line with Zero Waste practices and principles. The implementation of the *Diversion Potential Assessment*, represent action items that will be effective strategies for increased waste minimization and diversion in the university's current and future waste management programs. It is likely that additional Zero Waste initiatives will require funding in the future. Applicable recommendations include:

a. additional collection cabinets in academic, administrative, and residential buildings;
b. continual placement of outdoor public containers
c. expanded list of acceptable materials as low-grade paper
d. establishing acceptable locations for vendors to deliver recyclable materials
e. expansion of corrugated cardboard collection in academic/administrative buildings
f. implement Styrofoam collection
g. provide refillable mugs to CU employees
h. additional outreach campaigns to students, faculty, and staff

This project is an expansion of existing programs already existing on campus.

Financial Analysis

Assumptions

Project Cost: $260,000
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: $112,000 year

Cost Avoidance: $23,452
Revenue Generated: $51,414
NPV: no risk = -$546,739; with risk = -$662,358
IRR: no risk = n/a; with risk = n/a

The upfront project cost of $260,000 is related to capital investments to support a zero waste program at the university. These capital costs include: containers, equipment costs, collection facilities, and promotional materials. An annual expenditure of $112,000 supports the necessary operations expansion to support the program. These costs can be split between Housing and Academic/Administration budgets. Housing's cost percentage is approximately 25 percent for capital costs and 30 percent of operation and maintenance costs; Academic/Administration's share takes up the remainder.

It is estimated that this project can divert 902 tons of waste from landfills on an annual basis. This results in a reduction of tipping fees (currently at $26/ton) and increase revenue from recyclable materials (currently at $57/ton).

Risk Value: .80

The risk for this project is related to the level of involvement on campus. For Zero Waste programs to work, everyone must be more aware of their behavior regarding recycling, composting, and trash. This project is also influenced by the possibility of a carbon tax. By implementing a Zero Waste program, the university can save approximately 870 metric tons of carbon emissions. It can also help to reduce tipping rates. Similar programs on campus have shown high levels of success, such as levels of recycling and the "Green Stampede" program for a zero-waste football stadium.

Carbon Estimate

$/ton
Tons reduced

Strategic Considerations

This project will reduce tipping fees for the university, as well as support the governor's goal for zero waste from operations, including a 20 percent paper reduction goal.

Next Steps

An expanded outreach campaign to faculty, staff, and students will need to be implemented in order to increase participation in waste reduction programs. Identifying areas of campus with the potential to increase diversion rates, as well as identifying additional materials for collection will also be necessary.

Critical Success Factors

Full participation by all members of campus is needed for this initiative to succeed. This involves not only increased waste diversion (such as recycling), but also an awareness of the impact of purchases in terms of the impact on the university's waste stream. Expansion of existing facilities is also necessary.

Alternate Fuel Vehicle Revolving Loan Pool

Description

The Alternate Fuel Vehicle Revolving Loan Pool would provide a fund of money to help purchasing departments offset the higher cost of an alternative fuel vehicle as compared to a similar vehicle model using traditional gasoline or diesel fuels. The fund would be repaid by an incremental maintenance fee that the purchasing department would pay over the life of the vehicle. This premium is expected to be recouped by reduced maintenance costs and better fuel efficiency. This is a new project for the university, but would help to overcome the price barrier to purchasing alternate fuel vehicles, enabling a greater number of such vehicles to be added to the campus fleet.

Financial Analysis

Assumptions

Project Cost: $500,000 would be used to set up the fund
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: $20,000/year
Revenue Generated: $40,000/year
NPV: no risk = -$36.70; with risk = -$175.69
IRR: no risk = 3.46 percent ; with risk = -3.1 percent

This project involves an upfront investment of $500,000 that would be drawn down over time as departments used the funds to offset vehicle purchase prices. At the same time, departments would be paying money back into the fund according the loan agreements. Cost savings are a result of fuel savings from the use of vehicles with higher fuel efficiency, and also from reduced maintenance costs resulting from a younger fleet. In addition, it is likely this project will see diminishing returns due to the aging of the vehicles, which results in increasing maintenance costs over time.

Risk Value: .7

Fuel prices have considerable variability, ranging from about $2/gallon of regular unleaded gasoline in 2009 to double that price in 2008, just one year ago. Given this unknown variability and a likelihood that fuel prices could rise again in the future, it makes sense to hedge against these costs by diversifying the campus fleet and focusing great attention on the purchase of alternate fuel vehicles and vehicles with greater fuel efficiency. The primary risk for this project is that repayment is not guaranteed. It is also difficult to calculate the expected savings from the project, as this depends in part on the number and type of vehicles purchased.

Carbon Estimate

$/ton
Tons reduced

Strategic Considerations

The Facilities Task Force for Flagship 2030 recommended the following:

> *Establish environmental sustainability as a central value of the university regarding facilities, transportation and parking and place these needs on a sound fiscal footing.*

In addition, vehicles continue to be added to the fleet over time, yet only a small portion of alternate fuel vehicles are being added. It is unlikely that CU will meet the petroleum reduction goals mandated by the Governor's Executive Order without this and other initiatives.

Next Steps

Repayment terms and conditions for the loans would need to be established, as well as an application process.

Critical Success Factors

Departments must be ready to purchase vehicles and alternative fuel vehicles must exist that meet the multitude of needs the presently exist. For example, an AFV must be available with the necessary towing capacity or utility needed to meet existing uses and future demands on campus.

Fleet Resizing

Description

Presently when departments purchase vehicles they do so either by 1) selecting a vehicle that replaces a similar and older vehicle or 2) adding a new vehicle based on new and specific work requirements. The idea behind fleet resizing is that when purchase decisions are made, the entire fleet (for a department or multiple departments) is considered instead of the typical approaches suggested above. Through sophisticated analysis, the process of making vehicle purchase decisions will consider the total utility of more than a single vehicle when deciding what to buy. This process should also be allowed to consider the vehicle needs and inventory of more than one department when making purchase decisions. For example, Housing may have a certain specialized kind of vehicle that Facilities Management also uses. Both use the vehicle relatively infrequently.

This initiative would likely require a single source of authority that would be responsible for working with departments to make appropriate purchase decisions but would have specific authority to make campus vehicle purchase decisions.

Financial Analysis

Assumptions

Project Cost: $18,584
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a

Cost Avoidance: $70,000
Revenue Generated: n/a
NPV: no risk = $46,243 with risk $30,027
IRR: no risk = 120.32 percent with risk 78.2 percent

Initial costs include approximately 200 hours of staff time in model and data base development. It is difficult to estimate cost savings as they depend completely on the vehicles selected, shared, or eliminated. Cost savings are an estimate based on cost savings of the Alternative Fuel Vehicle Revolving Loan Pool due to the fact that source of the cost savings for both projects are a result of saved operating and maintenance costs.

