University of Pennsylvania Carbon Reduction Action Plan

May 27, 2009
Contents

Team Members ........................................................................................................................................................................... 3
Acknowledgements ........................................................................................................................................................................ 4
Executive Summary ........................................................................................................................................................................ 5
1 Introduction: Scenarios for Carbon Reduction .................................................................................................................. 6
2 Carbon Footprint ......................................................................................................................................................................... 6
  2.1 Sources of Emissions ......................................................................................................................................................... 6
  2.2 Carbon Offsets ................................................................................................................................................................. 6
  2.3 Emissions from Buildings ................................................................................................................................................... 7
3 Emissions Projections ............................................................................................................................................................... 8
  3.1 Categories of Carbon Emissions ...................................................................................................................................... 9
  3.2 Carbon Reduction Plan ..................................................................................................................................................... 10
  3.3 Long-term Reduction Targets ............................................................................................................................................ 10
  3.4 Five Year Reduction Targets .......................................................................................................................................... 14
  3.5 Recommendations: ......................................................................................................................................................... 16
Summary: Carbon Footprint, 1990-2008 ..................................................................................................................................... 17
Five Year Reductions and Energy Budget ............................................................................................................................... 18
University of Pennsylvania Carbon Reduction Action Plan

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Executive Summary

In 2007, University of Pennsylvania President Gutmann signed the American College and University President’s Climate Commitment (ACUPCC). This pledge committed Penn to developing plans for reducing its emissions of climate-altering greenhouse gases (GHG) over time to achieve climate neutrality. This report summarizes the analysis of Penn’s current carbon footprint completed over the past 2 years along with the proposed strategies developed to achieve the carbon reduction goals.

Process

The TC Chan Center was commissioned to prepare and provide the technical input and analysis for the report to meet the requirements of the ACUPCC. The effort was headed by the Penn Department of Facilities and Real Estate Services (FRES). An Environmental Sustainability Advisory Committee (ESAC) was created to gather input and develop recommendations for carbon reductions. Chaired by FRES Vice President, Ann Papageorge, the ESAC included students, staff and faculty, and was organized into six subcommittees to address campus carbon reduction in all areas of campus operations.

Campus Carbon Footprint.

A simplified calculator was developed to facilitate the ongoing tracking of carbon emissions at Penn. The gross GHG emissions for FY2008 were 355,800 Metric Tons of Carbon Dioxide Equivalent (MTCDE), a slight drop from the previous year. The net emissions of 250,500 MTCDE are considerably lower in FY2008 due to a larger purchase of Renewable Energy Credits (RECs) that offset approximately 30% of the gross emissions.

As with most universities, the largest share of campus emissions are related to energy use in buildings. In Penn’s case, almost 90% of the carbon footprint comes from the production of electricity and steam. (Fig Ex.1)

Carbon Reduction Scenarios.

Using the current carbon footprint along with anticipated campus growth, a base-case was developed projecting Penn’s GHG emissions into the future. Under this “Business-As-Usual” scenario, assuming no carbon reduction strategies are implemented, Penn would nearly double its total carbon emissions by 2050.

With this base-case as the starting point, a variety of alternate strategies were studied to develop scenarios for reducing the carbon footprint. The preferred scenario describes a variety of individual emissions reductions achieved through ambitious yet achievable strategies. This plan bases the short term carbon reductions on realistic strategies that have been demonstrated on campus projects. The mid- and long-term assumes progressively more aggressive reductions, anticipating advances in technology, improvements in economic feasibility and increased community awareness.

Using the assumptions described above, along with the continuing purchase of RECs at about the current level, Penn’s plan for carbon reduction has the potential to reach climate neutrality by 2050.

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1 American College and University President’s Climate Commitment, which was organized by the Association for the Advancement of Sustainability in Higher Education (AASHE).
2 A carbon footprint is “the total set of GHG (greenhouse gas) emissions caused directly and indirectly by an individual, organization, event or product” (UK Carbon Trust 2008).
3 “Renewable energy certificates (RECs) represent the attributes of electricity generated from renewable energy sources.” (U.S. NREL) By purchasing REC’s that have zero carbon emissions, Penn can claim an indirect “offset” of its own emissions.
1 Introduction: Scenarios for Carbon Reduction

This report presents a long term, strategic scenario by which the University can achieve a significant reduction in carbon emissions. When combined with carbon offsets from purchasing Renewable Energy Certificates, this scenario is Penn’s plan for achieving carbon neutrality. It was prepared in partial fulfillment of the ACUPCC pledge signed by Penn President Gutmann in 2007, which sets out the steps leading to an action plan and target date for significant carbon reduction. This report includes both a simplified and updated carbon footprint through fiscal year 2008, from which the scenarios are developed, and which in turn provide a framework for identifying a target date for significant carbon reduction.

