Campus Sustainability Plan
First Edition

Submitted

October 15, 2010

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I. EXECUTIVE SUMMARY

Keeping with its Jesuit tradition, Xavier University has a history of commitment to social and economic justice. It now seeks to broaden the traditional interpretations of those commitments to include an emphasis on environmental stewardship.

On April 29, 2008, Fr. Michael Graham, S.J., formally convened the Sustainability Committee. It was one of the steps required subsequent to his signing the American College and Universities' Presidents' Climate Commitment. Fr. Graham framed sustainability as a pivotal global issue in which the United States has a very important role, and The President's Climate Commitment as an important vehicle by which to initiate a call to action. The commitment also resonates with the Jesuit mission and philosophy in which we are all stewards of this planet. This stewardship is central to the outward expression of our faith and institutional identity.

The three-fold charge to the group laid out, then, was to:

- Develop the reputation as an institution that does sustainability well
- Become an inspiration to the broader community
- Establish regional best practices

The Campus Sustainability Plan is a dynamic document that results from 18 months of work on the part of the committee and the community. Multiple kinds of forums including lunch discussions, Sustainability Day community conversations, draft plan feedback sessions, electronic feedback options, and conversations with key constituencies for all sections of the plan, were held to solicit feedback from the University community on the Plan and the specific actions it should take,. The entire committee took a role in drafting the Plan in five major sections: Academic, Transportation, Community Engagement and Communications, Energy and Infrastructure, and Purchasing. In each section, there is a set of immediate, mid-term and long-range goals, and a discussion of resource needs and obstacles. The goals and reductions are set based on 2008 levels, as calculated in our first greenhouse gas survey.

A. Plan Highlights

Below we list all the vision and goal statements for each section.

<u>Energy and Infrastructure</u>

Long-term Vision: To minimize GHG emissions from the purchase and use of electricity and natural gas (stationary fuel sources) to the fullest extent possible; to reduce the consumption and withdrawal of fresh water; to reduce the rate of or eliminate stormwater runoff from Xavier premises; to reduce solid waste through conservative practices, reuse items that can still serve a function, and recycle used materials; to provide clean, aesthetically rewarding outdoor facilities for all students, staff, and visitors.

I. EXECUTIVE SUMMARY

Goals:

1. Energy Use

According to Xavier University's GHG inventory completed in the Spring of 2009, purchased energy in 2008 accounted for 63% of the entire CO2 equivalent emissions of the University. Two paths have been identified from which to choose the initial reductions in the GHG emissions from purchased electricity and stationary fuel sources. To achieve our goals, investments in a multitude of alternative energy, energy conservation measures, and offsets to are necessary. The trajectory of emissions reductions will depend on the path taken.

Path 1

- Invest in alternative technologies such as solar, geothermal, co-generation and fuel cells to achieve at least a 7% reduction from 2008 levels by 2012 and use the cost avoidance savings to fund other carbon reduction initiatives.
- Further reduce greenhouse gas emissions to 50% reduction (an additional 43%) by 2030 through other alternative energy and energy conservation measures with an intermediate step of 35% reduction by 2018.

Path 2

- Gradually reduce our greenhouse gas emissions to achieve a 25% reduction by 2018 through higher ROI energy conservation measures.
- Further reduce greenhouse gas emissions to 50% reduction (an additional 25%) by 2030 through higher ROI alternative energy and energy conservation measures.

Regardless of the path chosen

- Investment in offsets (preferably tangible, measureable initiatives in the surrounding community) will probably be required for the remaining 50% by 2030.
- All subsequent planning and new construction will require that achieving carbon neutrality is key to the overall design.

2. Building and Planning
   - Payback analysis should reflect the actual life of the structure, with material and equipment selections based on GHG emission reductions, since some funds will need to be used to buy offsets if this is not done.
   - Devise ways to achieve academic program goals while building as little new space as possible. Construction costs, energy costs, and emissions would be lower. No amount of conservation can avoid increasing campus emissions when additional square footage is built.

3. Water Conservation

a. Consumption
- Reduce overall water consumption levels by 40% from 2008 levels.
- Examine water-consuming systems and implement changes to high-consuming devices.
- Provide water usage feedback and education to change individual behavior.

b. Withdrawal
- Seek ways to capture and reuse storm water to minimize fresh water use for irrigation and cooling towers.
- Implement practices that reduce the need for irrigation and cooling water.

4. Stormwater Management

Stormwater runoff is a matter of serious concern to Cincinnati's Metropolitan Sewer District (MSD) due to combined sewer overflows (CSOs).

a. Runoff
- Seek an MSD grant to reduce storm-water runoff by 10,000,000 gallons per year within 5 years.
- Investigate water retention systems and implement changes to capture hard surface runoff.

b. Reuse
- Seek ways to capture and reuse storm water to improve the feasibility of retention systems.

5. Solid-Waste Management

Solid waste includes materials purchased by the University, materials carried in from off campus, and materials generated on campus.
- Prevent useful material resources from being wasted and reduce the consumption of raw materials by 30% from 2008 levels within 5 years.
- Expand recycling in all areas for all recyclable products.
- Create a campus wide information exchange and educational system about material recycling, reuse and reduction.

6. Grounds Maintenance
- Reduce dependence on fossil fuels, other extracted minerals, chemical fertilizers and pesticides while retaining an award-winning appearance.
- Develop policies to ensure that sustainability is incorporated into landscape design, maintenance and management.

Transportation

Long-term Vision: To reduce transportation-related greenhouse gas emissions by 50 % by 2030.

Goals:

1. To reduce faculty, staff and student vehicle miles (55% of transportation emissions) by:
- Developing an effective carpool/rideshare program.
- Working with community leaders, University planners, city officials, and the region's transit authority to develop viable mass transit options for the Xavier community.
- Developing an incentivized parking system, including developing non-daily parking passes to encourage ride sharing, expanding motorized two-wheeled vehicle parking, and designating preferred parking locations for compact cars/high-efficiency vehicles, and carpooling.
- Supporting bicycle and pedestrian commuting by installing additional bike racks in key locations on campus and creating a centralized bike parking lot(s), developing bike-route maps for commuters within a five-mile radius of campus, implementing an on-campus bike-sharing program, working with City officials, University planners and community leaders to encourage bike-lane construction to improve safety, and partnering with local retailers to support purchases and repairs (of bikes?).

- Reducing on-campus vehicle emissions by requiring the purchase or lease of high efficiency fleet vehicles as well as transitioning fleet vehicles to more sustainable fuel options such as vegetable oil, biodiesel, electric or hydrogen.

2. Reduce university-related air travel for intercollegiate competitions, recruitment, professional development, and study abroad (12% of Xavier's greenhouse gas emissions) by:
   - Using new and affordable teleconferencing technology and through educational efforts to inform University divisions about the impact of air travel.
   - Purchasing carbon offsets as part of the University's larger plan to be carbon neutral by 2030.

3. Establish a formal body or office to oversee and coordinate transportation initiatives and infrastructure improvements.

Academics and Student Life

Long-term Vision: To create an academic and co-curricular experience that introduces every Xavier student to ideas and issues of sustainability from a variety of perspectives. For those who wish to engage more, there are academic, experiential and leadership opportunities on campus and in the community to provide skills and knowledge for future efforts and careers. Xavier becomes a hub of sustainable events and a dynamic research center for interdisciplinary collaboration in the region.

Goals:

1. Teaching—To increase the number of courses with sustainability content on campus so that every student is exposed to the topic in multiple courses throughout their four-year career by:
   - Facilitating faculty development in sustainability topics by offering annual workshops for faculty to foster dialogue between disciplines that will aid faculty in incorporating more sustainability themes into existing courses.
   - Developing a major in Environmental Sciences.
   - Encouraging students to enroll in courses with sustainability content.
   - Identifying courses with sustainability content in the course catalog.

2. Research—To foster interdisciplinary collaborations between interested faculty and opportunities for students to participate in research on campus and in local organizations.

3. Co-curricular Activities—To raise awareness of students, faculty and staff through a multitude of sustainability-focused initiatives including:
   - Providing better publicity for the recycling program.
   - Incorporating sustainability and related topics into the Manresa Orientation Program.
   - Reducing waste during move-in and move-out by making recycling options widely available and widely publicized.
   - Providing all incoming students with a guide for sustainable living on campus and in the community.

- Supporting an annual or semi-annual sustainability lecture series.

4. Service Learning—To ensure that every Xavier student has at least ten hours experiential learning related to sustainability.

5. Campus Events—To promote events that educate about sustainability in the wider community.
    - Develop and maintain campus sustainability calendar on the website.
    - Develop annual community-wide sustainability event.
    - Become known for local, green conferences.

Purchasing

Long-term Vision: To make purchases that will promote a healthy community and environment by incorporating key environmental and social factors with traditional price and performance considerations.

Goal: To develop and implement sustainability-focused purchasing policies by 2012.

Community Engagement and Communications

Long-term Vision: To develop and maintain significant outreach efforts, both through community engagement and communications, in order to communicate lessons learned and market successes so that Xavier's sustainability efforts are known, appreciated, understood, and replicated by the public from the surrounding neighborhoods to the Midwest region and beyond. Xavier will become locally and nationally recognized as a model for sustainability efforts.

Goals:

1. Community Engagement—To engage as both a leader and active participant in inspiring thinking, developing models, and enacting plans that spur creative ideas and innovative projects in step with community partners by:
    - Developing an Office of Sustainability for the coordination of sustainability efforts that may also serve as a resource for the local neighborhoods, our city, and groups beyond.
    - Identifying and cataloging, in a central manner, already existing sustainability efforts within the University, in our city and our region that can inform collaboration, learning opportunities and coordinated alignment of efforts.
2. Communications—To position Xavier as a place to which the city, the region and the country can turn to for innovative thinking and creative accomplishment as related to sustainability efforts.

I. EXECUTIVE SUMMARY

B. Top Priorities and Conclusions

The Campus Sustainability Plan is comprehensive ,ambitious and includes many recommendations for immediate, short-term, mid-term and long-term consideration. While all of the recommendations would help make Xavier more sustainable, some are critical, especially as we begin the process of implementation. Below is a list of those crucial tasks:

1. Create a sustainability center
2. Invest in energy-conservation measures and alternative energy
3. Promote building use and planning with sustainability as a priority
4. Promote teaching and research of sustainability
5. Educate students about sustainability in their dorms and at Manresa
6. Develop viable mass transit options by working with the community
7. Establish a formal body to coordinate transportation initiatives
8. Implement Best Total Value Model in purchasing
9. Establish an effective vehicle for internal and external communication on the University website

This is an exciting time for Xavier and the world. Humanity is at a crossroads. Working on these complex issues together will build our communities and our ability to reduce the long-term effects of global climate destabilization. It will also promote our communities' resilience so that we are well-situated to weather the effects of destabilization that cannot be mitigated.

We see this as an opportunity to grow and learn. Over the last two years, the committee and the University as a whole have learned a tremendous amount about the complex nature of sustainability work. It involves systemic and holistic change; not just small, incremental changes. As Einstein famously stated, "We can't solve problems using the same kind of thinking we used when we created them." As a result, our University is entering a new phase of systemic and creative adaptation. Minimally, we see four ways in which our University will likely be transformed.

First, in terms of academics, sustainability calls upon us to learn across disciplines, and we will need to continue to promote such opportunities in our teaching and our research. We will also need to see that our campus and neighboring communities are laboratories for engaged learning around built environments, alternative transportation, gardening, energy use and alternative energy, among many other topics.

Second, within four to five years as this Plan is re-evaluated, a more holistic approach to sustainability planning and funding will be necessary. This will involve moving beyond the rubric of the climate commitment and its assessment tools, for example, to something like an Ecological Footprint Assessment (see appendix). Such an assessment would take into account other environmental factors, such as water usage and the amount of landfill space used, in addition to greenhouse gas emissions.

Third, and perhaps most importantly, we foresee planning and budgeting becoming a long-range undertaking that allows us to include resource conservation, educational benefits, building life cycles, and other measures alongside the more typical short-range financial measures. The combination of long-term planning and thinking and an ecological footprint assessment will mean that we take the future of our planet and our students' grandchildren as seriously as we take our educational quality, our enrollment numbers, and our endowment.

I. EXECUTIVE SUMMARY

Finally, as David Orr has stated, “Successful sustainability work, no matter where it takes place, requires total institutional commitment because of its holistic nature and because of the gravity of the ecological crisis we face.” We have been gratified by the University’s support of sustainability work up to this point and foresee a strong need to build on this success until we reach the point that sustainability is as much a part of our mission as educating students for solidarity, success, and service. Xavier has made great strides in promoting a more sustainable campus over the last few years and is poised to take the steps necessary to meet the challenges ahead.

II. INTRODUCTION AND HISTORY

Xavier University's physical location and academic tradition both inspire and influence our sustainability efforts. A Jesuit, Catholic University founded in 1831, we have occupied our present location in urban Cincinnati since 1919. The campus currently owns 148 acres; our buildings total approximately 1.8 million square feet (not including the buildings currently under construction). Xavier's mission is "to serve society by forming students intellectually, morally and spiritually, with rigor and compassion, towards lives of solidarity, service and success." In addition, our University catalogue notes that our "Jesuit education seeks to develop intellectual skills for both a full life in the human community and service in the kingdom of God; critical attention to the underlying philosophical and theological implications of issues; a world view that is oriented to responsible action and recognizes the intrinsic value of the natural and human values; an understanding and communication of moral and religious values through personal concern and lived witness, as well as by precept and instruction; and a sense of the whole person—body, mind and spirit." Clearly, such goals lend themselves to active engagement in the current ecological crisis. In addition, the faculty wrote an Academic Vision Statement in 2001 to guide our efforts for the next decade. Part of that vision included a desire for "an open, collaborative learning environment that is responsive to its immediate community as well as external communities, that encourages genuine engagement with civic, social, cultural, and global issues and that provides opportunities for international experiences."

With such an academic outlook, the University and its students, staff and faculty embrace opportunities for engagement in the complex issues of the world. Historically, this engagement has been around issues of poverty and social and racial inequalities, more than the environment, but the University has displayed a growing trend of engagement and thinking around environmental stewardship and education over the past decade.

Sustainability Committee

President Michael J. Graham, S.J., signed the American College & University Presidents' Climate Commitment in 2008, and the Xavier University Sustainability Committee was established shortly thereafter. With members selected from faculty, staff and students, the 14-member group is charged with developing and updating this evolving Campus Sustainability Plan toward carbon neutrality, as well as oversight of tangible actions stemming from this Plan.

The University Sustainability Committee initially embarked on the Greenhouse Gas Inventory, as well as the establishment of various communication tools, including the "Xavier Green" website. The sustainability website (http://www.xavier.edu/green/) contains information on what the University has already achieved, including links to relevant areas of the University and community that may be helpful.

The first institutional financial support was put forward in 2009 by President Graham, funding a new student-intern position, beginning with the inception of the 2009-2010 school year. The first intern greatly enhanced student participation in the work of the committee. In spring 2010, at the President's request, another student-intern position was created so that the committee will always have two interns minimum at one time.

Student involvement and engagement around the topic of sustainability has grown significantly with the addition of student sustainability interns to the sustainability committee. Additionally, several clubs under the umbrella of Peace & Justice programs have repositioned themselves to take on an "eco" or environmental focus. For example, the "Earthbread" club repositioned themselves as the "EARTH Coalition" to tackle a host of environmental issues.

II. INTRODUCTION AND HISTORY

The committee planned and hosted "Sustainability Day" on October 27, 2009, featuring guest speaker Nancy Tuchman from Loyola University of Chicago. Dr. Tuchman founded Loyola's "Center for Urban Environmental Research & Policy" (CUERP), which brings together a diverse faculty with an array of academic expertise to help students explore the relationship of human beings to the natural environment, and to develop the mental acuity and technical skills needed to formulate solutions to complex environmental problems. In addition to the Tuchman lecture, Sustainability Day also included cross-campus discussions that proved to be a highlight of the day for many. Sustainability Day created momentum within the student body for sustainability initiatives. This campus-wide conversation has greatly informed the contents of this document. The second annual Sustainability Day will be held on October 25, 2010 and feature William McDonough, world-renowned architect and designer, as guest speaker.

Energy and Infrastructure

The most significant way in which Xavier University has demonstrated commitment to sustainability thus far has been at the nexus of its economic and environmental sustainability with regard to energy use. Xavier made the decision many years ago to invest in central-plant systems to provide heating and cooling for the majority of the buildings on campus that resulted in higher-energy efficiency. Thermal storage minimizes the operation of equipment during the day. Automated building-management systems monitor all building operations and identify opportunities to reduce energy consumption. The adjustment to schedules and temperature set-points through this system significantly increases energy efficiency. Xavier continues the process of building upon the Greenhouse Gas Inventory findings with ongoing campus-wide energy evaluations. Additional energy efficiencies are realized campus-wide through the following actions:

- Low-emitting glazing added to all windows
- Roofing materials specified with improved insulation
- Light fixtures and lamps replaced with more energy-efficient units, especially compact fluorescent light bulbs that use 75% less electricity
- Motion detectors used to activate the use of lights only when needed

Over the past three years, Xavier University has been in the process of acquiring land and demolishing existing buildings as it grows and expands. Due to this expansion process and the subsequent demolitions and renovations, Xavier established a policy that a minimum of 75% of construction and building demolition waste must be diverted from landfills and sent for recycling and reuse processes. In recent demolition projects, Xavier recycled 45,356 tons of concrete/masonry, 206 tons of asphalt, 3,202 tons of steel/metals and 176 tons of paper/cardboard. In the same vein, Xavier building design policy stipulates that 20% of the total value of the materials in any given project incorporate pre- and post-consumer recycled content and, further, that building materials are to be produced within 500 miles of the building site.