Risk Value: .7

While development of a process to evaluate purchase decisions is somewhat complicated and may not be able to take into account all variables appropriately, this is a relatively easy "low hanging fruit" project. The major risk in this project is stakeholder buy-in, and to help them to realize the benefits of sharing resources. There may also be some disputes resulting from conflicts over shared vehicles.

Carbon Estimate

$/ton
Tons reduced

Strategic Considerations

Resizing the campus fleet supports the recommendation of the Facilities Task Force to "establish sustainability as a central value of the university regarding facilities, transportation, and parking." Further, because the university continues to add to the campus fleet over time, it is unlikely that CU will meet petroleum reduction goals without this and related projects.

Next Steps

A central authority for vehicle purchases needs to be identified or established. Some time and effort needs to be spent in developing a purchasing model and creating a vehicle data base. It will also be necessary to determine how operating and maintenance costs will be split. A review of existing university policies regarding vehicle use may also need to be reviewed.

Critical Success Factors

Current vehicle decision makers must agree to this process and be willing to concede some decision making authority. Departments must also have available funds to make vehicle conversions and purchases.

Student Parking Ban

Description

Instituting a student parking ban would limit on-campus parking eligibility to faculty and staff or a smaller student segment than the system of unrestricted permits presently in place. This project is a reiteration of previous initiatives that have been proposed but never implemented.

Financial Analysis

Assumptions

Project Cost: $1,200,000 (loss of $1,200,000 in annual permit revenues)
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: $1,200,000 in lost annual revenues
Cost Avoidance: $61,200,000
Revenue Generated: n/a
NPV: no risk = $35,586,547; with risk = -$1,255,556
IRR: no risk = 123.22 percent ; with risk = -45.8 percent

Cost factors include lost revenues from student populations restricted from obtaining a parking permit, loss or gain of revenues from fines associated with improperly parked student vehicles, as well as outreach to students to discourage local vehicle ownership. These outreach costs could be rolled into existing outreach regarding alternative transportation options on campus.

This project may reflect cost savings in the long run, but not in the short run. In the long run – if successful – this project would demonstrate that the campus may grow or remain stable without student demand for cars. This may result in savings for construction projects that include much less parking.

Risk Value: .2

As previously stated, this project will require thorough planning, communication and outreach and implementation to be successful. Scalability of the project is essential in order to ensure support and participation. If done incorrectly, students will increasingly flood neighborhood streets and worsen university relations with the city and community – without reducing local student vehicle ownership and thus student vehicle miles traveled.

Carbon Estimate

$/ton
Tons reduced

Strategic Considerations

This project does not comport with existing strategic plans. The reduction in revenues for Parking and Transportation Services while at the same time developing new parking facilities and maintaining existing structures can create a potentially unstable financial model for the department. This should be a long-term, phased project, if implemented.

From a broad perspective, this initiative, if successful, reduces the university's dependence upon private vehicle infrastructure and its users' dependence on a private vehicle for access to the campus. From a limited/short-term perspective, this project will worsen the campus' strategic position by creating additional logistical difficulty, hazardous economic situations and strained community relations.

Next Steps

A detailed estimation of the impact of lost student parking permit revenues (or those of population segments–freshmen, e.g.) on the operations and maintenance of existing parking infrastructure must be completed. If existing infrastructure must be decommissioned because of reduced use and unsustainable operations and maintenance, there would be associated deconstruction costs. Alternatively, sales tactics and advertising to sell community or faculty/staff replacement permits for the new capacity must be estimated. A review of the political interests on the campus should also be included.

Critical Success Factors

For equity purposes, it may be necessary to eliminate student pass permit sales completely. However, there are several opportunities to scale this project: segment the eligible student population to new students, specific class-levels, residency status or other student classifications; eliminate student permits from specific lots, either starting from those most proximate or remote; or perhaps existing student permit proportions.

As discussed above, this should be a long-range plan only; immediate projects affecting parking operations, management and construction/deconstruction are underway and will significantly affect parking supplies, costs, proximities, student proportions and more. Furthermore, long-range plans within the master plan and capital construction plans and elsewhere either incorporate or avoid parking, and will complicate calculations of revenue projections, advertising projections. Finally, this project has been rejected by administration in the past, so a political assessment of campus interest must occur first.

An assessment of parking in near-by neighborhoods might also influence the success of the program.

Telecommuting/Flex Scheduling

Description

The telecommuting portion of the project proposes that it is the option for faculty or staff to work from home or an alternative location. The flex scheduling portion of the project assumes that employees work when convenient. The outcome of both is to reduce the number of personnel vehicle trips to campus.

Financial Analysis

Assumptions

Project Cost: Average of 4 hours a month per manager at an average compensation of $95K is equal to $2,192 per manager's occurrence. ((95,000/2080 hours worked annually) x 4 hours month x 12 months))
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: same as project cost
Cost Avoidance: n/a
Revenue Generated: n/a
NPV: no risk n/a; with risk n/a
IRR: no risk n/a; with risk n/a

It is assumed that the only direct cost is from the extra effort required by management. There currently are 6,700 employees on the Boulder campus. Assuming a ratio of 7 employees per manager, there are at least 838 managers impacted, the annual cost is estimated to be $1.8M. Costs associated with missed coverage, lost productivity, and reduction in services is not included. There is assumed to be zero cost savings to the campus. Space is still required to be maintained due to the nature of campus business. Reductions in utilities expenditures for space underutilized would be more than offset by increased costs by those costs above that are not included yet relevant.

65 percent are eligible → 4,350
5 percent would actually participate → 218
218/7 → 31 managers impacted
Cost = $68,000
5 days/month

Risk Value: .20

Carbon Estimate

$/ton
Tons reduced

Strategic Considerations

There is conflict with meeting unit and individual work expectations versus managing work time hours if this approach is applied broadly across all campus units. There already are telecommuting and flex schedules arrangements done on campus. To broadly assign this as a right with employment and to be utilized by jobs that require presence at certain times would cause loss of productivity that creates a negative financial impact well beyond the cost of implementing and managing this as an entitlement. Equity claims could be an issue if it is an entitlement for employment.

Next Steps

This proposed project fundamentally impacts campus operations. It should be decided whether to broaden this as an entitlement of employment or let it remain status quo, which is at the discretion of managers.

Critical Success Factors

Consistent application and management of this project is necessary if it is to be implemented as an entitlement. Some jobs are not structured for this, such as front office staff positions and trade positions since both require onsite presence during certain hours.