2 Carbon Footprint

The current carbon footprint of the main campus was developed with a carbon calculator developed for Penn, using the conventions and assumptions set out by the World Resources Institute and modeled on a similar calculator developed for Harvard. While Penn owns or controls many buildings around the world, but for this plan it was decided to focus on the main campus in West Philadelphia that contains the largest concentration of its buildings.

Institutional GHG emissions are typically divided into categories based on the source and the institution’s level of control of the emissions. The categories are referred to as “scopes” and there are three basic scopes. Scope 1 includes all direct sources of emissions that are released directly by the institution, such as natural gas and fuel oil combusted on campus, refrigerant leakage, and University owned vehicles. Scope 2 emissions include indirect sources of emissions from the purchase of electricity, heat or steam. Scope 3 emissions include all other indirect sources of emissions that may result from the direct activities of the University, but that occur from sources owned or controlled by other entities, such as commuter travel, solid waste disposal, and institutionally sponsored air travel.

2.1 Sources of Emissions

Over 86% of carbon produced by the University is from building-related sources. At present, steam, electricity, oil, and natural gas are all used in the operation of the University campus, though steam and electricity account for the vast majority of emissions. Air Travel by students, faculty and staff is the next largest source comprising 8% of emissions. It should be noted that this total includes only travel that was arranged directly through the University. The balance of the emissions are from commuting, solid waste disposal, Penn owned vehicles, refrigerant leakage and replacement and agriculture (limited). Using historical data, the GHG emissions of the University were calculated for the years 1990 – present (Fig. 2.1).

2.2 Carbon Offsets

Reducing or eliminating energy consumption is the most direct method of reducing Penn’s carbon footprint. The focus of this plan is a set of strategies to achieve significant reductions in energy use. However, the campus will never be able to stop using energy completely. Even with substantial reductions in energy use, Penn will continue to have carbon emissions until the power supply is itself carbon free. Carbon offsets provide a second tier approach to reduce the campus’s carbon footprint to near zero. These offsets can range from the on-site production of non-emitting sources of power, such as solar energy, or the purchase of green power generated elsewhere. In 2004 the University began to purchase a percentage of its annual electric power from wind generation through Renewable Energy Certificates. Wind power purchases are considered a carbon offset as they have little or no carbon emissions associated with their production. These REC’s are a major reason why the University’s overall carbon emissions have declined over the past 5 years, as seen in Fig. 2.1.

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4 http://www.greencampus.harvard.edu/ggi/docs.php
2.3 Emissions from Buildings

As noted above, utility consumption in buildings constitutes the majority of carbon produced by the University. Therefore, much of the focus of this plan is on carbon reductions in campus buildings. To reduce utility consumption, and the associated carbon emissions, will require many kinds of improvements to buildings and their systems, and changes in the purchasing and use of the power consuming equipment within them.

In order to understand where energy is used and carbon is produced the results of the BPAT+ audits are used. The BPAT+ audits are a way to provide strategic information on individual building performance, but leave open the question of how much to reduce that energy consumption. For that we have to compare Penn’s buildings to some kind of performance measure, which will allow us to estimate how much energy might be saved and how difficult it would be to achieve those savings.

There are many kinds of standards used at different stages in the process of designing or analyzing building energy performance. The local building code in Philadelphia, for example, uses ASHRAE 90.1 (2004), because it provides information specific to the design process, but it is not well suited to the analysis of existing building performance or for strategic decisions. For that purpose, we have drawn on a national energy consumption survey conducted every four years by the Department of Energy (DOE), called the Commercial Building Energy Consumption Survey (CBECS), which has in turn been used by the Environmental Protection Agency (EPA) to establish Energy Star performance targets for building construction and renovation. To help strategize the improvement of Penn’s buildings, we used the Energy Star standard to evaluate the buildings of the main campus.

Drawing on the CBECS data, Energy Star identifies annual energy consumption amounts in thousands of BTUs per square foot of building (kBTU/SF) for specific building types and occupancies, which is as close as we can get to a

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5 ASHRAE is the American Society of Heating, Refrigeration, and Air-conditioning Engineers.
“miles-per-gallon” metric for buildings. These consumption amounts are then correlated to a percentile ranking on a scale of 1 to 100, with 50 representing the average energy consumption for that building size, type, occupation, and location. To actually obtain an Energy Star label or certification, a building has to rank at Energy Star 75 or above, meaning it has to perform better than 75% of the buildings of its type (www.energystar.gov).