Since 2005, all new construction on campus has been built to LEED Silver standards. The two newest on-campus buildings are designed with reflective roofs, low-VOC emitting materials, water-flow restrictors, natural lighting, and several other conservation design practices. It is the intent of Xavier University to realize a 14 to 17.5% reduction in overall energy consumption in new buildings above what is mandated by code and standard design practice. To help realize that goal, in addition to the actions listed in the aforementioned bullet points, the following features were included in the buildings to increase energy efficiency and, thus, reduce greenhouse gases:

II. INTRODUCTION AND HISTORY

- High-efficiency lighting and motors
- Building management system that optimizes and controls the quality of the indoor environment based on occupancy and outdoor conditions while saving energy
- Pre-occupancy commissioning of the building support systems to help insure proper operation and functionality
- New building-site placement takes advantage of daylight harvesting that is energy efficient and enhances indoor environmental quality

Academics and Student Life

For many years, Xavier University has offered classes throughout the curriculum that include sustainability issues. Some of these courses were organized into an interdisciplinary Environmental Studies minor in 1998. The minor is rooted in two main disciplines: Ecology and Economics. Students seeking the minor also have an elective that can be satisfied from a variety of departments such as Theology, English, and History. A 2009 campus-wide survey of faculty revealed that 81 different courses from 35 departments incorporate some discussion of sustainability. In responding to the survey, many professors said they would like to include more sustainability-related content into their courses. Two international experiences, an Ireland and Costa Rica program, both feature environmentally-focused courses. A few faculty members, mostly biology professors, engage in sustainability-related research at this time.

In support of academic pursuits, Xavier University has a long history of promoting experiential and co-curricular learning that leads students toward active and engaged citizenship, particularly in solidarity with marginalized populations. The Academic Service Learning Semesters, the Community Building Institute, the Eigel Center for Community Engaged Learning, Faith and Justice Programs, the student-run Alternative Breaks program, and service learning courses have all played an important role in fulfilling this part of our mission in the past. These experiences have frequently actively worked on environmental justice or sustainability issues, such as mountaintop-removal coal mining, food and farming issues, animal rights and species preservation.

In terms of the shaping of the University culture and policy concerning sustainability, students, faculty and staff have a storied history of engaging in social-justice causes, including environmental issues. Some examples include:

- As early as the 1950s, student protests targeted many issues, including the war in Vietnam, race, poverty and the environment.
- Offices like the Center for Faith & Justice Programs support student clubs, speakers, and educational sessions on food and farming issues, environmental justice, and stewardship.
- A small group of faculty and students, under the “Justice Across the Campus” Committee, spent several years educating the campus community about green building and organic and local food resulting in distinct changes in Xavier’s building practices and food offerings through campus dining.
- The Student Activities Council has sponsored “Earth Week” in April for many years. In 2009, student groups provided a number of events during Earth Week, which included the distribution of re-usable water bottles, an organic local meal and tours of a car run on vegetable oil.
- In other greening efforts, Peace and Justice Programs launched a campus community garden project in 2009 with 6 plots and 27 participants that will expand to 30 plots in

2010. A series of twice monthly workshops were held in conjunction with the garden in order to promote sustainable practices and lifestyles.

In addition, the Ethics, Religion and Society lecture series over the last two years has had Sustainability and Ecology as its theme. For the first year in 2008-09, the focus was on global climate change and featured Robert Kennedy, Jr. and David Orr. The second year of 2009-10 focused on food and agriculture and included Michael Pollan and Wendell Berry. Prior to each lecture series 12-20 faculty participated in a workshop to learn more about the upcoming topic and to incorporate some of the speakers and readings into their courses. Thus, hundreds of students over the past two years have learned more about both topics and took part in the guest lectures.

Xavier has participated in the "Recyclemania" intercollegiate competition that has served as a benchmarking tool to promote waste reduction activities since 2007. Xavier strives to make recycling easy with recycling containers in every office and large gathering spaces. Cell phone, printer cartridge and battery recycling are also available in the Gallagher Student Center.

Transportation

Xavier University has made some steps in recent years toward reducing the emissions from our fleet vehicles and to promote alternative means of traveling to campus. Mail Services purchased an electric vehicle to replace a gasoline-powered delivery van. Physical Plant purchased two electric vehicles with plans to replace the remainder of the gasoline-powered fleet with higher fuel standard vehicles as the fleet ages. In 2009, the number of bike racks available around campus more than doubled.

Purchasing and Services

At the present time, the campus purchasing process is nominally centralized, however, a number of University departments and individuals make independent purchasing decisions. Toilet paper, copier paper, computer monitors and photocopiers all have recycled content. Compact fluorescent light bulbs are used in many locations on campus. Since 2006, custodial services have used environmentally-safer cleaning chemicals, and food vendors, retail stores and dining services promote some sustainable products (fair-trade, organic, etc.).

Community Engagement and Communication

Increasingly over the past decade, Xavier University has provided both leadership and space for sustainability-related dialogue and public education. With entities in place to facilitate these opportunities, such as the Community Building Institute, Brueggeman Center for Dialogue, and the Ethics, Religion, and Society program, Xavier possesses multiple venues for working with and informing our immediate communities, our city and our region. Xavier also has a history of hosting community and regional groups who are actively and creatively thinking about issues of sustainability and systemic change, including the Earth Spirit-Rising Conference, U.S. Conference of Catholic Bishops' Climate Change Commitment gathering, and U.S. Green Building Council Awards. Xavier must continue to build upon this path as both activator and host, with a spirit of cooperation, recognizing both the strengths and needs of our surrounding communities.

Communication efforts from Xavier's campus are coordinated by a few offices within the University, including Public Relations, Information Resources, and Marketing. Input for online and print publications is sought from all sectors of the University. Individual offices manage a certain amount of their own outreach through mailings, websites and social media decentralized from these main coordinating offices. Xavier possesses a strong network of media contacts, both local and regional, through which events and accomplishments can be communicated. Community and campus partners have specialized contacts in other areas which can be incorporated into this network.

III. ORGANIZATION

In fulfilling the requirements of the American College and University Presidents' Climate Commitment (APUPCC) Agreement, Xavier University has put together a team with the aim of making sustainability a more significant part of the higher-educational experience. The Sustainability Committee is composed of two co-chairs representing Physical Plant and Academics. Committee members are as follows: Academics (3), Student Life (1), Students (3), Public Relations (1), Information Services (1), and Staff (2). In addition, we have added a number of members on an ad-hoc basis to fulfill specific needs, and to accommodate those with expertise and interest in our work. Thus, we currently have three ad-hoc members, one faculty, one from Grant Services, and three to five students. Last year, we engaged a faculty member to help plan and our first Sustainability Day, and someone from administration to help with data assessment for our Greenhouse Gas Inventory. The experience of the committee over the past two years has been that a campus-wide network is essential for getting the work done.

During mid-2009, co-chairs began to work with our president-appointed cabinet liaison, Bob Sheeran, Associate Vice President for Facility Management, to make sure that our work was more-closely integrated with administrative priorities.

Long-term Vision: To build and maintain an infrastructure for sustainability work on Xavier's campus and in the various communities.

Goal: To establish a sustainability center capable of supporting campus sustainability programs as soon as is feasible, no later than 2020.

1. **ACTION PLAN**:

Short-term Goals (1-2 years)

- *Create a sustainability-director position and advisory team (similar to the current Sustainability Committee) comprised of stakeholders at all levels to advise campus leaders on sustainability initiatives and to oversee sustainability efforts. This individual will be tasked with responsibility for coordination across all sustainability-related activities. The individual will possess an advanced degree in a pertinent field, have expertise in one or more areas of energy, environmentalism, ecology and organizational sustainability, and be housed in an academic department with a direct link to the President and the Associate Vice President of Facility Management.*
- *The advisory team will act as sustainability coordinators for each functional area. Coordinators will be trained in sustainability initiatives and policies and act as an onsite resource and voice on sustainability-related matters.*
- *Designate sustainability responsibilities and opportunities for all stakeholders to formalize and publicize Xavier's commitment to sustainability.*

Mid-term Goal (3-5 years)

- *Establish a campus sustainability endowment fund to provide a method for donors and community stakeholders to provide funding resources necessary to continue Xavier's work toward a sustainable campus and outreach efforts for global sustainability. The environmental knowledge gleaned by students during their educational experiences will be shared with communities across the world.*

III. ORGANIZATION

2. CHALLENGES AND FUNDING:

- It will take a commitment of resources to create a Sustainability Center. A Sustainability Director would probably require $78,000 per year and a Sustainability Center would be at least twice that amount, with the primary additional cost being for administrative support.

- An appropriate level of funding will be required for successful implementation of the Campus Sustainability Plan. Regardless of which funding sources are identified, the human resources are a pre-requisite to being able to request and manage any financial and institutional resources. The recommendation to establish a sustainability endowment fund would provide one instrument for focusing resources, e.g., by collecting donations, revenues, or cost-savings.

IV. ENERGY AND INFRASTRUCTURE

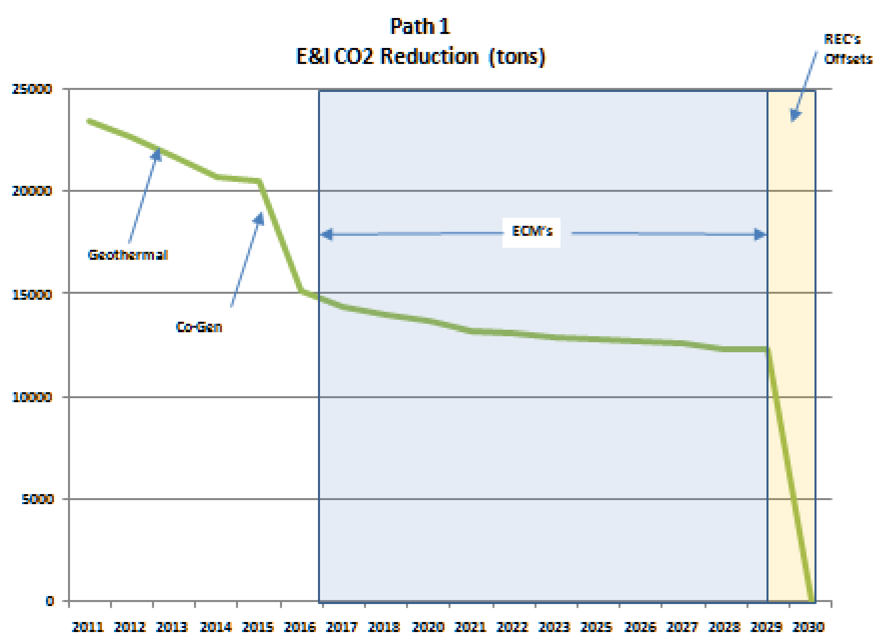
Xavier University's Physical Plant Department has responsibility for managing the physical fixed assets of the University in a responsible, professional manner. This includes adherence to a strong sustainability and fiscal policy to minimize waste and reduce consumption, thereby reducing carbon dioxide emissions to the absolute minimum.

PURCHASED ENERGY

Long-Term Vision: To minimize GHG emissions from the purchase and use of electricity and natural gas (stationary fuel sources) to the fullest extent possible, considering the mix of buildings, available and future technologies, capital investment requirements, and the impact of market forces. Two paths have been identified from which to choose the initial reductions in the GHG emissions from purchased electricity and stationary fuel sources. To achieve our goals, investments in a multitude of alternative energy, energy conservation measures, and offsets to are necessary. The trajectory of emissions reductions will depend on the path taken.

<u>Path 1:</u>

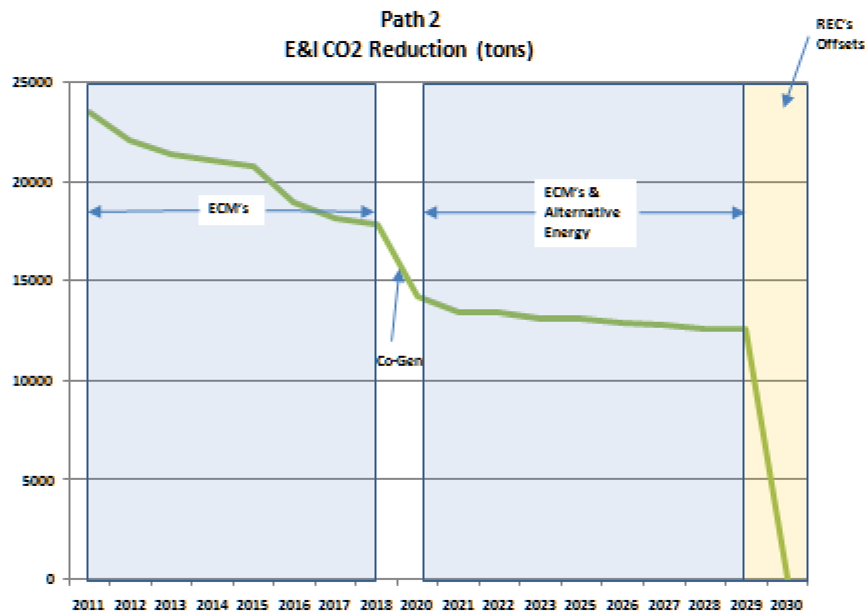
- Invest in alternative technologies such as solar, geothermal, co-generation and fuel cells to achieve at least a 7% reduction from 2008 levels by 2012 and use the cost avoidance savings to fund other carbon reduction initiatives.
- Further reduce greenhouse gas emissions to 50% reduction (an additional 43%) by 2030 through other alternative energy and energy conservation measures with an intermediate step of 35% reduction by 2018.



IV. ENERGY AND INFRASTRUCTURE

Path 2:

- Gradually reduce our greenhouse gas emissions to achieve a 25% reduction by 2018 through higher ROI energy conservation measures.
- Further reduce greenhouse gas emissions to 50% reduction (an additional 25%) by 2030 through higher ROI alternative energy and energy conservation measures.



Regardless of the path chosen:

- Investment in offsets (preferably tangible, measureable initiatives in the surrounding community) will probably be required for the remaining 50% by 2030.
- All subsequent planning and new construction will require that achieving carbon neutrality is key to the overall design.

PATH 1

A. Alternative Energy Systems First

The University can have the most significant impact on GHG emissions by investing in alternative or renewable-energy projects.

Goal: To invest in energy saving capital investment projects that achieve a reasonable annual return-on-investment (ROI) and also effectively reduce the overall carbon footprint and enhance our good citizenship and green image.

IV. ENERGY AND INFRASTRUCTURE

1. ACTION PLAN:

Short-term Goals (1-2 years)

- *Invest in alternative energy projects that maximize monetary savings while at the same time reducing GHG emissions by 7%. The savings from these investments would fund other GHG reduction strategies. See Appendix "D" for details concerning alternative energy options.*
- *Track the costs, commodity markets, and suppliers of renewable energy credits and GHG offset credits.*

Mid-term Goals (3-5 years)

- *Invest in alternative energy projects with longer-term ROI. As the payback period for a potential project increases, a point is reached where the ROI target is no longer met. Longer payback projects still earn a ROI that is better than buying GHG credits which have no ROI. Again, refer to Appendix "E" for details.*
- *Invest in other alternative energy and high ROI ECMs (see Path 2 below) to achieve a cumulative 35% reduction.*
- *Research technological advances and incorporate into a revised strategy as they become viable.*

Long-term Goals (5-10 years)

- *Invest in alternative energy technologies that matured to the point they have a reasonable payback period (highly dependent on the cost of credits at this time).*
- *Invest in higher ROI ECMs keeping in mind that the goal is to achieve a 50% reduction by 2030.*
- *Invest in off-campus energy-saving projects that avoid the need to buy GHG credits to achieve zero emissions.*[1]
- *Avoid the purchase of GHG credits or renewable-energy credits, which are a pure cost and have no savings stream.*

2. CHALLENGES AND FUNDING:

- The current technology is undergoing rapid change. It is doubtful that investing in the current state-of-the-art technology will provide the same advantages as later-stage technology. Having said that, it is important to seize opportunities as soon as possible because grants and other sources of funding may not be available later. The sooner investment is made in renewable sources, the sooner the University can realize the benefits.
- The market price for a REC at the present time has a wide range ($0.001 to $0.030 per kWh). Market forces will likely drive this price much higher in the future as more building owners seek to reduce their carbon footprint.

[1] For projects that save electric energy, the maximum target discounted payback period ranges from zero years if there is no cost for credits, up to 1.2 years if credits cost $20/ton/year. For projects that save natural gas, the maximum target discounted payback period ranges from zero years if there is no cost for credits, up to 1.5 years if credits cost $20/ton/year. **The conclusion is that the University should invest in off-campus projects as an investment in the community, not as an economical path to GHG emission reductions.**

IV. ENERGY AND INFRASTRUCTURE

PATH 2

A. Retrofitting Existing or Constructing New Buildings First

Investment in physical fixed assets through proper application of energy-saving projects produces monetary savings for XAVIER UNIVERSITY and reduces the amount of GHG credits that must be purchased to achieve zero emissions.

Goal: Future buildings and building retrofits must be as efficient as economically possible.

1. ACTION PLAN:

Short-term Goals (1-2 years)

- *Devise ways to achieve academic program goals while building as little new space as possible. Construction costs, energy costs, and emissions would be lower. No amount of conservation can avoid increasing University emissions when additional square footage is built. Strategies could include better monitoring of space utilization to guide needs, "congestion pricing" for academic departments and tuition rates (lower rates at times when space usage is low), and building more flexible space that can be used for more functions more hours of the day.*
- *Perform operational optimization through effective use of the building controls system. This could mean establishing thermostat set points and reducing the ability of the end user to modify set points. If the University adopted a policy of uniform temperature settings (74 degrees during the cooling season and 70 degrees during the heating season), an 8% - 10% savings could be realized. Specifically, the University could anticipate saving $200,000 in electric cost (or 2,300,000 kWh of electricity) as well as $60,000 (or 10,000 MCF of natural gas).*
- *Identify and implement high-value Energy Conservation Measure (ECM) projects in the existing buildings and central utility plants.*
- *Review, verify and update University data. Refine the calculation methodology used in this plan based on individual ECM investigations on a building-by-building and system-by-system basis. Identify and verify the University facilities with the highest energy consumption per square foot. This will require additional metering and/or modeling. Organize the data streams using automated tools, dashboards, and smart reporting. Communicate performance to all participants (building occupants, Physical Plant, academic departments). While not a direct energy saver, metering can provide valuable information on where attention and investment should be focused. It can help spot anomalies and wasteful practices, guide facility policies, and allow charge-back of energy costs to the end users (to incentivize conservation).*
- *Follow the development and commercialization of new technologies that would be applicable to the University, including more effective lighting and better control algorithms.*
- *Be flexible in the program direction based on changing energy price signals, particularly higher electric rates that would make electrical savings more valuable. GHG emissions are strongly impacted by electricity use.*
- *Take advantage of incentive programs and grants. Recently, Duke Energy adopted their Save-A-Watt campaign in Ohio which pays for part of the cost of energy*

analyses and is integrated with their prescriptive and custom incentive (rebate) programs.