Kitchen Efficiency

Description

The layout of kitchens does not generally take into account energy efficiency. Refrigerators are placed next to stoves, causing the refrigerators to work harder to maintain cold temperatures. This project seeks to increase kitchen efficiency by considering the layout and ventilation systems.

Financial Analysis

Assumptions

Project Cost: $250,000
Rate of capital: 5.0 percent
Terms: 10 years
On-going costs: n/a
Cost Avoidance: $50,000
Revenue Generated: n/a
NPV: no risk = $187,380; with risk = $99,904
IRR: no risk = 17.76 percent ; with risk = 12.2 percent

The project costs include the repositioning of equipment to take advantage of heating and cooling aisles, as well as the engineering costs for the ventilation system. The cost avoidance is based on an estimated 5-year payback schedule. Cost savings are a result of energy savings and include a 3 percent inflation rate for increasing energy prices.

Risk Value: .8

The risk is in the uncertainty of the energy savings. The kitchens on the university are very energy intensive and inefficient, so any improvement made will improve their efficiency.

Carbon Estimate

$/ton
Tons reduced

Strategic Considerations

Kitchen efficiency will improve not only energy efficiency, but could also result in improved water efficiency and reduce the use of natural gas use.

Next Steps

An engineering study should be undertaken to identify a layout that results in the greatest improvement in energy efficiency, ventilation, heat recovery, etc. Kitchens should then be identified for remodeling.

Critical Success Factors

For this program to succeed, there must be buy-in from the kitchen staff. Improving kitchen efficiency should consider not only energy efficiency, but also how the kitchen staff use their space.

9.6 Appendix 6 — Academic Assets

1. Existing Research Institutes, Centers, and Initiatives

The following Institutes, Centers and Initiatives house an outstanding array of researchers who are defining the leading edge of Climate Change and Innovation for a Sustainable Future

Cooperative Institute for Research in Environmental Sciences (CIRES)

CIRES provides comprehensive environmental research and outreach through a variety of interdisciplinary efforts, including the work of the Center for Limnology, the Center for Science and Technology Policy Research, the Center for the Study of Earth from Space, the Climate Diagnostics Center, the National Snow and Ice Data Center, and the CIRES Education and Outreach Group. http://cires.colorado.edu

Institute for Arctic and Alpine Research (INSTAAR)

INSTAAR develops scientific knowledge of physical and biogeochemical processes at local, regional, and global scales, and applies this knowledge to improve society's awareness and understanding of natural and anthropogenic environmental change. The world's high latitude and high altitude regions are the Institute's traditional focus due to their sensitivity to environmental change. INSTAAR has increasingly broadened its geographic focus in a wide range of interdisciplinary studies of Quaternary and modern environments, including studies of climate, oceanography, biogeochemistry, geochronology, human and ecosystem ecology, and landscape evolution. Interdisciplinary Research Groups include the Past Global Change Group, Ecosystems Group, and Geophysics Group. Research facilities include over 30 labs, and facilities such as the university's Niwot Ridge Long-Term Ecological Research Site. INSTAAR's mission also includes Education and Societal Outreach through such programs as REU (Research Experiences for Undergraduates) and SOAR (Significant Opportunities for Advancement in Research and Science). http://instaar.colorado.edu

Institute for Behavioral Sciences (IBS) Environment and Society Program

Provides a setting for collaborative research on societal problems that transcend disciplinary boundaries, including work through its Natural Hazards Center to advance and communicate knowledge on natural hazards mitigation and disaster preparedness, response, and recovery.
http://www.colorado.edu/ibs

Colorado Renewable Energy Collaboratory (CREC)

CREC Combines skills and capabilities of CU-Boulder, Colorado School of Mines, Colorado State University, and the National Renewable Energy Laboratory for the pursuit and advancement of renewable energy technologies in the state of Colorado. Efforts include the Colorado Center for Biorefining and Biofuels (C2B2), the Center for Revolutionary Solar Photoconversion (CRSP), and the Center for Research and Education in Wind (CREW). http://www.coloradocollaboratory.org

Renewable and Sustainable Energy Initiative (RASEI)

Discovers, develops, and promotes new energy technologies that will transform the social, economic, legal, and political forces that influence energy use. Crosses all facets of the university, including the research and development activities of dozens of science and engineering faculty, the entrepreneurial work of the Leeds School of Business-based Transforming Energy and Markets (TEAM), the policy and law work of the Colorado Law School Center for Energy and Environmental Security (CEES), and numerous education and outreach efforts. http://ei.colorado.edu

Colorado Power Electronics Center (CoPEC)

Based in the Department of Electrical and Computing Engineering, CoPEC mixes power electronics with analog and mixed-signal integrated circuit design to conduct energy research that spans the range of power management applications—from ultra-low-power energy scavenging devices, biosensors, and high-efficiency converters for portable battery-operated systems; to high-wattage wireless, computer, aerospace, lighting, and medical applications; to hundreds of kilowatts for wind power generation systems. http://www.colorado.edu/~pwrelect

Center for Energy and Environmental Security (CEES)

Interdisciplinary research and policy center based in the Law School, works to develop practical strategies and solutions for moving international society toward a global sustainable energy future. Addresses issues of energy security and climate change by anticipating emerging concerns, establishing new lines of inquiry, developing and deploying strategic programs and projects, and charting the territory for responses by government, business, and society. http://cees.colorado.edu

Center for Environmental Journalism

Enriches public understanding of environmental issues by elevating the quality, range and depth of coverage by journalists. Helps seasoned and emerging journalists enhance their knowledge of the scientific, economic, political, and social aspects of environmental issues. Focuses on both professional development of working journalists and student education.
http://www.colorado.edu/journalism/cej/index.html

Center of the American West (CAW)

Identifies and addresses such crucial issues as multiculturalism, community building, fire policy, and land, water, and energy use. The center brings together, for meaningful conversation and interaction, people as diverse as the American West itself, and has begun a series of reports that assemble most current information on energy efficiency and conservation into accessible and practical guides for individuals and businesses in the West who want to save money and conserve energy resources. http://www.centerwest.org

Natural Resources Law Center

Through a comprehensive program of research, education, and advice, the Center seeks to inform and influence legal and policy decisions on western natural resources. The Center focuses substantial intellectual and practical expertise on natural resources issues of importance in the American West through a network of leading legal and policy decision-makers, natural resources administrators, researchers, stakeholders, and concerned citizens, and in conjunction with the School of Law and the broader University of Colorado community and regional and national natural resources institutions. http://www.colorado.edu/Law/centers/nrlc