To understand the potential carbon reduction opportunities in buildings, emissions were analyzed in two ways: by building type (Fig. 2.2) and by uses of energy across all campus buildings (Fig. 2.3). Of campus building types, laboratory buildings, residence halls, health care, and office/classroom buildings represent the largest producers of carbon. For energy uses, equipment, cooling, fans, lighting, and heating make up the largest portions of carbon consumed by buildings on campus. These are the categories with the most potential for energy and emissions reductions.

3. Emissions Projections

In order to develop a plan for carbon reduction over time, it was necessary to determine a base case scenario of projected emissions from the University assuming no new carbon reduction strategies are implemented. This “Business-As-Usual” scenario started with the current carbon footprint extrapolated along with estimates for campus growth. Based on data over the last 20 years, the rate of growth (building square footage and campus population) was assumed to be 1% a year.

Another significant growth factor from the historical analysis is the steady increase in electrical intensity (watts per square foot). Every year the University uses about 1.5% more electricity per building area. This is consistent with national trends, and is mainly due to the use of more and more devices demanding electric power: computers, printers, scanners, copiers, cell-phone chargers, and so on. For the Business-As-Usual base case, we assumed this trend will continue.

Using these two basic growth factors for campus size and electricity use, the projected increase of the University’s emissions are shown in Business-As-Usual (BAU) graph (Fig. 3.1). If recent patterns of growth continue and no efforts are made to reduce energy use, the University will add 100,000 MTCDE to its emissions in 20 years, which would nearly double its total carbon output by 2050. There are significant limitations in this sort of long term trend analysis and these are reflected in the fading colors of the graph after the 20 year mark. However, as the journey to

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6 Energy Information Agency.
carbon neutrality will take many years, a long term projection is needed to provide a target for carbon reduction scenarios.

### 3.1 Categories of Carbon Emissions

![Figure 3.1 Base Case (Business-As-Usual)]

To understand and develop a scenario for significantly reducing the carbon footprint, Penn’s emissions over the next 40 years have been separated into four broad categories.

1. Emissions due to the construction of new buildings.
2. Emissions due to increased electrical intensity.
3. Ongoing emissions from existing buildings.
4. Ongoing emissions from other sources.

In Fig. 3.1, each of these categories of carbon emissions is illustrated as a colored area representing the total expected emissions in the Business-As-Usual scenario. Each measure begins at the current year, FY2009, and is extrapolated to 2050. All though this timeline is well beyond the range of reasonable prediction, these simple, linear projections allow for broad comparisons.

**New emissions due to increased electric intensity.** As noted above, the amount of electricity used per square foot of building has increased steadily at a rate of about 1.5% per year in excess of the growth in campus buildings. As this trend is projected forward, it describes a surprisingly large new wedge of carbon emissions and warrants immediate action. Since this form of growth is largely decentralized, both in the purchase of devices and in their use and operation, it will require a range of measures to reduce or eliminate this growth.

**New emissions due to the construction of new buildings.** Each year, new buildings are added to the campus. Each new building will require additional energy for its operations, and add more carbon to the university’s emissions. As indicated in the previous section, that rate of growth has averaged about 1% a year, which defines the slope of
the carbon wedge attributed to new buildings. To limit further growth of emissions, new buildings should be as energy efficient in their design and operation as possible.

Emissions from existing buildings. Existing buildings are currently the largest contributors of carbon on campus (86% of total emissions) and will continue to be so for the foreseeable future. This category of emissions obviously represents the largest opportunity for emissions reduction.

Emissions from non-building sources. Emissions due to non-building sources are primarily due to air travel at 8.2%, followed by commuting at 3.5%, and then by Solid Waste at 1.4%. Natural Gas, Fuel Oil, Agriculture, Refrigerants, Fleet Diesel, and Fleet Gasoline combined contribute a negligible amount of only 0.27% of total emissions from 1990 - 2008.

3.2 Carbon Reduction Plan

ESAC Subcommittees and Carbon reduction initiatives. The following subcommittees are a part of the initiative for a carbon reduction plan. Each of these 6 groups contributes to the implementation of carbon reduction measures with focused areas of reduction to approach carbon neutrality. Some of these groups are not likely to have direct carbon reductions. The only group with significant immediate annual carbon reductions is the energy and utilities group. The transportation group and the waste and recycling group can yield some smaller annual carbon reductions. The Built environment group yields some indirect carbon reductions through implementation of higher building standards. The explanations below summarize the types of immediate initiatives being planned by each ESAC subcommittee.

5. Energy and Utilities: Conservation programs, facilities renewal and replacements, capital project renovations, and recommissioning of existing building systems.

6. Academics: Enhance undergraduate, graduate, & faculty sustainability education opportunities. Highlights: new minor, course development, workshops, & student research.

7. Built Environment: Develop new standards compatible with the LEED system; provide trainings; and improve landscape maintenance protocols.