- *Develop a different financing model. The cost of new buildings are traditionally benchmarked against buildings of similar function and size that other entities have built. Budgets are usually set early in the project and the entire design and construction team works to meet that cost-per-SF, cost-per-bed, or cost-per-classroom-seat budget. Most historical cost data is from buildings that were not energy efficient or only make modest attempts to be more efficient. Perhaps a new model would involve benchmarking the construction cost to a base-building performance concept, then adding incremental funding to support "super efficient" concepts. This incremental funding could come from a different University budget, outside donors (naming rights for the energy systems?), or third-party investors who would finance the incremental investment over time.*
- *Set higher energy design standards for new and renovated buildings. Go beyond LEED certification as the benchmark. There is evidence that LEED buildings do not necessarily reduce GHG emissions[2]. As a result, systems are selected that have been routine over the last 20 years[3]. An alternative would be to set BTU/SF/year targets, use the "Energy Star" points system, or the "ASHRAE EQ Rating System" rather than a single percentage-reduction benchmark.*
- *Perform enhanced modeling – most building and energy system modeling is done after the concepts are established, to verify that the building meets code and to see how many LEED points can be earned. Modeling should be done early in the design process to examine dozens of variables and concepts while changes can still be easily made.*
- *Require equal marginal performance analyses for all systems and components. That is, if the desired ROI is 10%/year, the efficiency of every component and subsystem should be improved until the ROI limit is reached.*
- *Insure that the construction-cost benchmarks adapt to the GHG emission-reduction goals. Incentivize the design and construction teams to respond appropriately. State the cost of achieving net zero emissions – require the design team to calculate the life-cycle cost of the proposed building design, including purchasing renewable energy credits or GHG credits to offset all purchased energy. The life-cycle cost would equal the building first cost + the net present value of [the annual utility costs + the annual cost of GHG credits + the annual cost of maintenance]. This*

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[2] John H. Scofield, Oberlin College, examined the data from 121 LEED certified buildings and in his paper *A Re-examination of the NBI LEED Building Energy Consumption Study* stated the following: "*All strategies for reducing our nation's GHG emission start with improving building efficiency. LEED certification has not been useful at reducing building primary energy consumption and, by inference, GHG emission associated with building operation. There may be many green benefits from LEED certification – but reduction of primary energy consumption for building operation is not one of them…… There then appears to be no scientific basis for institutions such as colleges, universities, or the Federal Government to require that, as a GHG or energy reduction strategy, all new buildings obtain LEED certification. Similarly there is no justification for USGBC claims that LEED Certified commercial buildings are using significantly less electricity or have significantly lower GHG emission associated with their operations than do conventional buildings*."

[3] LEED points are earned for the %age cost reduction that the proposed building is expected to achieve compared to a base building, as defined by ASHRAE Standard 90.1. Depending on the type of building and the utility sources, Standard 90.1 is an inconsistent benchmarking tool. For example, small proposed buildings are allowed to be compared to less efficient base buildings, making the % savings appear higher even though the BTU/SF/year is no better than a large building would achieve. No credit can be earned for passive solar features or improved building massing. There is no baseline performance for fume hoods, IT equipment, and electrical equipment. The comparisons are made based on utility cost, not GHG emissions or source energy use. Thus, a proposed design may be more cost efficient but have higher GHG emissions due to greater reliance on electricity.

would insure that the building optimization process includes all future costs of the building in line with the University's environmental goals.

Mid-term Goals (3-5 years)

- *Continue to insure that the construction-cost benchmarks adapt to the GHG emission reduction goals.*
- *Add a cogeneration system. The larger the system, the greater the number of buildings that should be served from the new Central Utility Plant (CUP) so the recovered energy has a place to be used.*
- *Continue to identify and implement high-value "Energy Conservation Measure" (ECM) projects in the existing buildings and central utility plants.*

Long-term Goals (5-10 years)

- *Implement the remaining ECMs that apply to future buildings or require technology advancements as buildings are designed or as the technology becomes economical.*
- *Research technological advances and incorporate into a revised strategy as they become viable.*

2. ENERGY CONSERVATION MEASURES (ECMs)

Existing Buildings

The proposed ECMs for the existing buildings were arranged in order of increasing simple payback period and plotted against cumulative GHG emissions. Future technologies, such as LED lights and fuel cells, and central utility technologies, such as geothermal and photovoltaic, were not included.
Figure 1 shows that about 18-20% of the existing-building emissions can be cost-effectively reduced with ECMs that have a 10-12 year or lower simple payback period. To increase the emission reduction another 5% to 25% requires extending the allowable simple payback period to about 25 years.
The 12-year simple payback period cut-off excludes improved utility metering. The metering is valuable to allow monitoring of building performance and should be included in the mix. Most of the existing-building ECMs cost less than $400/ton of GHG emissions saved.
Figure 2 shows the cumulative capital investment as the GHG emission reduction increases. A capital investment of approximately $3.3mm would be required (including the cost of submetering) to achieve a 20% GHG reduction. The cumulative annual savings of $550,000 would result in an overall simple payback period of 6 years.

The ECMs included in the mix are:

1. Revised air filter program
2. Compact fluorescent lamps
3. Power management
4. Occupancy sensors
5. Variable speed drives
10. Infiltration reduction
11. "Energy Star" appliances/equipment
12. Pool upgrades
13. Ventilation energy recovery
14. Kitchen refrigerators - heat recovery

6. Modify controls
7. Motor replacements
8. Recommissioning
9. T5/T8 lamp conversions
15. Shading devices
16. Water conservation measures
17. Mall piping replacement

Existing + Future Buildings

The proposed ECMs for all buildings were arranged in order of increasing simple payback period and plotted against cumulative GHG emissions. Included were three major technologies: About 30% of the 50% reduction in the total emissions is due to three ECMs – LED lights, "next level" new buildings, and cogeneration. Due to the uncertain economics of these items there could be considerable variation in the actual cost-effective outcome (will LEDs become cost effective? can future buildings have 30% lower emissions? how much heat can really be recovered from a cogeneration system?).
Figure 4 shows that about 30% of the projected future emissions can be cost-effectively reduced with ECMs that have a 10-12 year or lower simple payback period. If the allowable marginal payback period is extended to about 14 years, a natural-gas-fired cogeneration system can be included in the CUP. This would increase the emissions reduction to 50%.
Figure 5 shows the cumulative capital investment as the GHG emission reduction increases. A capital investment of about $11mm would be required (including the cost of submetering) to achieve a 50% reduction. The cumulative annual savings of $1.5mm would result in an overall simple payback period of about 8 years.

1. Revised air filter program
2. Compact fluorescent lamps
3. Power management
4. Occupancy sensors
5. Modify controls
6. Lower coil/duct/filter velocities
7. Infiltration reduction
8. Recommissioning
9. Motor replacements
10. T5/T8 lamp conversions
11. Variable speed drives on pumps and fans
12. Energy Star appliances, equipment
13. Pool upgrades
14. 30% energy savings in new buildings
15. LED light fixtures
16. Ventilation energy recovery
17. Daylighting
18. Kitchen refrigerators - heat recovery
19. Boiler energy recovery (condensing economizer)
20. Shading devices
21. Super insulation
22. Water conservation measures
23. Mall piping replacement
24. Logan boilers decommission – serve from CUP
25. Cogeneration system

A geothermal heating system and a heat recovery chiller, while having better payback than the cogeneration system, is not as effective at reducing GHG emissions. These types of systems substitute greater use of coal-generated electricity for natural gas. The cogeneration system produces electricity from natural gas which results in a large reduction in GHG emissions. As long as a significant portion of the waste heat can be used, cogeneration is a better choice .from a GHG reduction perspective only. The cogeneration system costs about $275/ton of GHG emissions saved. For comparison purposes, the geothermal system costs $5,000/ton and the heat recovery chiller costs $1,500/ton. Geothermal provides better ROI and if employed the savings could be used to fund other ECM's.

Most of the future-building ECMs cost $500-$1,500/ton of GHG emissions saved. This is higher than the existing-building ECMs indicating a dependency on longer-payback, new-technology items.

Figure 6 shows how the capital investment is related to the emissions reduction. The investment level is nearly linear with increasing emissions reduction.

*Figure 7*a shows the net present value of the capital investments, energy savings, and GHG credit costs at $3/ton/year credit cost. The optimum net present value is at the 30% GHG reduction level. If the cost of GHG credits is increased to $20/ton/year, as shown in *Figure 7b*, the optimum GHG reduction %age increases to about 45-50% (the cogeneration system is cost effective). The curve is also shifted downward (lower net present value at every point).

Figure 8a shows the net present value of the capital investments, energy savings, and cost of purchasing green power. It was assumed that green power at $0.002/kWh would be purchased for all purchased electricity remaining after the ECMs are implemented. The optimum net present value is at about the 35% GHG reduction level (this does not include the cogeneration system).

If the cost of green power is increased to $0.015/kWh, as shown in *Figure 8b*, the optimum GHG reduction %age is still about 35%. The curve is also shifted downward (lower net present value at every point).

After implementation of the economical ECMs, the University site-energy intensity (without accounting for the cogeneration system) would be:

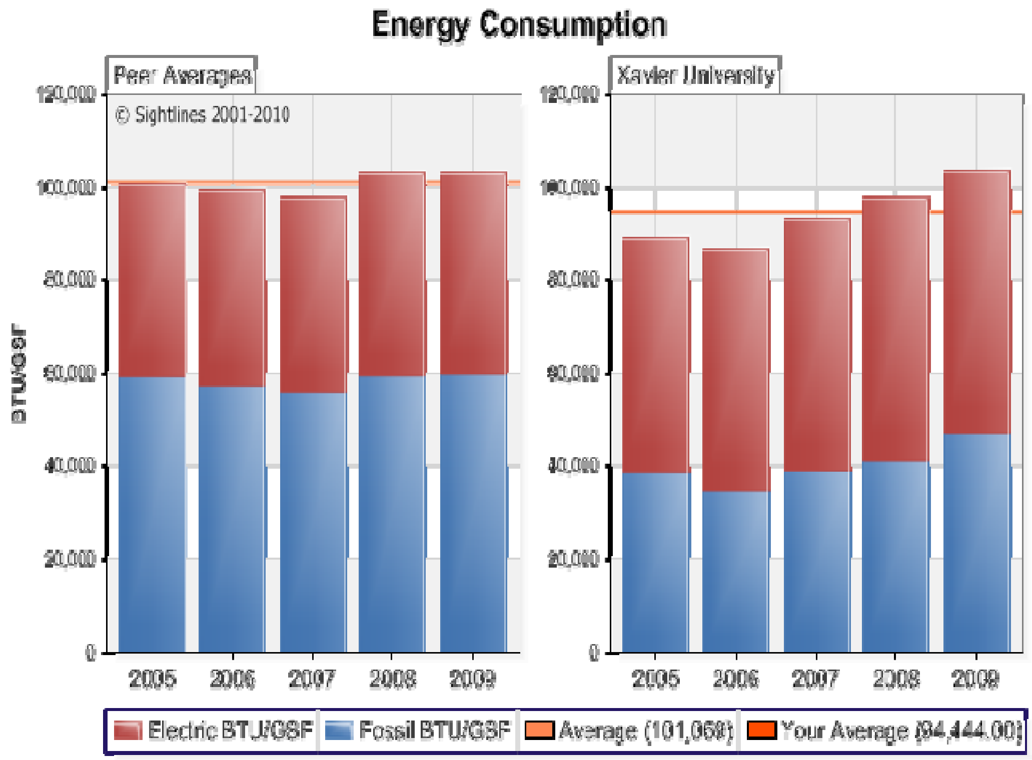
	Base Case, BTU/SF/Year	After ECMs, BTU/SF/Year
Existing buildings	104,000	59,000
Future buildings	73,000	40,000
All buildings	89,000	50,000

Implementation of the cogeneration system increases the University site-energy intensity to about 65,000 BTU/SF/year but decreases the overall GHG emissions. As the result of all ECMs, emissions would be reduced from 43,500 tons to about 22,500 tons (45-50% decrease).

3. CHALLENGES AND FUNDING:

- From a study performed by "Sightlines" (a company employed to benchmark Physical Plant in 2010), from 2005 to 2010, on a BTU/GSF basis, the University has increased consumption of all purchased energy, especially electrical energy, and currently exceeds the peer average. The root cause is unknown at this point, but it is suspected that increased use of the larger facilities and increased enrollment are factors.

IV. ENERGY AND INFRASTRUCTURE



- The future buildings being proposed could double the area of the campus under roof. No building can be made net-zero (without the inclusion of renewable-energy systems). They will only increase the carbon footprint of the University.
- Increased enrollment will place greater demands on all facilities and eventually cause an increase in purchased energy.
- Investment in super efficient buildings places a strain on University finances. In the short term, additional funds may need to be borrowed thus potentially affecting programming, scope and other features.

IV. ENERGY AND INFRASTRUCTURE

WATER CONSERVATION

Long-term Vision: To reduce the use of fresh water for University purposes by:

- Balancing the withdrawal of freshwater from the ecosystem to match the natural replenishment.
- Reducing energy consumption due to water pumping, delivery and wastewater treatment facilities.

Water used at the University is from the Ohio River, essentially an inexhaustible supply. Thus, the campus does not have a sustainability issue in terms of water supply. However, the water used at the University is processed by the GCWW to drinking water standards, an expensive process. So, in addition to the financial benefits from water conservation measures, the measures that reduce consumption by flushing toilets, bathing, cleaning, and irrigation also reduce the impact on GCWW and MSD.

A. <u>Reduce the Consumption and Withdrawal of Fresh Water</u>

<u>Goal</u>: To reduce overall water consumption levels by 40% from 2010 levels.

1. ACTION PLAN:

<u>Short-term Goals (1-2 years)</u>

- *Review, verify and update campus water consumption data. Identify the campus facilities with the highest water consumption.*
- *Provide water usage feedback and education to campus users.*
- *Initiate dorm competitions and provide water consumption data.*
- *Install faucet restrictors on any sinks that have not received flow restrictors.*
- *Investigate the reuse of captured storm water for irrigation.*

<u>Mid-term Goals (3-5 years)</u>

- *Encourage student, faculty and staff to report water waste on campus.*
- *Replace older high-volume flush toilets with low-volume flush toilets.*
- *Replace older high-volume urinals with low-volume urinals.*
- *Consider replacing the natural grass on Hayden Field with an artificial grass surface to reduce irrigation and maintenance costs.*
- *If feasible, implement the use of retained storm water for irrigation of turf areas.*

<u>Long-term Goals (5-10 years)</u>

- *Reduce irrigation needs through landscape design and planting of selective drought-tolerant species.*
- *Continue to encourage student, faculty and staff to report water waste on campus.*
- *Expand the use of retained storm water for irrigation of turf areas*

IV. ENERGY AND INFRASTRUCTURE

2. **CHALLENGES AND FUNDING:**

    - Without significant assistance from grants and other sources, most of the proposed goals requiring large capital expenditures cannot currently be funded and may be delayed.

STORM WATER MANAGEMENT

Long-term Vision: To reduce stormwater runoff by:

- Retention of water on site.
- Reduction of the rate of runoff.

Stormwater runoff is a matter of serious concern to Cincinnati's Metropolitan Sewer District (MSD) due to combined sewer overflows (CSOs). In addition, pollutants from parking and roof areas are conveyed untreated to rivers and streams and cause depletion of groundwater resources.

A. **Storm Water Runoff from all Manmade Surfaces**

   Goal: To reduce storm water runoff by 10,000,000 gallons per year within 5 years.