Deming Center for Entrepreneurship at the Leeds School of Business

The Sustainable Venturing Initiative offers tomorrow's entrepreneurial leaders and entrée into the fast-changing world of sustainable business opportunities, with a focus on the growing fields of clean technology and renewable energy. Students have the opportunity to engage in business development and technology transfer based on cutting-edge energy research being done at CU and the National Renewable Energy Laboratory (NREL). The initiative also offers an executive education program on sustainability, energy, and climate change.
http://leeds.colorado.edu/Deming/index.aspx?id=548

Institute for Ethical and Civic Engagement

Serves as a forum, catalyst, coordinator, and proponent for faculty, students, administrators and community leaders who wish to encourage ethical and civic education at CU Boulder, effectively integrating ECE into curriculum, co-curricular programs, and campus culture. Assists colleges, schools, departments, and student organizations to develop projects and courses in ECE, including service learning courses. Hosts conferences, workshops, and seminars for exchange of ideas http://www.colorado.edu/iece/index.html

Civic and Social Engagement (CASE) for Sustainability

Brings together scholars, practitioners, and students working to understand and implement communication strategies for a more sustainable world. Promotes sustainability at local, national, and global levels. Coordinated by the Department of Communications.
http://www.colorado.edu/journalism/cej/index.html

Conflict Information Consortium

Uses information technologies to provide citizens in all walks of life with the information they need to deal with conflicts more constructively. The Consortium sees efforts to enhance and mobilize the skills of the general population as critical to efforts to deal with complex, society-wide conflicts, including global warming. http://conflict.colorado.edu

Science Discovery

Science Discovery, established in 1983, is an experience-based educational outreach program of the University of Colorado at Boulder School of Education. Science Discovery's mission is to stimulate scientific interest, understanding, and literacy among Colorado's youth, teachers, and families by interfacing with university resources and academic expertise. Science Discovery is dedicated to engaging the whole person in the journey of learning, and strengthening individual capacities to participate actively in local and world communities. http://www.colorado.edu/ScienceDiscovery/

2. Current Academic Programs

The University of Colorado offers a wide variety of majors, programs, and certificates pertaining to the environment, sustainability, and energy

Degree Programs

College of Architecture and Planning

- Environmental Design
- Land Use, and Environmental Planning and Design

Department of Anthropology

Department of Atmospheric and Oceanic Sciences

- Graduate Certificate in Oceanography

Department of Civil, Environmental, and Architectural Engineering (CEAE)

- Building Systems Program
- Engineering for Developing Communities
- Environmental Engineering
- Geotechnical Engineering and Geomechanics
- Geo Environmental Engineering
- Graduate Program in Hydrology, Water Resources, and Environmental Fluid Mechanics

Department of Ecology and Evolutionary Biology

Environmental Studies Program

- Dual Degree in Environmental Studies and Business Administration
- Dual Degree in Environmental Studies and Law

Department of Geography

Department of Geological Sciences

Hydrologic Sciences Graduate Program

INVST Community Studies Program

Leeds School of Business

- Initiative for Sustainable Development
- Curriculum Emphasis on Social Responsibility (CESR)

School of Journalism and Mass Communication

- Environmental Journalism

School of Law

- Natural Resources Law
- Environmental Law

Department of Sociology

- Graduate Program in Environmental Sociology

Certificate Programs

Undergraduate Energy Certificate Program

Graduate Energy Certificate Program

Certificate in Engineering, Science, and Society

Graduate Certificate in Environment, Policy, and Society

Interdisciplinary Graduate Certificate Program in Environmental Policy

Graduate Certificate in Oceanography

Certificate Program in Peace and Conflict Studies

Certificate Program in Sustainable Practices (Continuing Education)

Western American Studies Certificate

Other Academic Programs

Engineering for Developing Communities Program
http://www.edc-cu.org/about.htm

Chancellor's Leadership Residential Academic Program
http://www.colorado.edu/chancellorslrap/

Baker Residential Academic Program for the Natural Sciences and Environmental Studies
http://www.colorado.edu/E-RAP/

Presidents Leadership Class (PLC)
http://www.presidentsleadershipclass.org/

INVST Community Studies
http://www.colorado.edu/communitystudies/

Puksta Scholars
http://www.colorado.edu/AcademicAffairs/UndergraduateEducation/pukstaweb/index.html

Other Student Opportunities for Engagement

There are many opportunities for individual students to work with faculty and staff on climate, energy, environmental, and sustainability issues through research and practicum. These include:

Undergraduate Research Opportunities/ UROP and URAP programs

Service Learning Community Outreach

- Course work, initiated by individual faculty and fostered by the Institute for Civic and Ethical Engagement.

Internships and Work Study Opportunities

- Facilities Management — green chemicals for custodial workers
- CU Recycling, Housing and Dining Services — Development and marketing to promote behavioral change to complement sustainability initiatives in operations
- Faculty/Staff/Student Partnerships — research and applications for carbon footprint reduction and other sustainability goals of campus operations, for example ENVS 4100-Carbon Neutral CU, and ENVS 3001- Sustainable Solutions Consulting

3. Student Organizations and Groups

The University of Colorado is renowned for its actively engaged student body. There are many opportunities that students have created for themselves with emphasis on the environment, alternative energy, and sustainability.

Environmental Center

The CU Environmental Center (E-Center) is the nation's oldest, largest, and most accomplished student-run environmental center, which educates, activates, and inspires the campus community to understand and engage in local and global environmental issues. With eight professional staff and over 100 student staff, dozens of volunteers and interns; and numerous programs that improve sustainability for the campus, community, and planet, the E-Center is among students' most popular organizations. Award-winning services include CU Recycling; climate, energy and water conservation efforts; student bus pass and bicycle programs; numerous events; environmental justice initiatives; and a library of books, periodicals, and videos. http://ecenter.colorado.edu/index.html

UCSU Environmental Board

The nation's largest student-run Environmental Center is run by a board of seven students and two non-students, with an unlimited number of interested, non-voting members.
http://www.Colorado.edu/ecenter/

University of Colorado Student Union

UCSU is the student body government for the University of Colorado at Boulder. UCSU creates, implements and oversees a $30 million budget generated by student fees and other revenue for the operation of UCSU Cost Centers. UCSU also serves as the liaison between the student body and university administration. Three branches, an executive, a legislative and a judicial, are governed by the student-adopted Constitution. Positions include a Sustainability Director.
http://www-ucsu.colorado.edu/webber/information.cfm

CU Biodiesel

CU Biodiesel is a student and community organization dedicated to education and implementation of petroleum-free fuels http://www.cubiodiesel.org

Colorado Public Interest Research Group (COPIRG) student chapter

COPIRG promotes the use of renewable energy sources, advocate for affordable higher education, and address hunger and homelessness.
http://www.copirgstudents.org