8. Transportation: Promote alternative commuting; provide incentives to use of public transit; improve bicycle and pedestrian experience on campus, and improve efficiency of Penn fleet.


10. Communications: Branding; website maintenance; marketing and advertisement; direct engagement.

3.3 Long-term Reduction Targets

Reduction measures. Starting with the emissions projections in the Business-as-Usual base case, a number of possible scenarios were analyzed consisting of varying combinations of carbon and energy reduction strategies. Four of the ESAC subcommittees (Energy and Utilities, Transportation, and Waste and Recycling, and Built Environment) developed recommendations for carbon reduction measures that, combined, produce a scenario for approaching carbon neutrality by mid-century. This plan, together with continuing the current amount of RECs purchased each year, has the potential to achieve climate neutrality by 2050.

The plan focuses on six targeted emissions reduction measures:

1. Reduction in electric intensity (watts/sf).
3. Renovation of existing buildings to higher energy standards.
4. Re-commissioning existing building systems.
5. Improving the efficiency of existing utilities and infrastructure.
6. Reducing emissions from air travel, solid waste, university vehicles and other smaller sources.

Each measure's potential for reducing emissions is shown as a wedge shaped areas in Fig. 3.2. The area of each wedge shows the amount of carbon eliminated over time if the associated measures are undertaken.

Figure 3.2 Long-term Carbon Reductions

**Reduce Electric Intensity.** This measure involves eliminating the current 1.5% annual growth in plug loads (electric intensity growth) and further reducing the current electric consumption of campus buildings. To achieve this, Penn will develop and monitor educational programs that focus on occupant behavior modification, as well as address the procurement process for equipment. This measure is estimated to yield a carbon reduction of 3,919 MTCDE annually for the first 2 years. The amount of savings decreases to 67% of the original savings until FY2050.

**High Performance New Buildings.** By adopting energy efficiency standards similar to those set by peer institutions for new construction, substantial energy savings can be achieved with cost-effective investments. This measure assumes that any new campus buildings will be designed and constructed to meet an equivalent of Energy Star 90 or 30% below ASHRAE 90.1. This will yield an annual carbon reduction of 2,673 MTCDE which continues through FY2050.

**Renovate Existing Buildings to Higher Energy Standards.** This measure assumes that the existing buildings which are renovated each year are improved to a minimum standard of Energy Star 75 (some recently renovated campus buildings have already met this goal). After the first few years of improvement to Energy Star 75, the standard would be raised to reach Energy Star 90 standards.
Renovating existing buildings and systems to an Energy Star 75 standard can yield up to a 10% annual payback on the initial dollar investment, and up to an annual carbon reduction of 14,417 MTCDE for the first year or so. This annual payback decreases after the worst performing buildings have already been renovated. The annual carbon reduction reduces to 5,648 MTCDE annually after the worst buildings have been renovated. The annual carbon reduction will continue to reduce in savings until it reaches 1,561 MTCDE in FY2040 and levels off.

Recommission Existing Building Systems. Recommissioning involves adjustments and recalibration of the energy consuming systems so they will operate more efficiently. Anticipated carbon reduction in the plan, based on Penn’s experience with an initial sample of buildings that were recommissioned, are 30% savings for the first three years and a gradual decrease to level off at a 9% of those savings after the 80 worst performing campus buildings have been recommissioned every 10 year cycle. The associated reductions assume that a minimum of 600,000 SF of buildings is recommissioned annually with a higher SF in the first five years while the largest buildings are recommissioned first. With the recommended installation of meters on each campus buildings, accurate recording of each building’s individual consumption and subsequent savings will be possible.

Improve Efficiency of Existing Utilities. This reduction encompasses a variety of infrastructure improvements to increase energy efficiency, including strategies such as steam line insulation and insulation of man hole covers to reduce energy loss in the overall system. The measure assumes that after FY2009 the utility measures are increased to produce an annual carbon reduction of 1,953 MTCDE until FY2014, and then cut by half to produce an annual carbon reduction of 976 MTCDE until FY2024. After the first 15 years this measure assumes that all of the existing utilities will have been improved to a better energy standard.

Reduce Air Travel and Other Emissions. This measure assumes that the carbon emissions produced by the University’s air travel is cut by 1% annually as well as all emissions from Commuting, Fleet, Solid Waste, Natural Gas and Diesel Generators are cut by 1% annually. The carbon reduction from this particular measure is relatively small in the overall wedges scenario and is represented as a very small sliver in the wedges graph.