1. **ACTION PLAN:**

   Short-term Goals (1-2 years)

   - *Analyze multiple options to determine the feasibility of each, as well as quantify the potential reduction in storm water discharge into the MSD combination sewers.*
   - *Obtain geotechnical data to determine the feasibility of storm water management features into the soils in various areas.*
   - *Consider the installation of green roofs for all new construction.*
   - *Investigate the reuse of captured storm water for irrigation.*
   - *Perform routine cleaning of parking lots.*
   - *Install educational and informational signage at all rain gardens or other retention areas.*
   - *Conduct ongoing storm water public education and outreach programs. Schedule public education events to coincide with "Earth Day" or "Sustainability Day" activities.*
   - *Expand the Sustainability website to include Storm Water Management education.*

   Mid-term Goals (3-5 years)

   - *Capture storm water runoff from the Cintas Center and Cohen Center parking lots to possibly provide irrigation for the intramural field located north of the Cintas Center.*

- *Convert the existing detention basins at the north end of the Cintas Center parking lots to retention ponds to provide a storage mechanism for the runoff from the Cintas Center and Cohen parking lots during the winter (non-irrigation) months.*
- *If porous pavements are viable, install areas of pervious pavement, bioswales, and/or rain gardens within the Cintas Center and Cohen Center parking lots to promote soil infiltration rather than direct storm water runoff from these areas.*

Long-term Goals (5-10 years)

- *Install an underground detention structure on the west side of the Gallagher Student Center to provide irrigation in areas on the west side of Victory Parkway. Hayden Field and/or the open space area to the north of Hayden Field could be possible areas to irrigate using the stored water from the underground detention structure.*
- *Replace the 7-year old Corcoran Field synthetic turf. An increased size of the gravel base below the field could be utilized to provide increased storm water storage and infiltration.*
- *Install an underground vault near the Learning Commons, College of Business, and/or the new Residence Hall sites to capture storm water runoff from the roofs of the buildings to use as irrigation water on the site(s). Irrigation of the exterior areas surrounding the Schott Hall Admissions Office could be serviced from the Learning Commons underground vault to inform campus visitors of the University's commitment toward the application of green building principles.*
- *Install multiple underground irrigation vaults within the Academic Mall area to capture storm water runoff from the roofs of the surrounding buildings for irrigation uses in the Academic Mall.*
- *Install an underground irrigation vault by capturing runoff from Husman Hall for irrigation use in the open space on the west side of Husman Hall.*

2. CHALLENGES AND FUNDING:

- Without significant assistance from grants and other sources, most of the proposed goals requiring large capital expenditures cannot currently be funded and may be delayed. Fortunately, MSD is currently promoting a Green Infrastructure Demonstration Program. This program requires a two-step application process. The initial application (Part I) is a concept application that is submitted to MSD and outlines the planned strategy of incorporating storm water management initiatives. The cost for this step is $13,000 and must be completed in 2010. Upon review of the Part I application, MSD will determine if the proposed project is eligible for participation in the Green Infrastructure Program. The Part II Design and Implementation application would then be completed if the project is selected for inclusion into the program. MSD will fund all of Part II.

IV. ENERGY AND INFRASTRUCTURE

SOLID WASTE MANAGEMENT

Long-term Vision: To remove solid waste through conservative practices including materials purchased by the University, materials carried in from off campus, and materials generated on campus. Solid waste is transported by Rumpke to landfills designated for the various types of waste. The amount of solid waste to be removed from the campus can be reduced in a number of ways:

- Through conservative practices that minimize the amount of materials that are used and/or wasted,
- Through the reuse of items that can still serve a function, be valued by another user, or have salvageable parts, and through
- Recycling of used materials and redeploying them as new products.

Solid waste reduction is often a lifestyle choice that requires behavior modification at the individual level.

A. <u>Increased Recycling and Landfill Waste Minimization</u>

<u>Goal</u>: Prevent useful material resources from being wasted and reduce the consumption of raw materials by 30% from FY09-10 levels within 5 years, thereby reducing energy usage along with the associated greenhouse gas emissions required to create the original material or product.

1. ACTION PLAN:

<u>Short-term Goals (1-2 years)</u>

- *Create a solid waste oversight committee tasked with developing policies and programs while providing reports on recycling initiatives and performance.*
- *Encourage users(through signage and other means) to use the scanning function in the existing photocopiers and print and copy double-sided instead of single-sided.*
- *Reuse paper from bad print jobs for scrap paper and notes.*
- *Eliminate individual trash cans and only provide recycling bins at the desk. Regular trash can still be deposited in centralized locations.*
- *Enhance the current campus recycling efforts for paper, newspaper, cardboard, print cartridges, cell phones, cans, bottles and scrap metal.*
- *Devise methods to combat contamination of recycled materials with other waste.*
- *Add additional recycling receptacles in strategic locations.*
- *Encourage dependence on information technologies (e.g., University servers and portable media; backup software) that can reduce printing and photocopying (and their production of waste paper). Provide case studies of individuals already performing their work in a paperless manner.*
- *Recycle at all campus events such as athletic competitions, concerts and graduation ceremonies.*

- *Expand "Recyclemania" through additional resources (student involvement, dedicated staff, funding, improved weighing system) and better education.*
- *Further reduce or eliminate take-away food containers that cannot be recycled or composted (e.g., polystyrene cups, most plastics, aluminum foil) and replace with recyclable/biodegradable plastics and wax-free paper products.*
- *Investigate organic/inorganic trash management systems and produce a feasibility report.*

Mid-term Goals (3-5 years)

- *Enhance and publicize policies and procedures for existing collection sites that collect potentially hazardous waste (e.g., batteries, electronics, light bulbs, paints/polishes/removers, cleaners, lighters, medicines, etc.).*
- *Expand paper reduction in computer labs by either increasing the user fee or reducing the number of pages that can be printed before a fee is incurred.*
- *Increase "Recyclemania" participation to 50% and include additional levels of participation.*
- *Improve residence hall recycling in general, especially on move-in and move out days. Create processes and procedures for carpeting, food, clothing, shoes, furniture, computers, CDs, paper, cardboard, etc.*
- *Develop a campus-wide solid waste management educational series*

Long-term Goals (5-10 years)

- *Compost all grounds and compostable waste on site.*
- *Create a campus-wide online exchange program to increase reuse.*
- *Institute a trash bag fee that discourages disposal and encourages recycling. Bags with a green(recycling) tag are free, but bags with a black tag are not. Special procedures may be necessary for retail and other large-scale operations on campus.*

2. CHALLENGES AND FUNDING:

- The major challenge associated with solid waste management is modification of individual behavior. Either the individual chooses not to participate or is not diligent about the choice of waste receptacle resulting in contamination of recycled materials with other waste. When contamination occurs, the entire load is rejected to the landfill, negating the recycling efforts of most of the campus community.
- Additional funding is required to implement many of the goals.

IV. ENERGY AND INFRASTRUCTURE

GROUNDS MAINTENANCE

Long-term Vision: To provide clean, aesthetically rewarding outdoor facilities for all students, staff, and visitors.
Sustainable grounds landscaping and maintenance practices can have a positive impact upon the environment and play a role overall in campus sustainability efforts. Xavier University has received many awards for the beautifully landscaped grounds throughout the campus. The 130 acre site is undergoing significant changes as newly acquired properties are incorporated into the landscape inventory. The more developed areas of campus provide a beautiful environment for reflection, education and, yes, even play.

A. Sustainable Groundskeeping.

Goal: Reduce dependence on fossil fuels, other extracted minerals, chemical fertilizers and pesticides while retaining an award-winning appearance.

1. ACTION PLAN:

Short-term Goals (1-2 years)

- *Develop policies to ensure that sustainability is incorporated into landscape design, maintenance and management.*
- *Continue the selection of plantings appropriate to the Cincinnati environment. Increase the planting of native species and remove invasive non-native species.*
- *Incorporate leaf mulching for turf areas as a standard practice.*
- *Expand the use of wood refuse that is run through a chipper and converted into mulch for use in campus flower beds.*
- *Increase the use of perennial plantings to replace annuals.*
- *Expand the use of biodegradable and environmentally-safe, ice-melting chemical treatments.*
- *Reduce the use of ice-melting chemicals by utilizing more sand and biodegradable materials where appropriate.*
- *Increase the use of drip irrigation to reduce water use.*
- *Continue grounds keeping educational offerings for students, faculty and staff.*

Mid-term Goals (3-5 years)

- *Incorporate cellulosic bio-diesel in all diesel fueled equipment.*
- *Incorporate plantings of diverse plant species and native species, especially drought-resistant varieties*
- *Compost all grounds and compostable waste on site.*
- *Devise methods that will enhance the storm water management recommendations stated above (i.e., improved maintenance of rain gardens to decrease storm water runoff).*

- *Test herbicides claiming to be environmentally safe to determine their effectiveness; if the products work, the campus should minimize the use of conventional chemical herbicides such as "Roundup".*
- *Replace current grass species with a variety that is more drought-tolerant and reduces mowing.*

Long-term Goals (5-10 years)

- *Enlarge composting site to enhance composting capacity.*
- *Build a greenhouse to propagate plants and increase the amount of available plant material. If a greenhouse is available, the campus would be able to reuse existing plants rather than throw away and purchase new each year. (A greenhouse would also support other sustainable and education activities on campus.)*

2. CHALLENGES AND FUNDING:

- The development of a more sustainable approach to landscape design and planning requires a change in thinking and must incorporate the best knowledge available. This may initially involve a high level of uncertainty followed by monitoring and re-evaluation of plans in order to optimize the process and, thus, 'learn by doing.'
- Perennials have a shorter flowering time possibly resulting in a less colorful campus.
- Additional funding is required to implement many of the goals, especially the greenhouse.

Figure 1
Simple Payback vs. GHG Emission Reduction In Existing Buildings

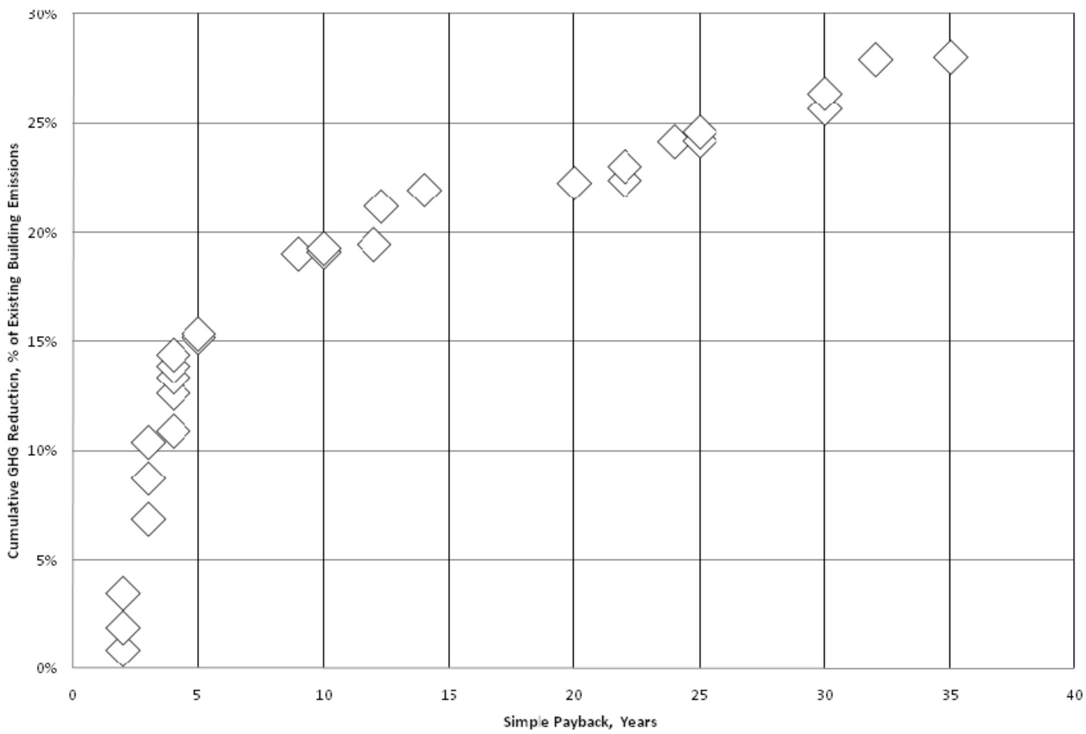
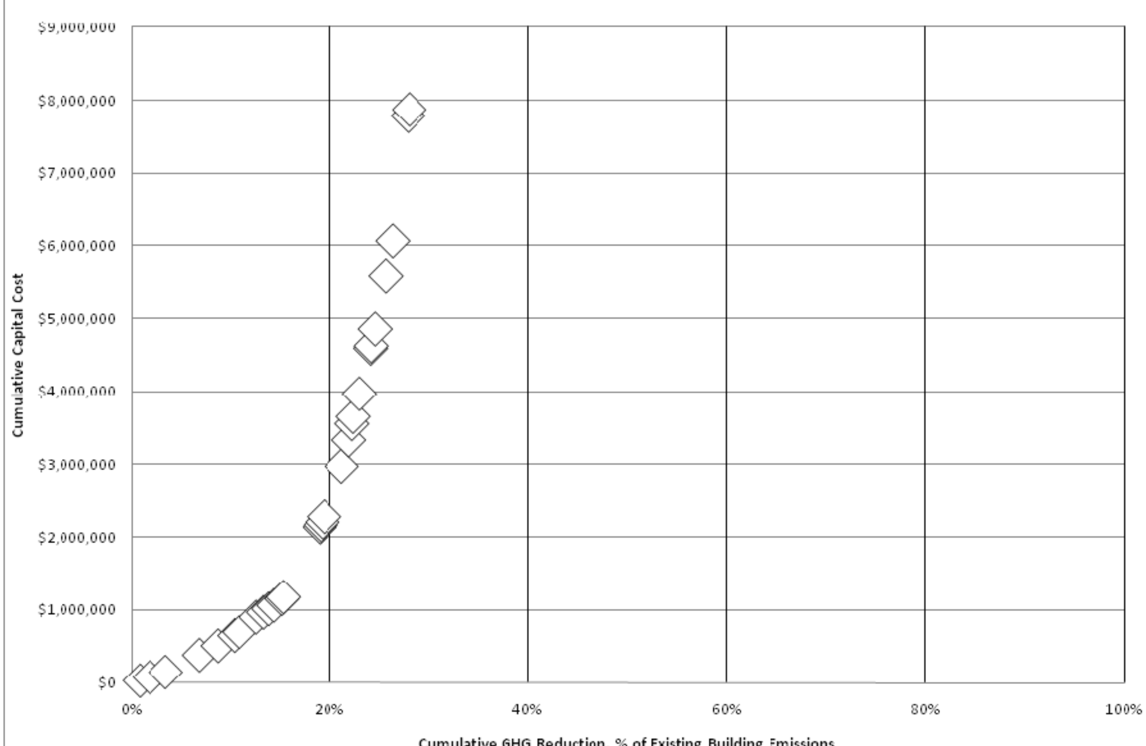


Figure 2
GHG Emissions Reduction vs. Capital Cost in Existing Buildings



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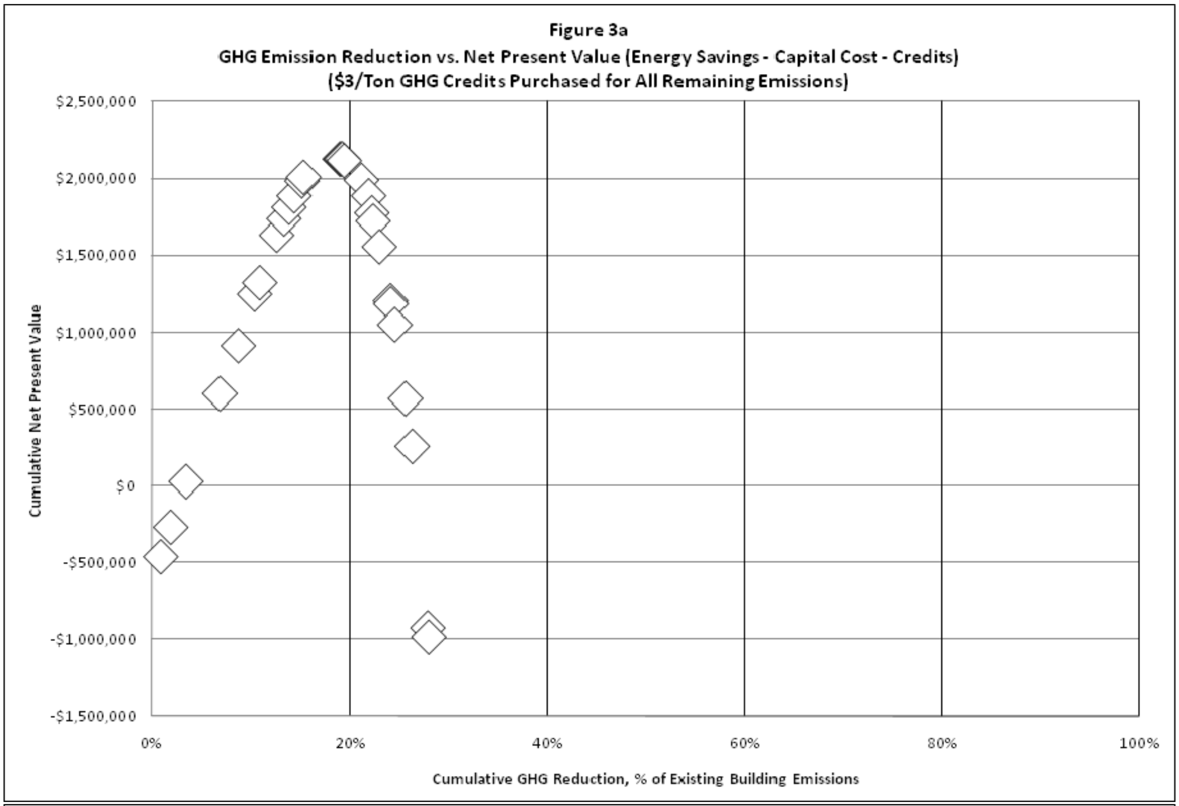
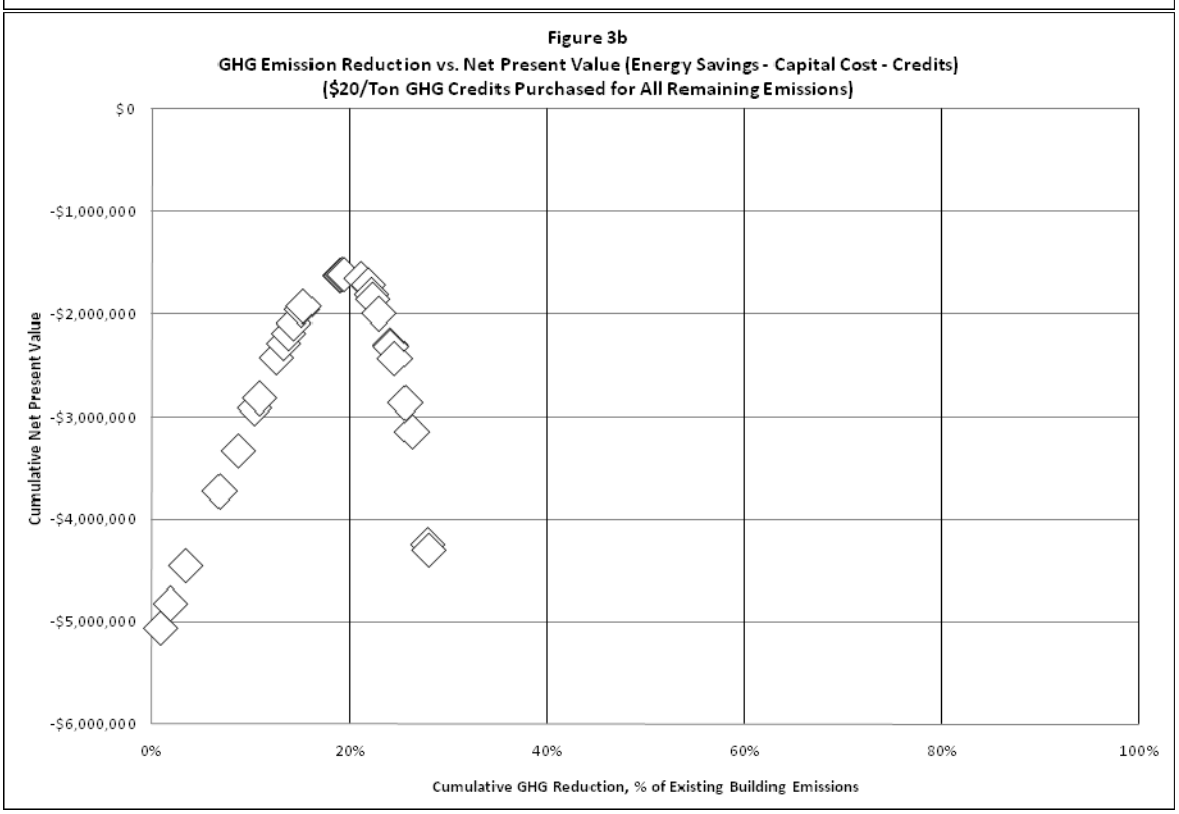