CU Recycling

One of the nation's leading campus recycling programs. A variety of volunteer, research, and internship opportunities exist. http://www.Colorado.edu/recycling

CU WILD: Rainforest Action Group

Committed to preserving tropical and temperate ecosystems, indigenous peoples' rights, and the promotion of sustainable alternatives to wood products.
http://www.colorado.edu/StudentGroups/cuwild/

CU WILD: Study Group

Dedicated to the preservation of Colorado's wild and primitive areas, sponsors educational programs, monitors timber sales, and provides outlets for student activism.
http://www.colorado.edu/StudentGroups/cuwild/

CU WILD: Wildlife Initiative

Dedicated to the protection and recovery of wildlife with a focus on native carnivores and their habitats in the Southern Rocky Mountain eco-region and its neighboring high plains and deserts. http://www.colorado.edu/StudentGroups/cuwild/

Earth Education

Helps elementary and middle school students gain a better understanding of environmental problems and solutions through outdoor programs, classroom projects, or planning and discussion sessions. http://ecenter.Colorado.edu/earthed

Environmental Studies Club

Working to gain financial, administrative and faculty support, and curriculum reforms for the University Environmental Studies Program. The club also helps Environmental Studies students find jobs and network with program alumni.
http://www.Colorado.edu/envirostudies

Environmental Law Society

Gives law students opportunities to immerse themselves in the larger natural resources law community that Colorado has to offer. Organizes service outreach activities and outdoor adventures. 303.492.8073

Environmental, Population, and Organismic Biology Club

Offers field trips, hosts guest speakers, presentations, panels, and seminars related to diverse aspects of biology. Students experience first-hand the branches of biology and the careers, research possibilities, and volunteer opportunities available

Green Teams

Educate off-campus students about community recycling programs, composting, energy and water conservation, and other ecologically sound household practices. Facilitated through the Environmental Center http://ecenter.colorado.edu/get_involved/volunteer.html

EcoReps

Peer-to-Peer education program for students living in Residence Halls and Greek houses. Eco-Reps learn about recycling, sustainable transportation, energy and water conservation, and other environmental topics and the create education and outreach programs for their Hall to help other residents to be more environmentally engaged. Facilitated through the Environmental Center http://ecenter.colorado.edu/get_involved/volunteer.html

Population Connection

Focuses on local population-related issues such as human health, human rights, and environmental degradation. Population Connection is the national grassroots population organization that educates young people and advocates progressive action to stabilize world population at a level that can be sustained by Earth's resources.
http://www.colorado.edu/studentgroups/PopulationConnection/index.html

STAMP

Promotes non-motorized and mass transportation alternatives to the single occupancy automobile. Strives to motivate CU, Boulder, and the surrounding communities to embrace non-automobile transport as a solution to environmental, political, economic, and social problems created by the automobile.

Student Environmental Action Coalition (SEAC)

Works on environmental justice issues, community service, education, and networking, and sponsors speakers and action-oriented events. http://ucsu.Colorado.edu/~seac

CU Community Energy Connections

Student home energy auditing program for low-income residents in the extended Boulder area. Provides education and access around energy efficiency as a means to achieve self-sufficiency and create a broader awareness of and access to solutions that make economic, social, and ecological sense. http://cucec.org

CU Going Local

Focuses on relocalization of food resources by promoting local food production in urban gardens, on campus, and on "the Hill" area next to campus. http://cugoinglocal.com

Green Cord Graduation Pledge

Graduating seniors pledge commitment to social and environmental responsibility upon commencement and entrance into life beyond college.
http://www.colorado.edu/studentgroups/scc/graduationpledge.html

Ralphie's Green Stampede

Student, faculty and staff volunteers assist football fans in properly sorting their recyclable and compostable materials at CU Buffaloes Football zero waste home games. Program is facilitated through CU Recycling.
http://www.cubuffs.com/ViewArticle.dbml?&DB_OEM_ID=600&ATCLID=1549954

Student Representation on University committees

Student representatives are members of many standing and ad hoc committees. Some of these include the Board of Regents, the Fee Advisory Board, and the Chancellor's Committee on Energy, Environment, and Sustainability.

Sustainable CU

In 2005, students voted on the Sustainable CU Referendum, which dedicates $2.80/ student/semester to implement on-campus projects to reduce the campus' impact on climate and environment. Proposal review favors initiatives created and led by students.
http://ecenter.colorado.edu/greening_cu#sust_cu

4. Campus- Wide Behavioral Change Programs

Live Green Pledge

For spring 2009, for every CU student, faculty or staff member who signed the CUCU Buffs Live Green Pledge and committed to reducing their personal carbon footprint, CU pledged $5 towards campus sustainability projects that reduce CU's carbon footprint.

Turn Off Climate Change!

An ongoing effort to encourage responsibility for turning off lights not in use. Campaign focuses on behavioral change through stickers on light switches, energy consumption data by building, and web-linked information on lighting conservation.

Residence Hall Room Energy Virtual Tour

A user-friendly, "point and click" virtual tour instructing residence hall students on energy saving tips. http://ecenter.colorado.edu/dormenergy

5. Faculty Workshops and Education to Faculty

In the Spring of 2009, Dr. Geoff Chase of AASHE and San Diego State University, led two workshops on **integrating sustainability into the curriculum**. The first was open to all participants at the Rocky Mountain Sustainability Summit; the second was exclusively for CU faculty. Approximately 24 CU faculty members attended the workshop, representing Environmental Studies, Geography, EBiology, Political Science, Philosophy, Economics, Communication, Education, Western American Studies, ATOC, Mathematics, Baker RAP, Sewall RAP, Farrand RAP, Program in Writing and Rhetoric, and CIRES. The representation of different disciplines and outlooks was inspiring, especially the attendance of faculty who had not joined previous conversations. Participants showed interest in gathering together on a regular basis to network, provide support and help each other develop grass roots approaches for forwarding sustainability curricula, as well as moving the topic forward among the faculty. Pat Kociolek, Director of the CU Museum of Natural History, offered to host future meetings at the Museum. One meeting has been held since the workshop, and more are expected.

CIRES Education and Outreach has developed **"Making Climate Hot: Effectively Communicating Climate Change"**, a presentation on communicating climate change that is presented to CU faculty and students, as well as outside groups such as the National Weather Service. The website also includes numerous resources for teachers, including "taking the fear out of teaching global warming", and "how to talk to a climate skeptic."
http://cires.colorado.edu/education/k12/makingclimatehot/

CIRES Education and Outreach has also co-developed an online course for teachers through CU Continuing Education entitled **Climate 101, Essential Principles of Climate Literacy.**
http://cires.colorado.edu/education/k12/ClimateLiteracyP2P.pdf

6. Campus Events

The University of Colorado has a great number of Centers, Programs, Initiatives, and Departments that host and sponsor events of all sizes, from small gatherings to National Conferences with Keynote Speakers. Although this is a "good problem to have", there is no single coordinated clearinghouse where all events are posted. The following is a brief list of recent events.