Green Power RECs. This scenario assumes that the current rate of wind power REC purchases, 112,000 MW-Hr/yr would continue at the same level for the first five years of the plan. Over the next 15 years, the level of RECs purchased would increase by approximately 13% of the current level and increase again by approximately 29% until FY2050. This measure would reduce carbon emissions by 3,089,499 MTCDE, but at unavoidably negative cash flow.
**Individual wedges or pieces of the plan.** Each individual measure is a separate wedge in the chart (Fig. 3.3). In isolating each wedge as an individual piece one can see how much impact each specific measure carries on its own. Some of the measures have lower overall savings in comparison to other larger savings measures.

![Figure 3.3 Isolated Wedge Carbon Reductions](image-url)
3.4 Five Year Reduction Targets
The above scenario shows a long term approach to achieving carbon neutrality at the University of Pennsylvania. Based on the strategies that were analyzed fairly significant carbon reductions are possible within the first five years of this plan, as seen in Fig. 3.4. By fiscal year 2014, the net carbon footprint can decrease 169,840 MTCDE or 43% percent from the BAU line including the purchase of RECs (the BAU line at 2014 is 390,841 MTCDE). This is an actual reduction of 108,265 MTCDE or 30% from 2008 levels, not including the effect of wind power RECs. This shorter term projection includes implementation of all of the measures described above, though given the current economic situation, no new buildings are expected to be funded in the next five years. The first five years are an indicator of what measures can occur immediately to start the University on a path to reduce the overall carbon footprint to neutrality by FY2050.

**Figure 3.4 Five Year Short Term Targets**

**Reduce Electric Intensity.** For the first five years this measure involves eliminating the current 1.5% annual growth in plug loads (electric intensity growth) and a reduction in the current electric consumption in campus buildings by beginning to develop and monitor educational programs that focus on occupant behavior modification, as well as address the procurement process for equipment. The first two years start off with higher initial carbon reductions to yield 3,919 MTCDE each year. The next three years taper off the amount of carbon savings to 2,613 MTCDE each year. The decrease occurs due the inability to sustain the higher initial savings once the behavior modification programs have been in place for a while.

**Renovate Existing Buildings to Higher Energy Standards.** For the first five years this measure assumes that the existing buildings which are renovated each year are improved to a minimum standard of Energy Star 75. The first few years of renovation will yield a higher amount of energy savings by selecting the worst performing campus buildings to renovate immediately. The first two years yield a 10% annual payback on the initial dollar investment.
The next years decrease incrementally to 5% annual payback in FY2012 and then to 3% in FY2013 and FY2014. This annual payback decreases after the worst performing buildings have already been renovated.

**Recommission Existing Building Systems.** For the first five years this measure begins to tackle the worst performing buildings’ systems by recommissioning 8 buildings per year and installing meters. The first three years carry a possible 30% energy savings based on the Average kBTU/SF of 210.40 for the worst 40 performing campus buildings surveyed in the BPAT+. The energy savings decrease to 25% for FY2013 and FY2014. These reductions assume 600,993 SF in FY2010, 900,000 SF in FY2011, 800,000 SF in FY2012, 700,000 SF in FY2013, and 600,000 SF in FY2014. This measure starts to set up the campus for accurate recording of each building’s individual energy consumption by installing a meter on each building that is recommissioned.

**Improve Efficiency of Existing Utilities.** For the first five years this reduction begins to improve existing infrastructure to increase energy efficiency in the overall system. The first five years of activity produces an annual carbon reduction of 1,953 MTCDE. This measure yields a three year payback on the initial dollar investment for the first 5 years of implementation.

**Reduce Air Travel and Other Emissions.** For the first five years this measure assumes that the carbon emissions produced by the University’s air travel is cut by 1% annually as well as all emissions from Commuting, Fleet, Solid Waste, Natural Gas and Diesel Generators are cut by 1% annually.

**Green Power (RECs at current level).** This scenario assumes that the current rate of wind power REC purchases, 112,000 MW-Hr/yr would simply be continued over the first five years. This would yield an annual carbon savings of 61,575 MTCDE.

**Cost Savings for 5 year plan.** The initial five years of the action plan have been projected in the University budget, and are shown in Appendix A. For each year an initial implementation cost is determined along with the associated energy, carbon, and financial savings expected. The first five years of the plan will require an additional investment of approximately $12,850,000 with a cost savings potential of $15,528,367 and a carbon reduction of 104,477 MTCDE. The savings figures for the first five years do not include the cost to purchase RECs or the carbon savings associated with RECs. See appendix for detailed cost information of each year.
3.5 Recommendations:

With this carbon reduction action plan, the University has taken the first step towards a serious and sustained reduction in energy consumption, avoiding future costs and reducing carbon emissions. Although the target date for carbon neutrality is well beyond any certain predictions or projections about the future, it has served as a powerful organizing strategy for the reduction of campus carbon emissions and the improvement of the campus infrastructure. That strategic process has revealed or highlighted a number of items that are critical to the success of the carbon reduction action plan.