IV. ENERGY AND INFRASTRUCTURE

Figure 4
Simple Payback vs. GHG Emissions Reduction in Existing + Future Buildings

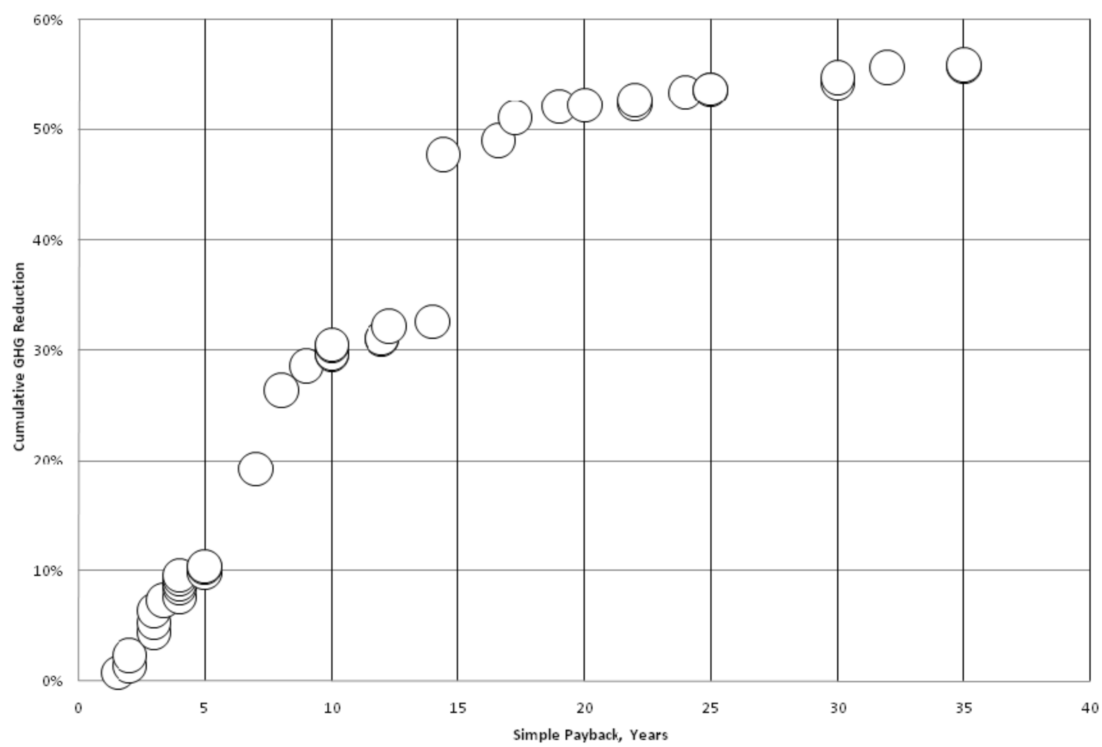
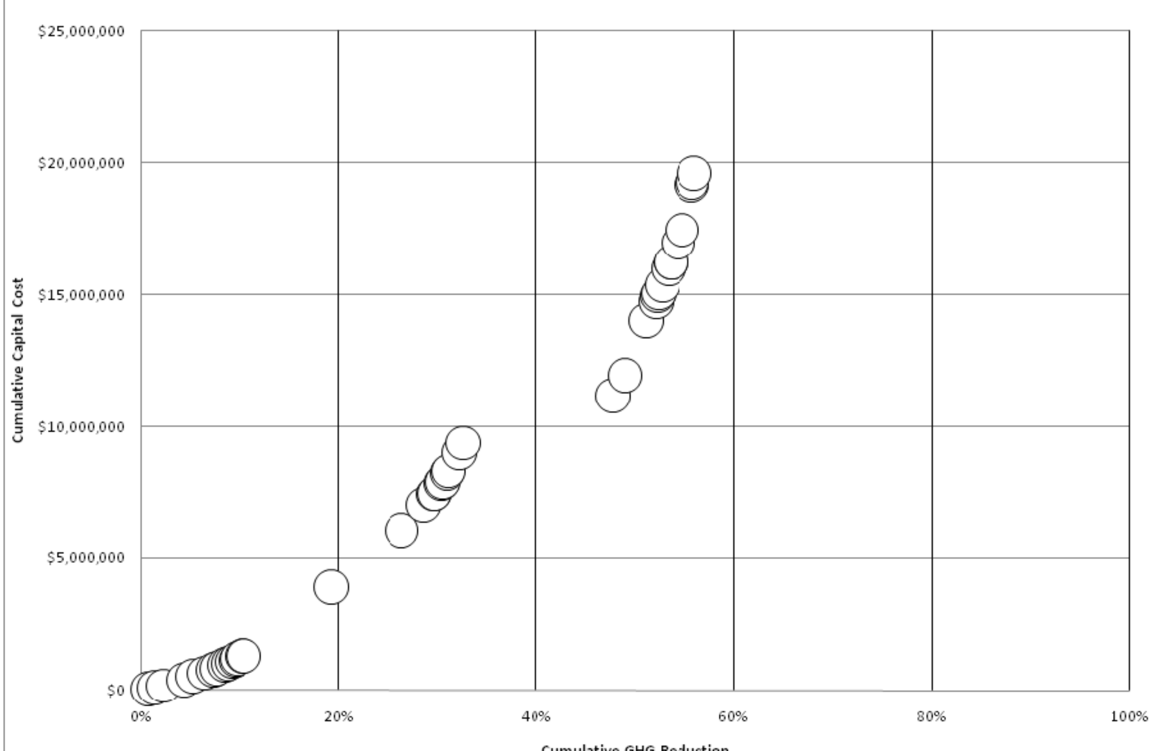


Figure 5
GHG Emissions Reduction vs. Capital Cost in Existing + Future Buildings



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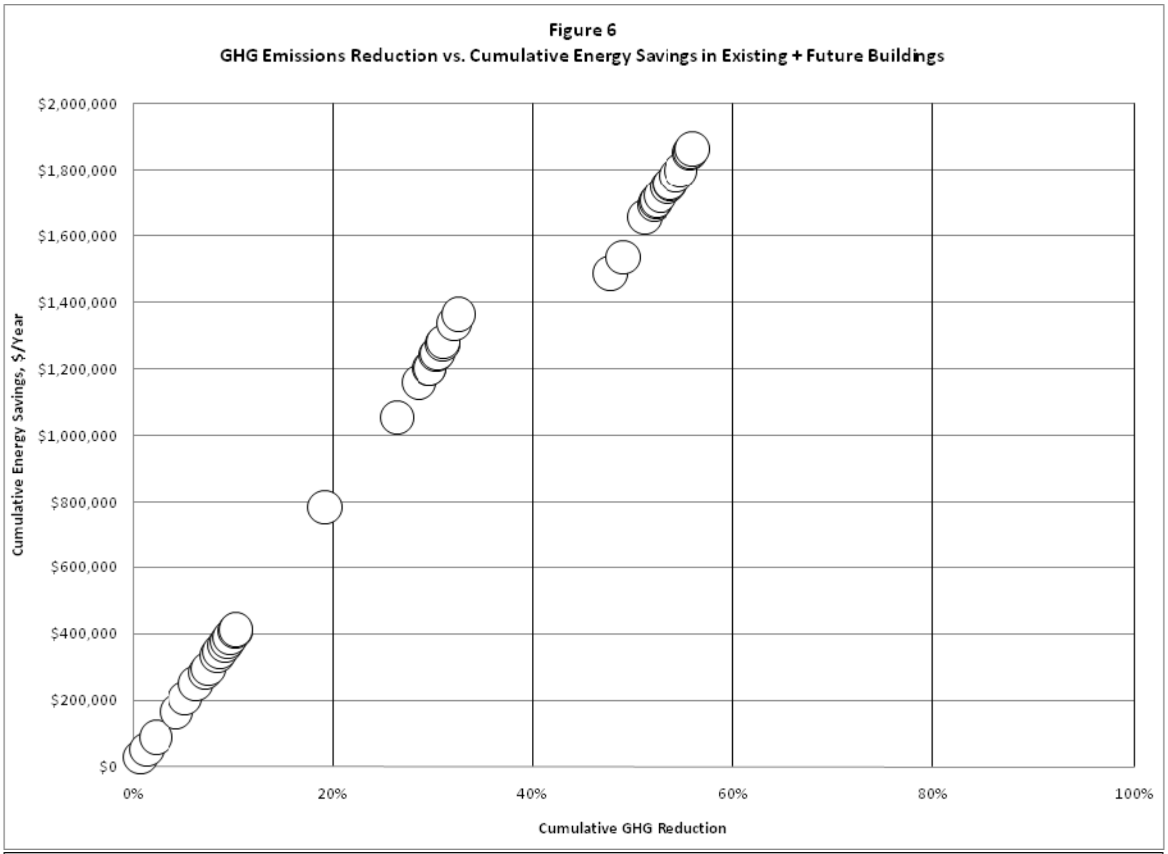
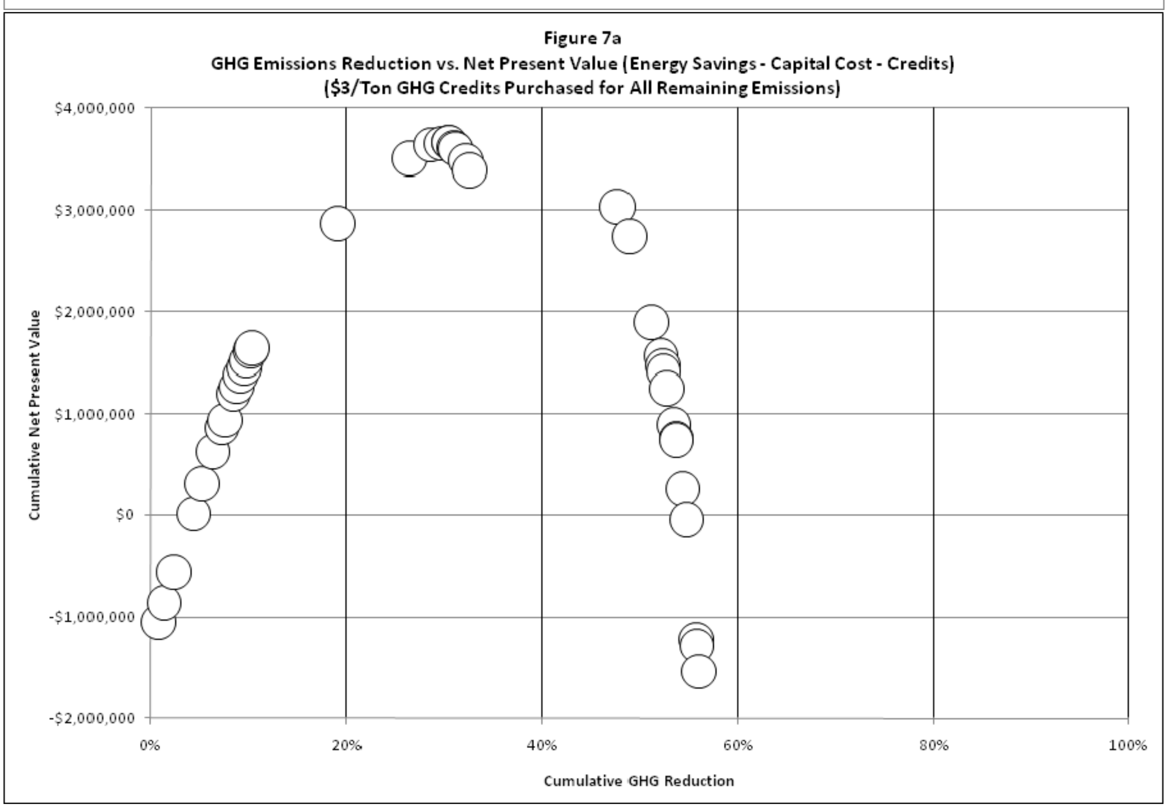




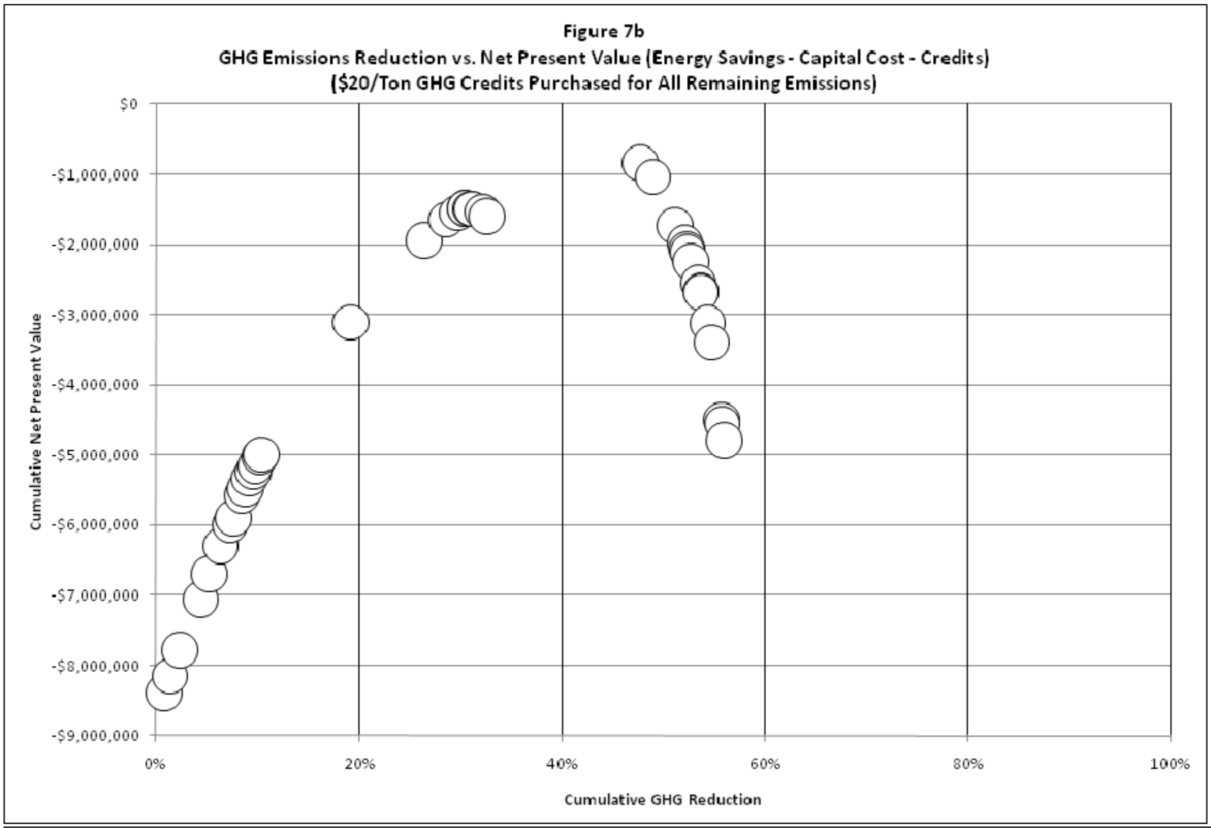


Figure 7b
GHG Emissions Reduction vs. Net Present Value (Energy Savings - Capital Cost - Credits)
($20/Ton GHG Credits Purchased for All Remaining Emissions)
$0
-$1,000,000
-$2,000,000
-$3,000,000
-$4,000,000
-$5,000,000
-$6,000,000
-$7,000,000
-$8,000,000
-$9,000,000
Cumulative Net Present Value
0%
20%
40%
60%
80%
100%
Cumulative GHG Reduction