Meeting the Global Climate and Energy Challenge, August 22-23, 2008
http://www.colorado.edu/climatenergy/news/events.html

12th Rocky Mountain Sustainability Summit Feb. 11-13, 2009
The biannual Rocky Mountain Sustainability Summit provides a learning and networking forum for participants from campuses in the Rocky Mountain region (CO, NM, UT, WY, MT, ID, and AZ) to advance sustainability. Features keynotes by leading experts, campus administrators and government officials. http://ecenter.colorado.edu/rmss2009

ELEVATE! The Future of Development, Climate Change and the New Frontiers of Urban Development February 26-27, 2009

More than 30 of the nation's leading thinkers and practioners in real estate, law, business and public policy gathered for a new symposium about sustainable land use and real estate development. http://www.lisc.org/docs/events/elevate_2009.pdf

Energy Initiative Research Symposium November 17, 2008

Hosted in partnership with regional federal labs.
http://ei.colorado.edu/index.php?id=177&pid=50&page=2008 percent 20EI percent 20Research percent 20Symposium percent 20and percent 20Seed percent 20Grant percent 20Competition&parent=64

Boulder Chapter of the United Nations

Millennium Development Goal #7, "Ensure Environmental Sustainability," specifically addresses the need for development that sustains natural resources and biodiversity, protects water supplies and increases the availability of safe drinking water where good water is scarce and water-borne disease is common. It is clear that achieving these goals will depend upon solutions to climate change, solutions based on science, new technologies and political will.

61st Annual Conference on World Affairs April 6–10, 2009

Forum on international affairs, media, science, diplomacy, technology, environment, spirituality, politics, business, medicine, human rights, and more.
http://www.colorado.edu/cwa

The 2009 conference on World Affairs included a keynote address by James Hansen entitled, "Climate Threat to the Planet: Implications for Intergenerational and Environmental Justice," April 9, 2009.

Mildred Dresselhaus, MIT, "Advanced Materials on Our Energy Future: Breakthroughs and Challenges" April 30, 2009

Thomas Friedman, "Hot, Flat and Crowded: Why we need a Green Revolution – and How it can Renew America" February 16, 2009.

9.7 Appendix 7 — Emission Reduction Projects, External Activities & Developments

Estimating future energy supply and demand is a difficult task with many ambiguities, all of which are compounded over the long term given the uncertainty in future economic and population growth and technology development. Regardless of these uncertainties, analysts agree that there will be greater energy demand in 2020 compared to today. Most agree that energy demand will increase by 35 percent to 50 percent by 2030 over today's demand[35,36].

Wind Power

The most promising and fastest growing utility-scale renewable energy project is wind turbines. Installation of wind power has seen tremendous growth over the past five years, with 5.2 gigawatts (GW) installed in 2007 and 8.3 GW in 2008, resulting in over 25 GW of total capacity by the end of 2008.[37] This growth represents 42 percent of all new power-producing capacity in the nation last year, which is a dramatic increase compared to 2002, when wind power represented just 1 percent of all new generation.[38]

Given the recent nationwide growth and Colorado's position as a leader in the wind industry, there is significant optimism for wind energy production in the United States and Colorado in the next 20 years and beyond. Xcel estimates that wind will provide 18 percent of its energy production in 2020, representing a nearly 1 percent /yr growth. This represents our medium implementation option, resulting in 48 percent of Xcel Energy's production in 2050. Our low is 0.5 percent /yr growth, while our high is 1.5 percent /yr growth, resulting in 33 percent and 63 percent of Xcel Energy's production in 2050.

Solar Power

Solar energy is another promising source of electricity production in the United States. Solar technology is split between photovoltaic arrays (PV), which is most common on the individual building scale, and concentrated solar plants (CSP), which hold the most promise for utility production.

It is difficult to determine how much of this growth will occur within Colorado or would provide electricity for the university. Currently, one of the largest utility-scale plants in the nation, with an 8.22 MW capacity, operates in the San Luis Valley in southern Colorado. [39] Furthermore, Xcel Energy has put

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[35] Energy Information Administration (EIA). (2008). World Energy Projections Plus. www.eia.doe.gov/eia
[36] Exxon Mobil. The Outlook for Energy; A View to 2030. 2007. www.exxonmobil.com
[37] American Wind Energy Association (AWEA). Wind Energy Grows by Record 8,300 MW in 2008, press release on January 27, 2009. www.awea.org
[38] AWEA.
[39] http://coloradoenergynews.com/2008/12/san-luis-valley-home-to-most-productive-uility-scale-solar-power-plant/

out RFPs for an additional 600 MW of solar production, much of which could be met with projects in the San Luis Valley.[40]

Given the recent growth in the solar industry and the potential in the San Luis valley, our medium estimate for concentrated solar plants in Xcel Energy's production is 0.5 percent /yr growth from 2020 to 2050. This growth would result in CSP providing 15 percent of Xcel Energy's electricity production in 2050, assuming that there was only marginal amounts of CSP in 2020. Our low and high growth rates are 0.25 percent and 0.75 percent /yr.

Carbon Capture and Storage

Coal currently provides 50 percent of US electricity production and will continue to play an integral part of energy production for the near future.[41] Xcel Energy forecasts that coal will constitute 46 percent of its electricity production capacity in 2020 for its entire territory.[42] Carbon capture and storage (CCS) involves the separation of CO_2 from the emissions of industrial and energy production sources and the long term storage of this CO_2 either on-site or at a central location.[43]

Given the tremendous coal resources in the United States and abroad as well as existing infrastructure, it is clear that significant research and investments will continue to focus on CCS. We believe that CCS will be utilized in 10 percent of coal plants in 2020 and then increasing by 10 percent per decade, resulting in 40 percent utilization in 2050. Using these estimates, we can expect a 4 percent reduction in emissions in 2020 from CCS (46 percent of electricity production x 10 percent utilization x 90 percent CCS rate). Assuming that coal provides 30 percent of electricity production in 2050, a 40 percent utilization would result in an approximately 11 percent reduction in emissions compared to if CCS was not used.