The most important is the principle advanced in the first sustainability plan, “if you can’t measure it, you can’t manage it.” The BPAT+ building audits provided the first building level energy consumption data on the campus, and have proved essential to the preparation of this plan and future management of building energy assets at the University, but real consumption data is necessary for the next steps. While BPAT+ provides useful strategic data, and can enable scenario testing, real metered data is required to verify any reductions as commercial vendors begin to take part in energy reduction programs and to achieve actual Energy Star operational ratings. Real metered utility data also provides the material to more equitably distribute costs, share savings, and provide incentives to the schools and centers. Although it is advisable to have meters installed for all campus buildings at once in order to have reliable data as a base line regarding individual buildings, metering can happen in stages. It should be part of an organized program of reforming the allocation of utility costs that prepares and protects the schools and centers from unexpected changes in costs.

The preparation of the plan and the discussions in the ESAC committees have underlined the importance of extending this work beyond the units typically involved in managing campus systems, because of the shared effort required, the powerful effects of behavior on many aspects of energy consumption, and the decentralized nature of the University. The leadership provided by the President and administration have been instrumental in realizing this plan, and will be necessary to its continued realization. At the end of the day, this plan involves a change in culture across the University that has only just begun.
Summary: Carbon Footprint, 1990-2008

University of Pennsylvania
Penn-Tsinghua T.C. Chan Center
Greenhouse Gas Calculator

Year (pick from drop down) FY08

Emissions (MTCDE)
- Scope 1 Emissions: 377
- Scope 2 Emissions: 338,140
- Scope 3 Emissions: 14,683
- Total Emissions (Scopes 1+2): 369,117
- Gross Emissions (Scope 1+2+3): 355,800
- Net Emissions (MTCDE): 258,526

Scope 1 Emissions (MTCDE)
- Agriculture: 0
- Emissions from Natural Gas: 652
- Emissions from R2 Oil: 60
- Emissions from Refrigerant: 3
- Emissions from Fuel: 263
- Other (Scope 1 Total): 377

Scope 2 Emissions (MTCDE)
- Emissions from Electricity: 238,123
- Emissions from Steam: 70,011

Scope 3 Emissions (MTCDE)
- Emissions from Commuting: 12,360
- Emissions from Solid Waste: 4,999
- Emissions from Air Travel: 29,324

Pie Chart Applies to: FY08

Scope 1, 2 & 3 Emissions by Source

Total Campus Emissions by Source

- Other
- Solid Waste
- Commuting
- Air Travel
- Steam
- Total Elec Minus Proc REC purchases
# Five Year Reductions and Energy Budget

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### Action Plan

1. **Energy Efficiency Improvements**
   - Implement LED lighting in all buildings.
   - Install smart thermostats in all offices.
2. **Renewable Energy Sources**
   - Expand solar panel installation across campus.
   - Develop a microgrid to support on-site energy generation.
3. **Transportation**
   - Increase usage of electric vehicles.
   - Implement a car-sharing program.
4. **Building Automation**
   - Enhance building automation systems for better energy management.
   - Integrate building energy data with academic research.

**Key Milestones**

- **2010:** 20% energy reduction and 40% CO₂ reduction achieved.
- **2015:** 40% energy reduction and 80% CO₂ reduction targeted.

**Challenges and Opportunities**

- **Challenges:**
  - Budget constraints.
  - Student and faculty resistance to change.
- **Opportunities:**
  - Partnership with leading environmental organizations.
  - Development of innovative technologies in renewable energy.

**Implementation Timeline**

- **2009-2010:** Baseline data collection and analysis.
- **2011-2012:** Implementation of major projects.
- **2013-2014:** Continuation of projects and monitoring of results.

**Feedback Mechanism**

- Regular updates to stakeholders.
- Student and faculty surveys to assess progress.
- Annual report on energy consumption and CO₂ emissions.
<table>
<thead>
<tr>
<th>Item</th>
<th>Activity</th>
<th>Base cost per PENN activity</th>
<th>Total Additional FY11 Needed per Activity (FY11 + Savings)</th>
<th>FY11 Cash Flow Savings vs. Previous Year</th>
<th>Carbon and Energy Savings</th>
<th>Energy Reduction per Activity (MBtu)</th>
<th>Energy reduction for campus (MBtu)</th>
<th>Energy reduction for scrubs (MBtu)</th>
<th>% reduced from baseline</th>
<th>Annual Savings Cost Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sustainability projects (Green Fund Projects)</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>2</td>
<td>Energy Conservation projects, Includes system wide initiatives, Activity,</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>3</td>
<td>Overview for window and building up to 2 years of energy costs for the existing building and 4 new systems estimated each year. (baseline options)</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>4</td>
<td>Evaluate the growth in usage in existing buildings through situation and management. Includes the cost of 1 contracted FYE at $75,000 each.</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>5</td>
<td>Refit high performance standards for all new buildings, for Passover River for 6, 100% Indoor, 90% Outdoor, 15% Total. Similar to standards in other institutions. Assumes a cost per unit related to the LRP study. Includes cost estimates. Costs shown in your planning agreement and Carbon footprint savings shown in your planning report. 40 projects approved in FY11.</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>6</td>
<td>Re-commission the equipment and systems design.</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
</tbody>
</table>