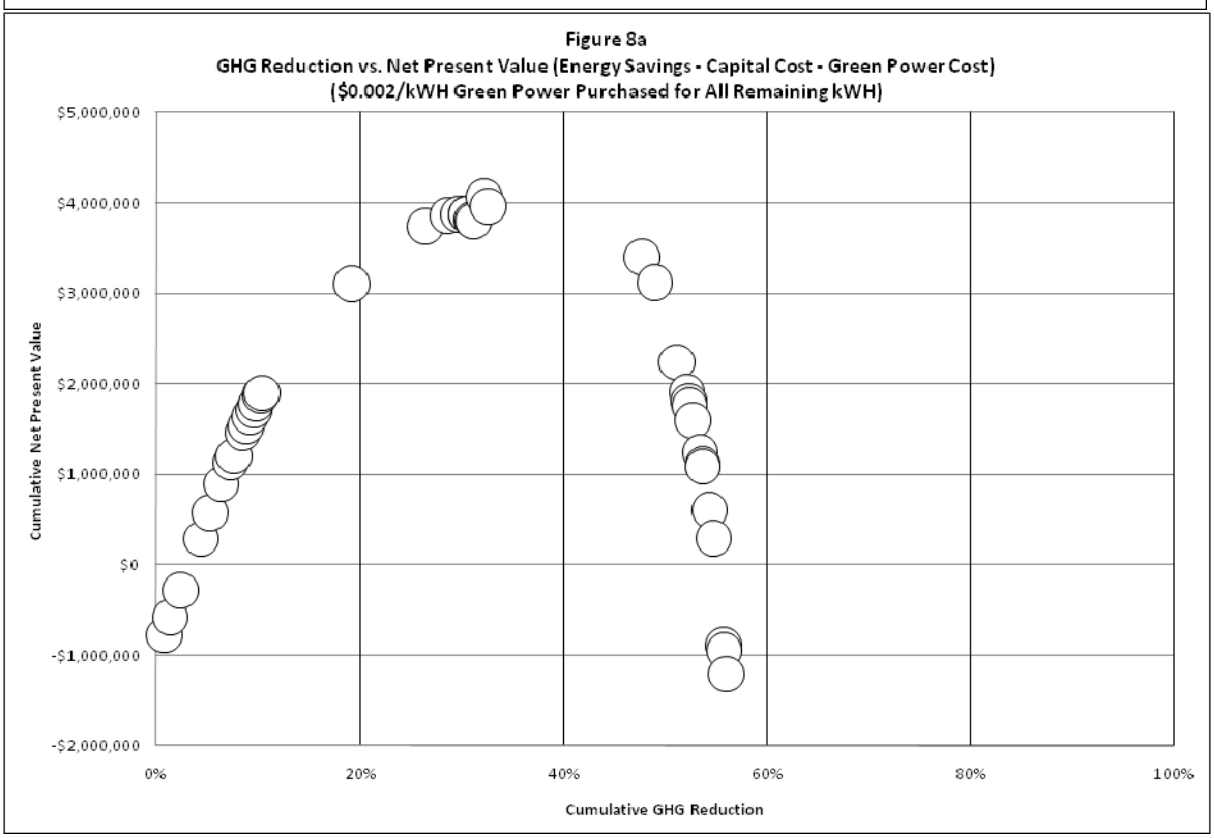
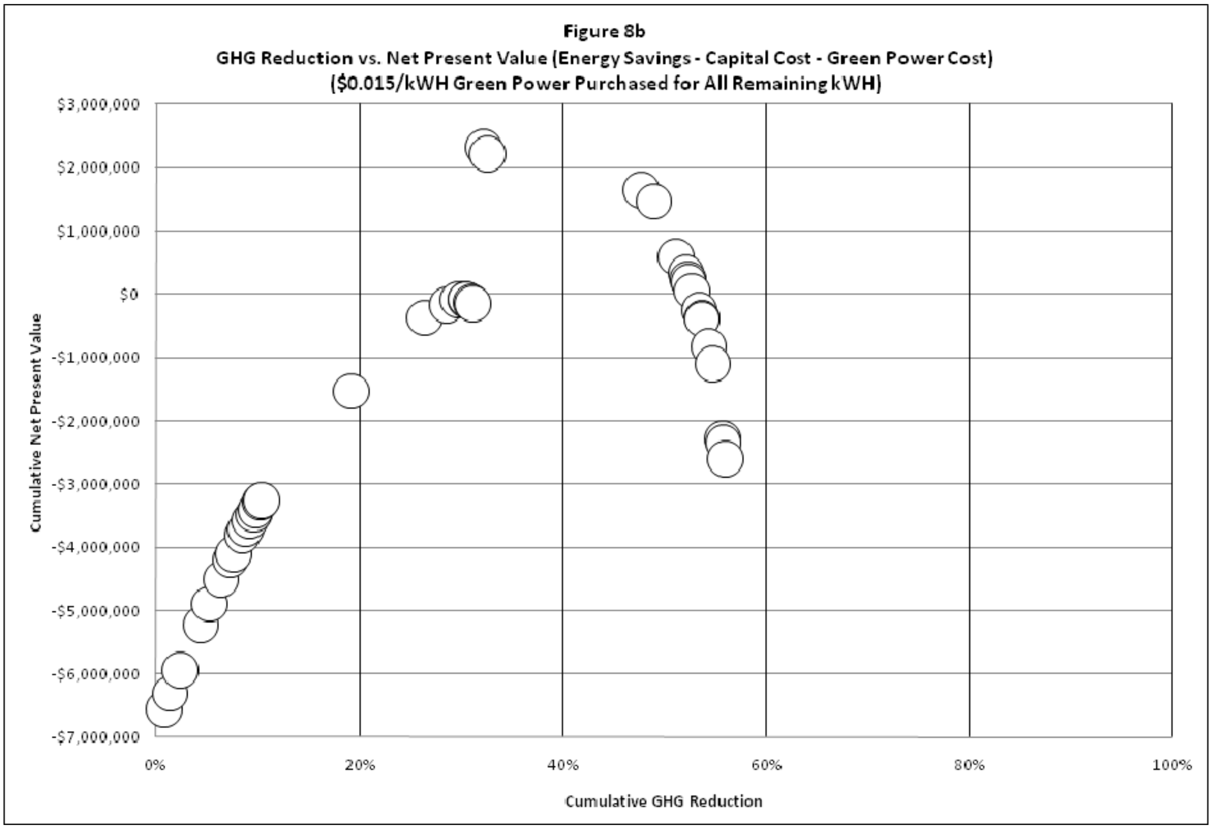


Figure 8a
GHG Reduction vs. Net Present Value (Energy Savings - Capital Cost - Green Power Cost)
($0.002/kWH Green Power Purchased for All Remaining kWH)
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
-$1,000,000
-$2,000,000
Cumulative Net Present Value
0%
20%
40%
60%
80%
100%
Cumulative GHG Reduction

IV. ENERGY AND INFRASTRUCTURE



IV. ENERGY AND INFRASTRUCTURE

Energy Conservation Measure	Category	Capital Cost	Annual Energy Savings	Average Simple Payback Period, Years	CO2 Reduction, Tons/Year	Capital Cost per Ton/Year GHG Savings	NPV per Ton/Year GHG Savings
Phase 1 Existing Buildings							
Revised air filter program	Ventilation	$46,000	$29,000	1.6	330	$137	$760
Compact Fluorescent Lamps	Lighting	$46,000	$23,000	2.0	270	$173	$723
Power management	Powered Equipment	$71,000	$36,000	2.0	410	$173	$723
Occupancy Sensors	Lighting	$234,000	$78,000	3.0	900	$260	$637
Modify controls	Cooling	$123,000	$41,000	3.0	380	$325	$789
Variable speed drives	Ventilation	$128,000	$43,000	3.0	490	$260	$637
Infiltration reduction	Ventilation	$47,000	$12,000	4.0	140	$347	$550
Recommissioning	Cooling	$165,000	$41,000	4.0	380	$432	$678
Motor replacements	Ventilation	$47,000	$12,000	4.0	140	$347	$550
T5/T8 Lamps	Lighting	$67,000	$17,000	4.0	190	$347	$550
VFDs on pumps and fans	Cooling	$47,000	$12,000	4.0	140	$347	$550
Energy Star appliances, equipment	Powered Equipment	$91,000	$18,000	5.0	210	$433	$463
Pool upgrades	Cooling	$24,000	$5,000	5.0	40	$573	$603
Ventilation energy recovery	Cooling	$958,000	$106,000	9.0	970	$991	$140
Kitchen refrigerators -heat recovery	Other Gas	$14,000	$1,000	10.0	10	$1,307	$30
Shading devices	Cooling	$39,000	$4,000	10.0	50	$867	$30
Water conservation measures	Other Gas	$73,000	$6,000	12.0	50	$1,568	-$231
Academic Mall piping replacement	Cooling	$698,000	$57,000	12.3	460	$1,518	-$254
Logan boilers decommission	Heating	$358,000	$26,000	14.0	200	$1,830	-$493
Enhanced submetering		$250,000	$0	-	0	-	-
Subtotal		**$3,526,000**	**$566,000**	**6.2**	**5,740**	**$615**	**$401**
Phase 2 Cogeneration System							
Cogeneration system	**Total Elect**	**$1,805,000**	**$125,000**	**14.4**	**6,580**	**$274**	**-$54**
Phase 3 Future Buildings, New Technology							
Additional 30% savings	Total Elect	$2,598,000	$371,000	7.0	3,850	$674	$319
LED Lighting	Lighting	$2,161,000	$270,000	8.0	3,120	$693	$203
Boiler energy recovery (condensing)	Heating	$400,000	$40,000	10.0	310	$1,307	$30
Daylighting	Lighting	$407,000	$41,000	10.0	470	$867	$30
Lower coil/duct/filter velocities	Ventilation	$116,000	$34,000	3.4	400	$292	$604
Super insulation	Heating	$342,000	$29,000	12.0	220	$1,568	-$231
Subtotal		**$6,024,000**	**$785,000**	**7.7**	**8,360**	**$721**	**$248**
Totals		**$11,355,000**	**$1,476,000**	**7.7**	**20,700**	**$549**	**$194**

V. ACADEMICS AND STUDENT LIFE

Xavier University is committed to educating students in the Jesuit tradition of a liberal arts education. To that end, students are trained in their particular field of choice, but are also exposed to a broad core curriculum from many other disciplines. As part of our Catholic heritage, it is of central importance to incorporate ideas of sustainability throughout the academic curriculum. Xavier seeks to prepare students for "lives of solidarity, service, and success." This includes training students to understand the issues and challenges of creating a sustainable future for all.

Sustainability as an academic field overlaps many traditional disciplines. It is important to have the scientific literacy understand research from the natural sciences in order to make informed decisions. It is equally necessary to understand how human systems work from the disciplines of History, Economics, Political Science, and Sociology. Within a Jesuit education, sustainability needs to be dealt with from philosophical and theological perspectives, as well as from the perspectives of ethics and social justice. In addition, many other disciplines (e.g., English Literature, Marketing, Entrepreneurial Studies, Fine Art, etc.) are integral to the weaving of sustainability themes throughout the curriculum. The goal is to infuse ideas of sustainability throughout the undergraduate academic experience where there exists the best chance to reach the broadest range of students.

On college campuses, learning is not limited to experiences in academic classes. Students are exposed to new ideas and perspectives in social and extra-curricular activities. Many of these can be more powerful in shaping future attitudes and behavior than academic work. Through both coursework and co-curricular activities, Xavier endeavors to foster a culture of environmental awareness and receptivity to new approaches to sustainability among students, faculty and staff.

ACADEMICS

Long-term Vision: To create an academic curriculum that introduces every Xavier student to ideas and issues of sustainability from a variety of perspectives in many different classes and to become a dynamic research center for interdisciplinary collaboration working toward sustainable solutions to environmental and societal problems.

A. Curriculum and Teaching

For many years, Xavier University has offered classes throughout the curriculum that focused on sustainability issues. Most of these courses have been organized into an interdisciplinary Environmental Studies minor. The minor is rooted in two main disciplines: Ecology and Economics. Students seeking the minor also have an elective that can be satisfied from a variety of departments such as Theology, English, and History. A 2009 campus-wide survey of faculty revealed that 81 different courses from 35 departments incorporate some discussion of sustainability. In responding to the survey, many professors said they would like to include more sustainability-related content into their courses

Goal: To introduce students to themes of sustainability from a variety of perspectives

V. ACADEMICS AND STUDENT LIFE

1. **ACTION PLAN:**

Short-term Goals (1-2 years)

- *Offer workshops for faculty to foster dialogue between disciplines that will aide faculty in incorporating more sustainability themes into existing courses. These would occur on a formal basis annually (rotating between offering during the semester and summer), as well as informally (through faculty brown bags) beginning in the Fall of 2010.*
- *Develop other ways to encourage and facilitate faculty incorporation of sustainability themes into existing courses.*
- *Develop new courses, with sustainability as a central element, with the support of the Center for Teaching Excellence, such as Faculty Learning Communities and other course-development supports.*
- *Pilot departmental self-written sustainability plans within the Business School before expanding this opportunity to the University as a whole.*
- *Develop a major in environmental sciences. Having a science degree focused on the environment will help Xavier recruit students interested in sustainability. These students, encouraged by their coursework, will help to change the culture on campus to be more aware of sustainability issues.*

Mid-term Goals (3-5 years)

- *Promote greater awareness of faculty and staff choices around sustainable living in order to give the students role models and guidance in their own personal choices.*
- *Continue to offer opportunities for faculty to develop sustainability into the courses they already teach as well as create new courses focused on sustainability. These may be summer workshops, brownbag lunches, or other informal meetings to provide faculty with information, motivation, and encouragement coordinated by the sustainability director.*
- *Continue to administer surveys of faculty to track the progress of including more sustainability themes into a diversity of courses.*
- *Engage all academic departments in self-written sustainability plans as modeled from the Business School pilot experience.*
- *Offer a sustainability certificate program within the Center for Adult and Part-time Students.*
- *Identify courses with sustainability content in the course catalogue so that students can make well-informed course selections.*
- *Develop relationships with local organizations to place students into practical internships as a supplement to their coursework in completion of the degrees in environmental science and sustainability studies.*

Long-term Goals (5-10 years)

- *Seriously consider requiring students to take one core class with sustainability content.*

- *Develop an interdisciplinary major in sustainability or environmental studies. As more sustainability- course content is developed across departments, we should be able to offer such an interdisciplinary degree. The "Association for the Advancement of Sustainability in Higher Education" reported in 2009 that there were more than 100 new majors and minors in sustainability, up from three in 2005. Two factors have led to this growth: student and employer demand for students trained in this area.*

2. CHALLENGES AND FUNDING:

- Academic changes, such as listing courses with sustainability content and slight modifications of the core curriculum, must pass through the faculty governing structures
- Funding will help academic programs grow. Specifically, a sustainability director is needed to help coordinate these efforts and others in this Plan. In addition, funding should be sought to provide for an endowed faculty-chair position as director of sustainability or environmental studies. Environmentally-conscious donors could be identified who will contribute to such a specific academic program.
- Unless sustainability becomes a key University priority, faculty engagement is likely to remain limited.

B. Research

Even though Xavier University is primarily an undergraduate teaching institution, the University has as part of its academic mission to engage in scholarly research. The faculty currently has expertise and active scholarship in a range of disciplines relating to sustainability, including Ecology, Economics, History, and Theology. Certainly more can be done to support and encourage research in these and other fields. In addition to faculty conducting research within their respective disciplines, undergraduate research experience is a fundamental component of the education at Xavier. The University highlights student research in its annual "Celebration of Student Research and Creative Activity."

Goal: To develop many sustainability-related research activities on campus. Foster interdisciplinary collaborations between interested faculty, and opportunities for students to participate in research on campus and in local organizations.

1. ACTION PLAN:

Short-term Goals (1-2 years)

- *Provide small internal research grants for faculty to develop sustainability-related research projects.*
- *Designate a sustainability category within the "Celebration of Student Research and Creative Activity" to offer special recognition through a sustainability award.*

V. ACADEMICS AND STUDENT LIFE

Mid-term Goals (3-5 years)

- *Hire new tenure-track faculty with expertise and research interests in sustainability. AASHE reports that in 2008, 57 sustainability-focused academic positions were advertised.*
- *Provide incentives for faculty to establish interdisciplinary collaborations addressing sustainability issues.*

Long-term Goals (5-10 years)

- *Establish a sustainability center, with designated space in an academic building, and a faculty director who is granted teaching-release time to focus on research activities.*

2. CHALLENGES AND FUNDING:

- At present, Xavier does not have available space for new scientific research labs.
- Xavier is growing and in the midst of a building phase. Some of this new construction should be devoted to research facilities to accommodate new faculty with research in sustainability.
- Funding sources should be identified to provide seed money for internal grants that will position faculty to apply for larger external grants from traditional (and nontraditional) sources.

STUDENT LIFE

Long-term Vision: To bring the campus culture to a greater awareness of the impact our daily decisions have on the local, regional, and global environment

A. Co-Curricular Activities and Raising Awareness

There have been a variety of initiatives that have taken place across the University campus. Xavier participated, to a small degree, in the nationwide "Recyclemania" competition with other colleges and universities. Student groups provided a number of events during "Earth Week," which included the distribution of reusable water bottles. Additionally, Xavier has brought in speakers through the ER/S lecture series to talk about sustainability (e.g., Robert F. Kennedy Jr., David Orr, Michael Pollan, Vandana Shiva and Wendell Berry.)

Goals:

- To raise the awareness of students, faculty and staff through a multitude of sustainability-focused initiatives occurring outside the classroom.
- To change the culture at Xavier University to create an aware campus firmly committed to a sustainable lifestyle.

1. ACTION PLAN:

Short-term Goals (1-2 years)

- *Increase participation in "Recyclemania," along with better publicity for the recycling program, which might include information displaying what is and is not recyclable and what happens to the recyclable materials.*
- *Use dorm metering to educate residents about energy use.*
- *Incorporate sustainability and related topics into the "Manresa Orientation Program."*
- *Reduce waste during move-in and move-out by making recycling and donating options widely available and widely publicized.*
- *Ensure that all Resident Assistants coordinate one sustainability-focused program each year.*
- *Create a Xavier-specific "Green Pledge" for students, faculty and staff to sign pledging to live a more sustainable lifestyle. The number of people pledged may be displayed in Gallagher Student Center or on the "Xavier Green" website.*

Mid-term Goals (3-5 years)

- *Develop sustainability consultants for students, student groups, faculty and staff to go to for help or advice regarding the environmental implications of their issue or event as well as provide advice to create greater sustainability.*
- *Provide all incoming students with a guide for sustainable living on campus and in the community.*
- *Establish an ongoing faculty and staff education program on sustainability to help increase the sustainable culture.*
- *Support an annual or semi-annual Sustainability Lecture series.*

2. CHALLENGES AND FUNDING:

- Most of these efforts can be accomplished with little funding. Some publicity and signage would cost several thousands of dollars on a one-time basis, i.e., an annual lecture series would cost approximately $25,000.
- The sustainability student group and interns can carry some of this out, but administrative and the Student Government Association (SGA) support will also be necessary.