Nuclear Energy

Nuclear energy currently provides approximately 20 percent of electricity production in the United States, although there is currently no nuclear electricity production in Colorado.[44] Xcel Energy forecasts little to no growth in the use of nuclear power in their electricity production by 2020, which is not surprising given the current regulatory environment.[45] It is reasonable to assume that this will change as the technology develops and the issue of nuclear waste storage is resolved. However, given that nuclear currently accounts for 0 percent of electricity production in Colorado, future growth will be modest. For these reasons, we assume that nuclear provides between 5 percent and 10 percent of

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[40] Colorado Energy News. http://coloradoenergynews.com/2009/01/the-outlook-experts-draft-2009-energy-road-map/
[41] EIA. http://www.eia.doe.gov
[42] Xcel Energy Overview. A presentation by Karen Hyde, VP for Resource Planning and Acquisition, January 7, 2009.
[43] Intergovernmental Panel on Climate Change. A Special Report of Working Group III of the IPCC: Carbon Dioxide Capture and Storage. 2005.
[44] EIA.
[45] Xcel Energy Overview.

electricity production in Colorado by 2050, which is the result of between 0.5 percent and 1 percent growth from 2040 to 2050.

Geothermal Heating and Cooling

Geothermal energy is a remarkable resource for providing base-load electricity and household heating and cooling needs in the United States. Experts estimate that geothermal energy sources contain 50,000 times the energy of all gas and oil resources combined.[46] The University of Colorado has ample opportunity to employ geothermal heat pumps on campus. For instance, many buildings on the main campus could be retrofitted while the space on east campus offers the opportunity to develop a central system to provide heating and cooling for any new development. Geothermal heat pumps should be given serious consideration by the university for heating and cooling operations.

Building Efficiency

The largest physical asset on the CU campus is the current building infrastructure. As the campus grows and changes, there is a continued need to renovate and build new buildings to fulfill this need. The university is a nationally recognized leader, with four LEED certified buildings with two to the gold standard, and a commitment to reaching this standard on all new buildings.

The National Renewable Energy Laboratory (NREL) and the American Institute of Architects (AIA) are calling for carbon neutral commercial buildings by 2030.[47,48] Both of these plans call for 60-70 percent increased efficiency over traditional buildings, with the remaining 30-40 percent of electricity needs being fulfilled by on-site renewable sources.

Given the expectations of NREL and the AIA, our high implementation option is for carbon neutral new buildings by 2030 (which would include 30 percent on site renewable energy).

Transportation

Faculty, staff and student commuting using both public transportation and personal automobiles, accounts for 8.4 percent of total 2008 greenhouse gas emissions at the university.[49] Improvements over the next 20 years should dramatically reduce emissions from commuting sources. Currently, through a grant from Xcel Energy, the University of Colorado is converting six Toyota Prius cars to plug-in hybrids. The emissions from these vehicles will be dependent on the grid, so as cleaner electricity is added, these emissions will drop. New development on a commercial scale, led by Chevy and Toyota, will bring these cars into widespread use over the next 15 years.

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[46] Geothermal Tomorrow 2008. A DOE Report on the Geothermal Technologies Program. http://www.nrel.gov/geothermal/publications.html#analysis.
[47] National Renewable Energy Laboratory. www.nrel.gov
[48] American Institute of Architects. www.architecture2030.org
[49] CU GHG Inventory, 2008. http://ecenter.colorado.edu/2008GHGinvetory

9.8 Appendix 9— Carbon Model Data

2031 2030-2031	2032 2031-2032	2033 2032-2033	2034 2033-2034	2035 2034-2035	2036 2035-2036	2037 2036-2037	2038 2037-2038	2039 2038-2039	2040 2039-2040
156,233	157,248	158,270	159,299	160,335	161,377	162,426	163,482	164,544	165,614
35,143	35,439	35,737	36,037	36,339	36,642	36,948	37,256	37,566	37,877
5,212	5,212	5,212	5,212	5,212	5,212	5,212	5,212	5,212	5,212
196,588	197,899	199,220	200,548	201,885	203,231	204,586	205,949	207,322	208,703
0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
196,588	197,899	199,220	200,548	201,885	203,231	204,586	205,949	207,322	208,703
1,568	1,568	1,568	1,568	1,568	1,568	1,568	1,568	1,568	1,568
1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380
603	603	603	603	603	603	603	603	603	603
200,139	201,450	202,771	204,099	205,436	206,782	208,137	209,500	210,873	212,254
0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
200,139	201,450	202,771	204,099	205,436	206,782	208,137	209,500	210,873	212,254
0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
-17,335									
-54,666	-54,666	-54,666	-54,666	-54,666	-54,666	-54,666	-54,666	-54,666	-54,666
-1,647	-1,785	-1,922	-2,059	-2,197	-2,334	-2,471	-2,608	-2,746	-2,746
-23,819	*-41,150*	*-43,484*	*-45,844*	*-48,231*	*-50,646*	*-53,089*	*-55,560*	*-58,059*	*-60,676*
-16,410	-27,892	-29,037	-30,194	-31,364	-32,548	-33,745	-34,956	-36,181	-37,475
-3,269	-5,850	-6,374	-6,905	-7,442	-7,985	-8,534	-9,090	-9,652	-10,236
-1,526	-2,730	-2,975	-3,222	-3,473	-3,726	-3,983	-4,242	-4,504	-4,777
-2,615	-4,680	-5,099	-5,524	-5,953	-6,388	-6,827	-7,272	-7,722	-8,189
-20,815	-21,459	-22,108	-22,760	-23,415	-24,075	-24,738	-25,405	-26,077	-26,752
-724	-727	-730	-733	-737	-740	-743	-747	-750	-754
-362	-363	-365	-367	-368	-370	-372	-373	-375	-377
-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121
-396	-690	-690	-689	-689	-688	-688	-687	-687	-687
-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182
-1,803	-1,820	-1,837	-1,854	-1,872	-1,889	-1,907	-1,924	-1,942	-1,960
-1,190	-1,213	-1,234	-1,254	-1,273	-1,291	-1,307	-1,323	-1,338	-1,352
2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
30,259	13,122	8,947	4,724	453	-3,867	-8,237	-12,658	-17,129	-21,694
30,259	13,122	8,947	4,724	453	-3,867	-8,237	-12,658	-17,129	-21,694
82,709	79,857	77,005	74,153	71,301	68,449	65,597	62,745	59,893	57,041
59,893	62,745	65,597	68,449	71,301	74,153	77,005	79,857	82,709	85,561
58%	56%	54%	52%	50%	48%	46%	44%	42%	40%
82,709	79,857	77,005	74,153	71,301	68,449	65,597	62,745	59,893	57,041
52,450	66,735	68,058	69,429	70,848	72,316	73,834	75,403	77,022	78,735
832,652	899,387	967,445	1,036,874	1,107,723	1,180,039	1,253,874	1,329,276	1,406,299	1,485,034
-7.6%	-56.6%	-31.8%	-47.2%	-90.4%	-953.9%	113.0%	53.7%	35.3%	26.6%
-7.6%	-56.6%	-31.8%	-47.2%	-90.4%	-953.9%	113.0%	53.7%	35.3%	26.6%