**Total FYE + FY Capital Plan "V" projects**

- Project: $75,000
- Campus RP: $12,000
- Baseline: KIT/USP at all buildings: $40,000
- KIT/USP (baseline to 2013): 37
- KIT/USP (75% to 100): 21
- Average KIT/USP savings for re-commissioning based on sampling of campus buildings studied: 20.59
- Average ERF savings for re-commissioning based on sampling of 9 campus buildings studied: 63.04
- Baseline KIT/USP for 40 buildings performing: 210.6
- 38% savings 30% savings 29% savings
- Percent: 0.3%

**Total**

<table>
<thead>
<tr>
<th>Total FYE + FY Capital Plan &quot;V&quot; projects</th>
<th>$75,000</th>
<th>$12,000</th>
<th>$40,000</th>
<th>37</th>
<th>21</th>
<th>20.59</th>
<th>63.04</th>
<th>210.6</th>
<th>38%</th>
<th>30%</th>
<th>29%</th>
</tr>
</thead>
</table>
| **Weighted Average for campus savings**
| 20.59 | 63.04 |
| **Total Savings Cost Avoidance** | $75,000 | $12,000 | $40,000 | $36,900 | $36,900 | $36,900 | $36,900 | $36,900 | $36,900 | $36,900 | $36,900 | $36,900 |

**Total ERF for re-commissioning**

- $75,000
- $12,000
- $40,000
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900

**Order Savings Total**

- $75,000
- $12,000
- $40,000
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900
- $36,900

**Percent Savings Projects**

- From $75,000.00
- 38%

**Total Savings Cost Avoidance**

- $111,605.89
- 38%
## University of Pennsylvania Carbon Reduction Action Plan

**Third Year Reductions: 2012**

### FY12 Cash Flow

<table>
<thead>
<tr>
<th>Item</th>
<th>Activity</th>
<th>FY11 Cash Open</th>
<th>FY11 Cash Closed</th>
<th>FY12 Cash Open</th>
<th>FY12 Cash Closed</th>
<th>FY11 Savings</th>
<th>FY12 Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sustainability projects / Green Fund Projects</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>2</td>
<td>Energy Conservation projects; isolated student housing</td>
<td>$256,000</td>
<td>$256,000</td>
<td>$256,000</td>
<td>$256,000</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>3</td>
<td>Eliminate the retrofit in existing buildings through education and management. (Includes the cost of 2 contracted PFE at $175,000 each)</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>
| 4    | Adopt high performance standards for all new buildings; for Energy Star WPI: 30% vs. 0% average.

### Carbon and Energy Savings

<table>
<thead>
<tr>
<th>Item</th>
<th>Activity</th>
<th>FY11 Savings</th>
<th>FY12 Savings</th>
<th>FY11 Savings</th>
<th>FY12 Savings</th>
<th>FY11 Savings</th>
<th>FY12 Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sustainability projects / Green Fund Projects</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>2</td>
<td>Energy Conservation projects; isolated student housing</td>
<td>$256,000</td>
<td>$256,000</td>
<td>$256,000</td>
<td>$256,000</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>3</td>
<td>Eliminate the retrofit in existing buildings through education and management. (Includes the cost of 2 contracted PFE at $175,000 each)</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

### Total New Money Encouraged for FY12

| Item | Total New Money Encouraged for FY12 | $2,950,000 | $1,650,000 |

### Annual Reductions Target

| Item | Annual Reductions Target | $17,758 | $115,639,401 |

May 2009
## Carbon and Energy Savings

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>FY13 Cash Flow</td>
<td>201,125</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Carbon and Energy Savings</td>
<td>2,185,919</td>
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</tbody>
</table>

### No Additional FY13 Funding Requested

<table>
<thead>
<tr>
<th>Activity</th>
<th>Base case per RIA Activity</th>
<th>Total Additional FY13 Needed per Activity (Base + School)</th>
<th>Emissions reduction per Activity (FY13)</th>
<th>Emissions reduction per Activity (FY14)</th>
<th>% Reduced from Baseline</th>
<th>Energy reduction per Activity (FY13)</th>
<th>Energy reduction per Activity (FY14)</th>
<th>% Reduced from Baseline</th>
<th>Annual Sinking/ Cost Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainability projects/Kleen Fund Projects</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>0.0%</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>0.0%</td>
<td>$1,000,000</td>
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<tr>
<td>Energy Conservation projects. Includes steam use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>reduction initiative and compressed air</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Alternatives. Also includes system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>integration, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>0.0%</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>0.0%</td>
<td>$1,000,000</td>
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</tbody>
</table>