B. Service Learning, Internships, and Volunteering

Xavier University has a long history of promoting experiential learning that results in students becoming active and engaged citizens, particularly in solidarity with the marginalized. Most notably, the Academic Service Learning Semesters, the Community Building Institute and, now, the Eigel Center for Community Engagement, the student-run Alternative Breaks program, and courses that offer service learning experiences as a component, have all played an important part in fulfilling this part of our mission in the past. We need to build on this breadth and depth of experience to ensure that students are exposed to ideas, not just about economic justice, but also environmental justice and sustainability.

<u>Goal</u>: To ensure that every Xavier student has at least ten hours of experiential experience with sustainability work before graduating.

1. ACTION PLAN:

<u>Short-term Goals (1-2 years)</u>

- *Secure funding for environmental fellows program.*
- *With students and Peace and Justice programs, help to develop a loca, sustainability-focused "Alternative-Breaks" trip.*
- *Encourage departments and student organizations to develop new service learning opportunities that provide exposure to sustainable practices.*

<u>Mid-term Goals (3-5 years)</u>

- *Identify and promote courses that have an experiential learning component that focuses on sustainability.*
- *Ensure that all off-campus learning opportunities operate in the most sustainable way possible, including transportation, food and purchasing.*
- *Join and participate in the "National Wildlife Federation Campus Ecology Program."*

<u>Long-term Goals (5-10 years)</u>

- *Create a sustainability center (equivalent to the Eigel Center) that promotes Xavier's sustainability efforts both on campus and in the community.*

2. CHALLENGES AND FUNDING:

- The biggest challenges to achieving the short-term and medium-term goals are funding, and faculty/student participation and interest. But the goals are not very expensive relative to other goals in the Plan, in the order of thousands of dollars.
- The environmental fellows program will cost approximately $6,000 annually for two students; the "Alternative Breaks" program should not have any additional cost. Encouraging departments and student organizations to develop new service and experiential-learning opportunities will be more successful with faculty-development opportunities. Depending on the level of opportunity, ranging from a semester sabbatical to summer research to Wheeler grants, the cost can be $5,000 to $50,000 or $2,000-3,000/individual. A sustainability center would require funding minimally in the range of $200,000-300,000, depending on the number of staff and the size of the space requirements.

C. <u>Campus Events</u>

Extra-curricular campus events from dorm-wing discussions with a faculty member to big-name lectures sponsored by the Ethics/Religion and Society Program are an important part of Xavier's community life. These events can help promote sustainability and educate the entire community and the campus.

Xavier has been offering a variety of sustainability-related events for some time. Various clubs, through Peace & Justice programs, have sponsored speakers and educational sessions on issues of justice, hunger, and poverty. The "Vision of Hope" speakers' series has had a sustainability focus as well. The "Justice Across the Campus" committee, and its environmental subcommittee, sponsored a forum on green building several years ago. and The Student Activities Council has sponsored "Earth Day" in April for many years. In addition, the Ethics/Religion and Society lecture series, over the last two years, has had sustainability and ecology as its theme.

<u>Goal</u>: To offer and help promote events that educate about sustainability. Ideally, Xavier will become a hub of sustainable events linked in with Norwood, Evanston, North Avondale and Avondale, the Greater Cincinnati area, area universities and citizen organizations.

1. ACTION PLAN:

<u>Short-term Goals (1-2 years)</u>

- *Develop and maintain the campus sustainability calendar on the website.*
- *Develop an annual community-wide sustainability event such as an" expo" or environmental film festival.*

<u>Mid-term Goals (3-5 years)</u>

- *Cintas Center has a greener operation that includes recycling for all events, washable dishware, choices of local and organic food for all catering, etc.*
- *Cintas arena and concessions become promoters of green operations, thanks, in part, to entrepreneurial students who work with them.*

<u>Long-term Goals (5-10 years)</u>

- *Become known for hosting local conferences that promote green practices but also networking of local scholars, business personnel, politicians, etc. rather than national conferences that promote long-distance air travel.*

2. CHALLENGES AND FUNDING:

- Most of the above actions will require commitments of both personnel and resources.

- Website maintenance requires that someone dedicate part of their workday to this task. The annual community-wide event will require a Xavier co-sponsor and willingness to pay for technical needs and space for the event. Cintas Center changes will likely have few costs. To become a “green conference host,” someone in Cintas would need to be trained in elements of green conferencing in order to handle this responsibility.

VI. TRANSPORTATION

Traditional transportation systems have a major impact on the environment, as well as the community/individual well-being. Automobile and airplane-centered systems such as our own are major contributors to a variety of social ills, from air pollution and the obesity crisis to global climate change. Due to the negative impact of conventional transportation usage on several levels, market, environmental and citizen demands are urging the transportation sector toward healthier and more efficient options.

According to Xavier University's Greenhouse Gas Inventory (GHG) completed in the Spring of 2009, transportation accounts for 31% of our University's collective greenhouse gas emissions. Although second only to energy, in terms of largest output category, transportation remains an afterthought in campus planning across the country. To oppose this trend, the American College and University Presidents' Climate Commitment "encourages use and provision of access to public transportation for all faculty, staff, students and visitors" and the establishment of "a policy of offsetting all greenhouse gas emissions generated by air travel paid for by our institution," among other recommendations, within two years of signing the commitment.

In addition to the telling results of the Greenhouse Gas Inventory, the recent increases in undergraduate and graduate enrollment at Xavier, along with the ongoing campus construction projects, have moved transportation-related issues to the forefront. The ever-expanding network of surface parking lots may temporarily meet campus parking needs, but they contribute directly to Xavier's greenhouse gas output. Parking lots encourage the use of automobiles, create heat islands, direct rainwater to storm sewers thereby reducing water in our local aquifers, and add significant costs to higher education by encouraging students to commute by car. In fact, a University of Wisconsin study found that, for many commuting students, the costs of maintaining and using an automobile for transportation may be the second-highest cost of college attendance after tuition, even equaling the cost of dorm housing. Thus, transportation options may also indirectly affect classroom success, retention and graduation rates. Nearly one-third of Xavier's carbon footprint is attributed to transportation therefore it is imperative that efforts to reduce transportation-related emissions take priority in movement toward our University's climate neutrality efforts.

Xavier has made some steps in recent years toward reducing the emissions from our fleet vehicles and to promote alternative means of traveling to campus. Mail Services purchased an electric vehicle to replace a gasoline-powered delivery van. Physical Plant purchased two electric vehicles with plans to replace the remainder of the gasoline-powered fleet with higher-fuel-standard vehicles as the fleet ages. In 2009, the number of bike racks available around campus more than doubled. Other efforts will be outlined, in more detail, within the section that follows.

Long-term Vision: To reduce transportation-related greenhouse gas emissions by 50 % by 2030

Daily Commuting:

With a total student population of 6,700 (3,700 undergraduates and 3,000 graduate students) and a total employee population of 1,277 (full-time and part-time faculty, staff, and administrators), there are thousands of trips, primarily by individual automobile to and from campus each day. In total, 4,761 students and nearly all faculty and staff live off-campus which, according to the GHG inventory, results in nearly 18 million automobile miles per year producing 7.2 million kg/year of CO_2 emissions.

VI. TRANSPORTATION

Transportation decisions are highly decentralized on Xavier's campus. Beyond daily choice in preferred mode of transport by faculty, staff and students, diverse entities including intercollegiate athletics, physical plant, and study abroad programs all make independent transportation choices without centralized recommendations or guidelines. Additionally, campus parking issues fall under the jurisdiction of the Parking Committee which is comprised of faculty, staff and students from across the University. The Parking Committee may make recommendations to the University Provost for parking policy changes. However, at this point in time, there are not incentives in place for the utilization of alternative modes of transportation.

The following are some recent initiatives that have occurred on campus which have the combined potential to reduce commuter-based transportation-related emissions on campus:

- Off-Campus: Shuttle shifted from evening to daytime routes beginning in the Fall of 2009 due to student input.
- Bicycle Racks: Additional on-campus bicycle racks purchased by Student Government Association (SGA) and installed by Physical Plant during the 2008-09 school year.
- Two-wheeled Vehicle Parking and Permitting: Proposal expanding parking and providing permitting for two-wheeled motorized vehicles approved by the University Parking Committee during the Fall of 2009.
- Walking: Pedestrian-friendly campus with vehicle-free malls, broad sidewalks and crosswalks.
- Rideshare Board: Available in the Gallagher Student Center for students to coordinate rides to and from campus for breaks.
- Airport Shuttle: Operated by SAC/SGA during peak departure times for breaks.

Goal: To encourage the adoption of, and provide infrastructure for, alternative commuting options in order to reduce commuting CO_2 emission to 50% of the total vehicle miles traveled by 2030.

1. ACTION PLAN:

Short-term Goals (1-2 years)

- *Develop easily-accessible electronic rideshare board inclusive of faculty, staff and students.*
- *Create promotional campaign on ride sharing.*
- *Promote off-campus shuttle stops, routes, and times to increase student usage.*
- *Develop a promotional campaign about Metro bus ridership that includes information on finding your route, bike and bus combo commuting, and the financial and environmental benefits of riding the bus.*
- *Enact a permitting system for two-wheeled motorized vehicles, so that parking is permitted on campus.*

VI. TRANSPORTATION

- *Expand parking for two-wheeled motorized vehicles in additional, strategic locations on campus, thus better utilizing existing space.*
- *Create a Non-Daily Parking pass to incentivize alternative transportation.*
- *Install additional bike racks in more convenient locations to accommodate and encourage increased usage.*
- *Develop bike route maps for commuters from communities within five miles of Xavier.*
- *Create an educational campaigns on the personal health benefits of and safety precautions for using alternative transportation.*
- *Promote understanding of the true costs of automobile ownership.*
- *Implement strategies that allow students to have better access to rental and purchase of new and used bicycles.*

<u>Mid-term Goals (3-5 years)</u>

- *Support rideshare/carpool website.*
- *Create new parking policies that allow for incentives (financial or preferred parking for employees and students who carpool, ride scooters or drive high fuel-efficiency compact cars.*
- *Establish an off-campus shuttle route that includes transportation to and from major Metro bus stops.*
- *Improve lighting and safety of surrounding bus stops.*
- *Support the Southwest Ohio Regional Transit Authority (SORTA) and the Cincinnati community in the improvement of the public transportation system.*
- *Provide electronic GPS tracking system for University shuttle.*
- *Advocate for a light rail system to pass through Xavier's campus existing tracks.*
- *Invite SORTA to partner with the University to promote discounted riding options for individuals interested in exploring public transportation as a viable option.*
- *Create desirable compact/hybrid car/ carpool-designated parking spaces in current and new lots.*
- *Establish a tiered system of permitting to incentive less frequent usage of single-vehicle transport.*
- *Provide central facilities for bikers to change and clean-up.*
- *Implement self-service bike rental stations/Bike Loan Program/Bike Sharing Program.*
- *Increase bike lane construction/implementation in partnership with surrounding cities and neighborhood policy makers.*
- *Partner with local bike shops to support repairs and purchases.*
- *Partner with local retailers to incentivize faculty, staff and students purchasing of scooters or electric bicycles.*

VI. TRANSPORTATION

Long-term Goals (5-10 years)

- *Provide a Metro Bus Ridership program for students and staff.*
- *Create a mass transportation hub at Xavier Square.*
- *Establish centralized bike parking lots.*
- *Provide support services for bike maintenance and storage.*

ON-CAMPUS VEHICLE USAGE

On-campus vehicle usage for University operations for campus fleet vehicle operations account is an important part of the transportation section of the Campus Sustainability Plan. Although this category of transportation accounts for only 1% of transportation-related emissions, improvements in vehicle efficiency are an important signal to the broader community of Xavier's commitment to sustainable actions. Recently, the University purchased or leased several small electric vehicles for use by Physical Plant and Mail Services departments for on-campus operations.

Goal: To increase efficiency and decrease impact of University-owned, leased and operated vehicles by 50% by 2030.

1. **ACTION PLAN:**

Short-term Goal (1-2 years)

- *Develop a policy that requires leased, rented and University vehicles to be as fuel efficient as possible*

Mid-term Goal (3-5 years)

- *Transition, University owned vehicles to a more sustainable fuel sources such as vegetable oil, ethanol, biodiesel, hydrogen, or electric*

AIR TRAVEL

Air travel, for purposes of intercollegiate competitions, recruitment, professional development and study abroad, accounts for about 5.7 million passenger miles per year at Xavier emitting 4,400 tons of CO_2 per year or 12% of Xavier's greenhouse gas emissions. Although the University contracts with a travel agent to provide travel-related services, decisions regarding air travel are highly decentralized on campus.

Goal: To reduce reliance on and impact of air travel for official University business through educational outreach, technological options to reduce travel needs, and offset purchases.

VI. TRANSPORTATION

1. **ACTION PLAN:**

Short-term Goal (1-2 years)

- *Provide educational opportunities to inform University departments about the impact of air travel on environment.*
- *Encourage-video and teleconferencing to make travel less frequently necessary.*

- **Mid-term Goal (3-5 years)**

  - *Adopt a plan for offsetting University-sponsored air travel, in coordination with the larger plan, to be carbon neutral by 2030.*

TRANSPORTATION SERVICES

In order to tackle transportation's current 31% contribution to Xavier University's overall carbon output, transportation must be addressed in a strategic and coordinated fashion. At this time, there is no University body that oversees, or takes responsibility for, setting transportation initiatives and policies in a comprehensive manner. The recommendation of this Plan is that a transportation services office, committee, or position be established to coordinate actions and activities in regard to transportation behavior and infrastructure from parking to commuting to air travel.

The University Parking Committee and Campus Police are the only two University bodies that plan and implement policies related to transportation. There is no central entity that coordinates transportation services at this time.

Goal: To establish a formal body or office to oversee transportation initiatives and infrastructure.

1. **ACTION PLAN:**

Short-term Goal (1-2 years)

- *Work with University administration and the parking committee to develop and to oversee comprehensive planning and implementation of sustainable transportation policies and strategies.*

Mid-term Goals (3-5 years)

- *Establish University office of transportation service.*
- *Hire full-time transportation services director.*

2. CHALLENGES AND FUNDING

- Overcoming the aversion to travel by any means other than cars - Trying to get people to change behavior is extremely difficult. Our city has had little in the way of accessible and reliable public transport, and bicycle commuting has not been embraced by this region.

- Given the hilly topography and the weather, a bike-to-campus program may have only limited impact. Those most likely to take advantage of this type of program are those living close to campus (e.g., less than 5 miles), those who are already reasonably fit, and those who own adequate bike transportation.

- Bike safety is an important issue. Many of the feeder roads coming into campus are dangerous for cyclists during peak travel times. Further improvements in the city to support bicycle commuting will go a long way toward making cycling to campus a safer and more impactful transportation option.

- A significant investment in human resources is required to initiate and sustain the programs designed to achieve the goals mentioned above. Educational efforts and promotional campaigns will require a sustained and coordinated effort as opposed to ad-hoc approaches that have been used in the past. Some of the important mid-term initiatives will require dedicated human resources.

- Administrative actions are needed - The Parking Committee is the sole means of enacting transportation policy on campus. While parking related issues are certainly important, a new administrative structure must be developed that takes into account a comprehensive transportation policy for the Xavier community.

- Several mid-term strategies require building relationships with governmental entities, community groups and private businesses, as well as University departments, divisions, and campus groups. The ultimate success of these efforts relies on collaboration with groups with potentially divergent interests and, therefore, the challenge cannot be overlooked.

- In terms of financial outlay for equipment and infrastructure, there will be costs associated with nearly all goals outlined in this Plan from short-term to long-term; some long-term strategies will incur significant costs. While some savings may be realized from reductions in air travel, it is likely that the purchase of carbon offsets may be necessary to realize a significant decrease in CO_2 emissions. Also, increasing faculty, staff and student use of public transportation may require investment in support infrastructure (e.g., a transportation hub, covered bus stops, etc.), as well as financial support for a bus ridership program. Identifying and converting underutilized campus space into centralized bike and/or two-wheeled vehicle parking will not require significant expenditure, but is still worth mentioning here.

VII. PURCHASING & SERVICES

The mission of the Office of Purchasing is to provide management oversight and to facilitate Xavier University purchasing processes in order to promote integrity, economy, effectiveness and accountability; and to provide sourcing, bidding and troubleshooting assistance to University departments and/or organizations.

The office of purchasing seeks to develop mutually-beneficial business relationships with suppliers capable of delivering Best Total Value which is driven by University business needs and includes a number of components, including: total cost of ownership, quality of goods or services, supplier's reputation for responsiveness and service, Minority Business Enterprise (MBE) or Historically Underutilized Business (HUB) ownership, local area supplier, sustainability and supplier's willingness to share risk and provide technical resources

At the present time, the campus purchasing process is nominally centralized but a number of University departments and individuals make independent purchasing decisions. Although there are some purchasing guidelines, including preferred for specific products, the University has not placed major emphasis on sustainable purchasing.

The following items are currently purchased with recycled content: toilet paper, copier paper, computer monitors and photo copiers. Over the past several years, we have replaced incandescent lights with compact fluorescents fixtures in many of the Residence Halls and administrative offices. Custodial Services began purchasing environmentally safer cleaning chemicals in 2006.Food vendors, campus retail stores, and Dining Services have made some sustainable products (e.g., fair trade, organic, local, cruelty-free, etc.) available for sale and special events.