2041 2040-2041	2042 2041-2042	2043 2042-2043	2044 2043-2044	2045 2044-2045	2046 2045-2046	2047 2046-2047	2048 2047-2048	2049 2048-2049	2050 2049-2050
166,690	167,774	168,864	169,962	171,067	172,179	173,298	174,424	175,558	176,699
38,191	38,507	38,825	39,145	39,467	39,791	40,117	40,445	40,776	41,108
5,212	5,212	5,212	5,212	5,212	5,212	5,212	5,212	5,212	5,212
210,093	211,493	212,901	214,319	215,745	217,181	218,627	220,081	221,546	223,019
0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
210,093	211,493	212,901	214,319	215,745	217,181	218,627	220,081	221,546	223,019
1,568	1,568	1,568	1,568	1,568	1,568	1,568	1,568	1,568	1,568
1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380
603	603	603	603	603	603	603	603	603	603
213,644	215,044	216,452	217,870	219,296	220,732	222,178	223,632	225,097	226,570
0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
213,644	215,044	216,452	217,870	219,296	220,732	222,178	223,632	225,097	226,570
0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
2041	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
-54,666	-54,666	-60,133	-65,599	-71,066	-76,533	-81,999	-87,466	-92,932	-98,399
-2,746	-2,746	-2,746	-2,746	-2,746	-2,746	-2,746	-2,746	-2,746	-2,746
-63,329	*-66,018*	*-64,806*	*-63,375*	*-61,726*	*-59,858*	*-57,772*	*-55,469*	*-52,949*	*-50,211*
-38,786	-40,114	-39,085	-37,955	-36,722	-35,387	-33,951	-32,413	-30,774	-29,033
-10,828	-11,429	-11,348	-11,215	-11,032	-10,796	-10,510	-10,172	-9,783	-9,344
-5,053	-5,333	-5,296	-5,234	-5,148	-5,038	-4,905	-4,747	-4,566	-4,360
-8,663	-9,143	-9,078	-8,972	-8,825	-8,637	-8,408	-8,138	-7,827	-7,475
-27,431	-28,114	-28,801	-29,492	-30,187	-30,886	-31,589	-32,296	-33,008	-33,723
-757	-761	-764	-768	-771	-775	-779	-782	-786	-790
-379	-380	-382	-384	-386	-388	-389	-391	-393	-395
-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121
-686	-686	-685	-685	-685	-684	-684	-683	-683	-682
-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182
-1,978	-1,996	-2,014	-2,033	-2,051	-2,070	-2,088	-2,107	-2,126	-2,145
-1,364	-1,377	-1,388	-1,399	-1,409	-1,419	-1,428	-1,436	-1,444	-1,451
2041	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
-26,325	-31,022	-33,378	-35,290	-36,760	-37,787	-38,372	-38,517	-38,222	-37,488
-26,325	-31,022	-33,378	-35,290	-36,760	-37,787	-38,372	-38,517	-38,222	-37,488
54,189	51,337	48,485	45,633	42,781	39,929	37,077	34,225	31,373	**28,520**
88,414	91,266	94,118	96,970	99,822	102,674	105,526	108,378	111,230	114,082
38%	36%	34%	32%	30%	28%	26%	24%	22%	**20%**
54,189	51,337	48,485	45,633	42,781	39,929	37,077	34,225	31,373	**28,520**
80,514	82,358	81,863	80,923	79,540	77,715	75,449	72,742	69,595	66,009
1,565,548	1,647,906	1,729,769	1,810,692	1,890,232	1,967,948	2,043,397	2,116,139	2,185,734	2,251,742
21.3%	17.8%	7.6%	5.7%	4.2%	2.8%	1.5%	0.4%	-0.8%	-1.9%
21.3%	17.8%	7.6%	5.7%	4.2%	2.8%	1.5%	0.4%	-0.8%	-1.9%

2051 2050-2051	2052 2051-2052	2053 2052-2053	2054 2053-2054	2055 2054-2055	2056 2055-2056	2057 2056-2057	2058 2057-2058	2059 2058-2059	2060 2059-2060
177,848	179,004	180,167	181,338	182,517	183,703	184,897	186,099	187,309	188,526
41,443	41,780	42,119	42,460	42,804	43,150	43,498	43,848	44,201	44,556
5,212	5,212	5,212	5,212	5,212	5,212	5,212	5,212	5,212	5,212
224,503	225,996	227,498	229,011	230,533	232,065	233,607	235,159	236,721	238,294
0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
224,503	225,996	227,498	229,011	230,533	232,065	233,607	235,159	236,721	238,294
1,568	1,568	1,568	1,568	1,568	1,568	1,568	1,568	1,568	1,568
1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380
603	603	603	603	603	603	603	603	603	603
228,054	229,547	231,049	232,562	234,084	235,616	237,158	238,710	240,272	241,845
0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
228,054	229,547	231,049	232,562	234,084	235,616	237,158	238,710	240,272	241,845
0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
2051	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**
-103,866	-109,332	-109,332	-109,332	-109,332	-109,332	-109,332	-109,332	-109,332	-109,332
-2,746	-2,746	-2,746	-2,746	-2,746	-2,746	-2,746	-2,746	-2,746	-2,746
-46,039	*-41,872*	*-42,541*	*-43,216*	*-43,895*	*-44,578*	*-45,266*	*-45,960*	*-46,658*	*-47,360*
-26,621	-24,211	-24,598	-24,988	-25,381	-25,776	-26,174	-26,575	-26,978	-27,385
-8,567	-7,792	-7,916	-8,042	-8,168	-8,295	-8,423	-8,552	-8,682	-8,813
-3,998	-3,636	-3,694	-3,753	-3,812	-3,871	-3,931	-3,991	-4,052	-4,113
-6,854	-6,233	-6,333	-6,433	-6,534	-6,636	-6,739	-6,842	-6,946	-7,050
-34,443	-35,167	-35,896	-36,628	-37,365	-38,107	-38,852	-39,602	-40,357	-41,116
-793	-797	-801	-805	-809	-813	-816	-820	-824	-828
-397	-399	-401	-402	-404	-406	-408	-410	-412	-414
-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121	-22,121
-682	-682	-681	-681	-680	-680	-680	-679	-679	-678
-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182	-1,182
-2,165	-2,184	-2,203	-2,223	-2,243	-2,262	-2,282	-2,303	-2,323	-2,343
-1,458	-1,465	-1,471	-1,477	-1,482	-1,488	-1,492	-1,497	-1,501	-1,505
2051	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**