### Fourth Year Reductions 2013

<table>
<thead>
<tr>
<th>Activity</th>
<th>Base case per RIA Activity</th>
<th>Total Additional FY13 Needed per Activity (Base + School)</th>
<th>Emissions reduction per Activity (FY13)</th>
<th>Emissions reduction per Activity (FY14)</th>
<th>% Reduced from Baseline</th>
<th>Energy reduction per Activity (FY13)</th>
<th>Energy reduction per Activity (FY14)</th>
<th>% Reduced from Baseline</th>
<th>Annual Sinking/ Cost Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-commission</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>0.0%</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>0.0%</td>
<td>$1,000,000</td>
</tr>
</tbody>
</table>

### Total

<table>
<thead>
<tr>
<th>Activity</th>
<th>Base case per RIA Activity</th>
<th>Total Additional FY13 Needed per Activity (Base + School)</th>
<th>Emissions reduction per Activity (FY13)</th>
<th>Emissions reduction per Activity (FY14)</th>
<th>% Reduced from Baseline</th>
<th>Energy reduction per Activity (FY13)</th>
<th>Energy reduction per Activity (FY14)</th>
<th>% Reduced from Baseline</th>
<th>Annual Sinking/ Cost Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>0.0%</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>0.0%</td>
<td>$1,000,000</td>
</tr>
</tbody>
</table>

### Carbon and Energy Savings

<table>
<thead>
<tr>
<th>Activity</th>
<th>Baseline Baseline</th>
<th>Total Additional FY13 Needed per Activity (Base + School)</th>
<th>Emissions reduction per Activity (FY13)</th>
<th>Emissions reduction per Activity (FY14)</th>
<th>% Reduced from Baseline</th>
<th>Energy reduction per Activity (FY13)</th>
<th>Energy reduction per Activity (FY14)</th>
<th>% Reduced from Baseline</th>
<th>Annual Sinking/ Cost Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>0.0%</td>
<td>$1,000,000</td>
<td>$1,000,000</td>
<td>0.0%</td>
<td>$1,000,000</td>
</tr>
</tbody>
</table>

---

May 2009
### Fifth Year Reductions 2014

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainability projects - General Fund Projects</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$8,000,000</td>
</tr>
<tr>
<td>Energy Conservation projects, includes shared project incentives, etc.</td>
<td>$0</td>
<td>$1,000,000</td>
<td>$0</td>
<td>$1,000,000</td>
<td>$2,000,000</td>
</tr>
<tr>
<td>Continue to increase and renew green space equivalent to Energy Star 75 standard for the existing buildings 4</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Monitor high performance standards for all new construction, for Energy Star 60 or 25% below ASHRAE 90.1 (gold)</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>No commissioned systems in existing buildings, new or replacement</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Total Energy Savings</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$8,000,000</td>
</tr>
</tbody>
</table>

### Seventh Year

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Sustainability projects - General Fund Projects</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$8,000,000</td>
</tr>
<tr>
<td>Energy Conservation projects, includes shared project incentives, etc.</td>
<td>$0</td>
<td>$1,000,000</td>
<td>$0</td>
<td>$1,000,000</td>
<td>$2,000,000</td>
</tr>
<tr>
<td>Continue to increase and renew green space equivalent to Energy Star 75 standard for the existing buildings 4</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Monitor high performance standards for all new construction, for Energy Star 60 or 25% below ASHRAE 90.1 (gold)</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>No commissioned systems in existing buildings, new or replacement</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Total Energy Savings</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$8,000,000</td>
</tr>
</tbody>
</table>

**Total Energy Savings**

$8,000,000

**Total Project Costs**

$10,000,000

**Total Net Savings**

$2,000,000

**Total Project Savings**

$10,000,000
### Five Year Summary

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Investment</td>
<td>$12,456,000</td>
</tr>
<tr>
<td>Total Return on investment</td>
<td>$15,528,367</td>
</tr>
<tr>
<td>Carbon Reduction MTCOE</td>
<td>184,477</td>
</tr>
<tr>
<td>Energy Reduction kJSTU</td>
<td>707,003,343</td>
</tr>
<tr>
<td>Percent reduction of carbon from Baseline FY07</td>
<td>-28.15%</td>
</tr>
<tr>
<td>Percent reduction of Energy from Baseline FY07</td>
<td>-20.80%</td>
</tr>
</tbody>
</table>