Long-term Vision: To select goods and services that promote a healthy community and environment by incorporating key environmental and social factors with traditional price and performance considerations.

Goal: To develop and implement sustainability-focused purchasing policies by 2012 and to pursue further goals as determined.

1. **ACTION PLAN:**

Short-term Goals (1-2 years)

- *Develop a University purchasing policy that articulates the goal of purchasing environmentally sustainable, cost competitive products and services. Products and services covered by this policy would have a reduced effect on human health and the environment compared to competing products or services that serve the same purpose.*
- *Auxiliary Services will make sustainable products and services easily available in convenience or "captive audience" situations (e.g., less harmful detergents in dorm laundry rooms, more sustainable choices in dining halls and vending machines, etc.)*
- *Educate the campus community about sustainability purchasing programs and policies.*

VII. PURCHASING & SERVICES

Mid-term Goals (3-5 years)

- *Adopt variable government standards for % recyclable materials purchased.*
- *Brochures that come out of XAVIER UNIVERSITY should be made from 100% recycled paper*

Long-term Goal (5-10 years)

- *Using a Total Cost of Ownership approach via the election of more sustainable products/services based on a lifecycle product cost approach. This includes analysis of factors such as energy-efficiency, reduced waste or health/safety considerations, as well as cost.*

2. CHALLENGES AND FUNDING

- While the costs associated with the purchasing portion of the action plan are not known, some indirect costs may be experienced. As the University moves to procure more sustainable products, an increase in costs may be experienced with "green" products.

VIII. COMMUNITY ENGAGEMENT AND COMMUNICATIONS

Whereas the Academics section speaks to on-campus internal plans, this section aims to reach those beyond the bounds of Xavier University in a coordinated strategic manner. Xavier's efforts to prepare students to live "lives of solidarity, service and success" and to become "men and women for others" requires the integration of academic pursuits with experiences to form a personal mission for the betterment of humanity and our world. Xavier University, as a citizen, also is called to fulfill a key role in our city and our region to lead the development, modeling and enactment of sustainable practices. With and alongside the immediate surrounding communities, and radiating out to our region, Xavier must intentionally engage and clearly communicate efforts and ideas in order to model and forward environmental-stewardship practices that are both innovative and collaborative.

Long Term Vision: To develop and maintain significant outreach efforts, both through community engagement and communications in order to communicate lessons learned and market successes so that Xavier's sustainability efforts are known, appreciated, understood and replicated by the public, from the surrounding neighborhoods to the Midwest region and beyond. Xavier will become locally and nationally recognized as a model for sustainability efforts.

COMMUNITY ENGAGEMENT

Xavier follows a distinctly Catholic and Jesuit call to be active participants in the building of a more just society that aims toward the common good. To this end, Xavier is committed to adding to and gaining from the conversation and action within the larger community concerning the issue of sustainability. For the purposes of this discussion, the community we speak of engaging refers to areas beyond the bounds of the University, including the local neighborhoods of Norwood, Evanston, Avondale and North Avondale, the City of Cincinnati, the Midwest region and beyond.

Goal: To engage as both a leader and active participant in inspiring thought, developing models and enacting plans that spur creative ideas and innovative projects in step with community partners.

1. ACTION PLAN:

Short-term Goals (1-2 years)

- *Define 'scope of community' when speaking of engaging around issues of sustainability (i.e., local neighborhoods, city, region, nation, etc.).*
- *Establish a regular presence at local, regional and national conferences focused on sustainability issues (including faculty, students and staff).*
- *Utilize a growing network of related internal and external groups to more effectively promote invitations to community-education opportunities, including speakers, events and campaigns (both student and University-sponsored), especially within the immediate communities.*
- *Ensure volunteer projects launched from the University serve mutually-beneficial needs and goals (NEXT collaborations, Earth Community Action Day, etc.).*
- *Employ the NEXUS Community Garden (Norwood-Evanston-Xavier Urban Sustainability) and other similar demonstration projects workshop series as a chance to learn together and promote sustainable lifestyle choices with the surrounding community.*

- *Consistently solicit ideas and feedback from internal-related groups and individuals, including faculty, students, staff, departments and offices, as well as external groups (agencies, institutions, groups and local leaders) responsible for community engagement initiatives.*

Mid-term Goals (3-5 years)

- *Identify and catalogue, in a central manner, already-existing sustainability efforts within the University, in our city and our region that can inform collaboration and learning opportunities, and coordinate alignment of efforts.*
- *Consider the dispersal of more-broadly applicable informational materials created by internal efforts, including recycling, safe bike routes, local food initiatives, etc., with local-neighborhood residents.*
- *Ensure a consistent voice from Xavier on planning commissions and non-profit boards related to the theme of sustainability to enable leadership and coordination among the University, the neighborhoods and the cities and communities within which Xavier resides.*

Long-term Goal (5-10 years)

- *Design a comprehensive plan for outreach related to sustainability in coordination with the Eigel Center and Community Building Institute plans and initiatives, incorporating community strengths and identified needs.*
- *Identify a physical location on campus for a sustainability center for coordination of sustainability efforts that may also serve as a resource for the local neighborhoods, our city and groups beyond.*

2. CHALLENGES AND FUNDING:

- Community engagement coordination efforts on campus led by the Eigel Center are young and evolving
- Student leadership transitions
- A history of neighborhood-relations challenges
- The need for more effective communications channels between Xavier and the surrounding neighborhoods and the city
- Diverse strengths and needs presented by each community that Xavier must adapt with in order to engage effectively

COMMUNICATIONS

Xavier University's mission calls us to the pursuit of knowledge and to the orderly discussion of issues confronting society. The University will use a number of internal and external tools to share, invite, inspire, challenge and inform our diverse communities. Traditional media, social media, internal Xavier communication tools, informative public signage and ongoing connection with various networks, are among the tools to be used. Our messages must be clear and well-coordinated to most effectively reach a broad audience in some depth and to be seen as a leader in sustainable efforts. Sharing and gathering best practices and successes will involve all of Xavier's constituents and uphold internal expectations of progress critical to the achievement of our goal.

Goal: To create a communications plan to inform the campus and surrounding community of the importance of sustainability and each individual's role. People will be encouraged to participate in campus and community sustainability efforts and to advocate their own ideas. The results of this engagement will be widely reported to show the benefits earned from successful implementation and to call for more input and engagement.

1. ACTION PLAN:

Short-term Goals: (1-2 years)

- *Finalize branding of Xavier Sustainability efforts.*
- *Improve and promote the Xavier Green website as a tool for both internal and external utilization.*
- *Grow the Xavier sustainability social-media presence (i.e., Facebook, Twitter, etc.).*
- *Define preferred target audience(s) for the message of Xavier sustainability (alumni, neighborhood residents, prospective students, etc.) in order to refine message.*
- *Utilize "Xavier Today" and the "Newswire" as a means of communicating sustainability-related policy changes, events, or requests to the campus community.*

Mid-term Goals: (3-5 years)

- *Share Campus Sustainability Plan with local leaders (Norwood, Evanston and North Avondale City and Community Councils), as well as peer Universities, the City of Cincinnati and Hamilton County, so that they are aware of our efforts and plans.*
- *Request partnership and ongoing communication from key external organizations and groups to ensure coordination.*
- *Establish a strategic communications plan utilizing both traditional media (TV, print, radio) and digital media (blogs, Wikis, Twitter) based on current trends and culturally-appropriate methods coordinated with already-existing internal efforts.*

Long-term Goals: (5-10 years)

- *Maintain, adapt, and create new (when necessary) effective vehicles through which interested parties, both within and outside of the University, can gain helpful information surrounding sustainability efforts at Xavier.*
- *Continue to foster strong relationships between Xavier and local and regional media, as well as strategically release stories that will be both interesting and valuable to different audiences.*

VIII. COMMUNITY ENGAGEMENT AND COMMUNICATIONS

2. **CHALLENGES AND FUNDING:**

- Improving communication channels within the University is an ongoing challenge which impacts Xavier sustainability as it launches its efforts.
- Capturing and sharing sustainability efforts that are happening and will continue to happen in a variety of areas throughout the University.
- Increasing use of electronic means of communications will reduce printing and marketing costs (both financial and environmental).

IX. ASSESSMENT & EVALUATION

This Campus Sustainability Plan is a pioneering effort for Xavier University. The future includes putting this Plan into motion, reconsidering priorities and adding the fresh ideas that will ultimately emerge. The future will lean heavily on assessment of 1) campus conditions (including areas not well studied at present); 2) the efforts to improve sustainability; and 3) organizational support. Below we describe a number of approaches to assessment and how they might be applied.

Long-term Vision: To acquire and use sufficient information to guide and make understandable its sustainability efforts, planning and decision-making such that efforts, planning and decision-making are regularly refined and adapted and become part of the day-to-day operations of the University.

<u>Goal</u>: To establish the means to assess campus sustainability and provide information to students, staff and community that will inform operations, programming, and behaviors.

1. ACTION PLAN:

<u>Short-term Goals (1-2 years)</u>

- *Refine our data collection for the nd second Greenhouse Gas Inventory.*
- *Annually review the Campus Sustainability Plan to assess goals accomplished.*
- *Continue to provide educational opportunities, e.g., student internships.*
- *Establish a budget line beyond energy rebates for sustainability work, including increased support for energy conservation measures.*
- *Maintain a strong website for dissemination and use of information.*
- *Install dorm electric metering with eco-awareness campaign. This will help assess student interest and engagement in and awareness of energy conservation.*

<u>Mid-term Goals (3-5 years)</u>

- *Continue to annually review the Campus Sustainability Plan.*
- *Establish a budget line for sustainability work as well as increased revenue available for energy conservation measures.*
- *Produce an annual energy report for campus-wide discussion of conservation, consumption trends, investment choices, future plans and the importance of staff/student cooperation and innovation.*
- *Develop processes for external reporting to allow for independent review and for comparison with peer institutions.*
    - *This might include AASHE's "Sustainability Tracking, Assessment & Rating System" (STARS), the College Sustainability Report Card or National Wildlife Federation's National Report Card on Sustainability in Higher Education.*
    - *Continue to report campus greenhouse gas emissions to the ACUPCC.*

2. CHALLENGES AND FUNDING:

- The resources needed for this effort include labor, website and outreach materials. Labor could be provided by sustainability committee, the sustainability student interns, and the student sustainability board and, eventually, by the sustainability director and sustainability center.

IX. ASSESSMENT & EVALUATION

- Increased support for the website will be a cost-effective and convenient tool for assessment in two ways. The website is an effective way to collect input from the campus community and to share results from assessment activities.

X CONCLUSIONS

This is an exciting time for Xavier University and the world; humanity is at a crossroads. Working on these complex issues together will build our communities and our ability to reduce the long-term effects of global climate destabilization. It will also promote our community's resilience so that we are well-situated to weather the effects of destabilization that cannot be mitigated.

We see this as an opportunity to grow and learn. Over the last two years, the committee and the University as a whole have learned a tremendous amount about the complex nature of sustainability work. It involves systemic and holistic change, not just small incremental changes. As Einstein famously stated, "We can't solve problems using the same kind of thinking we used when we created them." As a result, Xavier is entering a new phase of systemic and creative adaptation. Minimally, we see four ways in which our University will likely be transformed.

First, in terms of academics, sustainability calls upon us to learn across disciplines. We will need to continue to promote such opportunities in our teaching and research. We will also need to ensure that our campus and neighboring communities are laboratories for engaged learning around built environments, alternative transportation, gardening, energy use and alternative energy, among many other topics.

Second, within four to five years as this Plan is being re-evaluated, a more holistic approach to sustainability planning and funding will be necessary. This will involve moving beyond the rubric of the climate commitment and its assessment tools, i.e., an ecological footprint assessment (see Appendix). This assessment would take into account other environmental factors, such as water usage and the amount of landfill space used, in addition to greenhouse gas emissions.

Third, and perhaps most importantly, we foresee planning and budgeting becoming a long-range undertaking that allows us to include resource conservation, educational benefits, building life cycles and other measures, alongside the more-typical short-range financial measures. The combination of long-term planning and thinking, and an ecological footprint assessment will mean that we take the future of our planet and our students' grandchildren as seriously as we take our educational quality, our enrollment numbers, and our endowment.

Finally, as David Orr has stated, "Successful sustainability work, no matter where it takes place, requires total institutional commitment because of its holistic nature and because of the gravity of the ecological crisis we face." We have been gratified by the University's support of sustainability work up to this point and foresee a strong need to build on this success, until we reach the point in which sustainability is as much a part of our mission as educating students for solidarity, success and service. Xavier University has made great strides in promoting a more sustainable campus over the last few years and is poised to take the next steps, as outlined herein.

XI APPENDICES

A. President's Climate Commitment Agreement
B. Report on Xavier University GHG Emissions Survey
C. Energy and Infrastructure
D. Ecological Footprint Proposal
E. Glossary of Terms

APPENDIX A

American College & University President's Climate Commitment

We, the undersigned presidents and chancellors of colleges and universities, are deeply concerned about the unprecedented scale and speed of global warming and its potential for large-scale, adverse health, social, economic and ecological effects. We recognize the scientific consensus that global warming is real and is largely being caused by humans. We further recognize the need to reduce the global emission of greenhouse gases by 80% by mid-century at the latest, in order to avert the worst impacts of global warming and to reestablish the more stable climatic conditions that have made human progress over the last 10,000 years possible.

While we understand that there might be short-term challenges associated with this effort, we believe that there will be great short-, medium-, and long-term economic, health, social and environmental benefits, including achieving energy independence for the U.S. as quickly as possible.

We believe colleges and universities must exercise leadership in their communities and throughout society by modeling ways to minimize global warming emissions, and by providing the knowledge and the educated graduates to achieve climate neutrality. Campuses that address the climate challenge by reducing global warming emissions and by integrating sustainability into their curriculum will better serve their students and meet their social mandate to help create a thriving, ethical and civil society. These colleges and universities will be providing students with the knowledge and skills needed to address the critical, systemic challenges faced by the world in this new century and enable them to benefit from the economic opportunities that will arise as a result of solutions they develop. We further believe that colleges and universities that exert leadership in addressing climate change will stabilize and reduce their long-term energy costs, attract excellent students and faculty, attract new sources of funding, and increase the support of alumni and local communities.

Accordingly, we commit our institutions to taking the following steps in pursuit of climate neutrality:

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.

APPENDIX A

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% 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.

In recognition of the need to build support for this effort among college and University administrations across America, we will encourage other presidents to join this effort and become signatories to this commitment.

Signed,

____
President/ Chancellor Signature

____
President/ Chancellor Name

____
College or University

____
Date

Please send the signed commitment document to:
Presidents' Climate Commitment
c/o Second Nature
18 Tremont St., Suite 308
Boston, MA 02108
or fax to: 320-451-1612
or scan & email to: ACUPCC@secondnature.org

APPENDIX B

GHG REPORT OF THE PRESIDENT'S SUSTAINABILITY COMMITTEE

An inventory of Xavier University's greenhouse gas (GHG) emissions

Prepared February 25, 2009

XAVIER UNIVERSITY

EXECUTIVE SUMMARY

Background

In early 2008 Fr. Mike Graham signed the President's Climate Commitment, pledging that Xavier University will create a campus-wide greenhouse gas inventory and an institutional plan for achieving climate neutrality. This effort has been led by a Sustainability Committee appointed by the President. Members currently on the committee are: Kelly Akers, Chris Barbour, James Cave, Steve Cobb, George Farnsworth, Pickett Harrington, Dave Lococo, Annette Marksberry, Doug Olberding, Caroline Richardson, Mary Rosenfeldt, Greg Schaber, Brett Simmons, Kathleen Smythe, Caroline Solis and Samantha Thomeczek. Kathleen Smythe and Dave Lococo are co-chairs. Richard Pulskamp and David Menzel are providing invaluable support for the Committee.

In the words of Fr. Graham, this environmental initiative strongly resonates with both the University's Jesuit mission and the Catholic philosophy that we are all stewards of this planet. This stewardship is central to the outward expression of our faith and institutional identity. As an institution that educates tomorrow's leaders, Xavier University can serve as a model to other institutions in the area.

Process

The Sustainability Committee GHG efforts can be divided into two processes – data gathering and then analysis of that data. During the data gathering process, it was quickly realized that the University systems were not structured to provide the data to do a multi-year calculation. Thus a single fiscal year is all that is available at this time. We will need to identify and overcome any institutional obstacles that constrain the ability to gather the necessary data to monitor GHG emissions.

In the analysis phase, we are only able to identify the main sources of GHG emissions on campus. It is not possible at this time to predict future trends, except to say that the carbon footprint of the University will certainly increase without considerable effort to reduce it.

We used the Clean Air-Cool Planet (CA-CP) Campus Carbon Calculator, Version 6.1 to inventory greenhouse gas emissions since it is a common tool and consequently permits Xavier to benchmark itself against other institutions that have also decided to use this calculator. The inventory includes emissions from electricity consumption, natural gas consumption, student, faculty and staff commuting, faculty and staff air travel, fugitive emissions of coolants, solid waste, and other miscellaneous contributors to our carbon footprint. It should be noted that beyond the first three emissions sources, the data quality becomes highly uncertain.

EXECUTIVE SUMMARY

Calculation Results

Figure 1 displays Xavier University's GHG emissions by source. Of the top three, purchased electricity is the single largest source of GHG contributor, representing roughly 52% of total emissions, followed by commuting and air travel representing 31% of the total and natural gas (on campus stationary sources) representing roughly 11% of total emissions.

We suggest that for reporting purposes, a useful statistic is the number of kilograms of emissions per FTE student per year. If Xavier grows in enrollment as well as physical plant, this would provide a measure of efficiency relative to size. This statistic is estimated to be 7,450 kg for FY08 based upon 37,251,739 kgs of emissions and 5,000 FTE students.

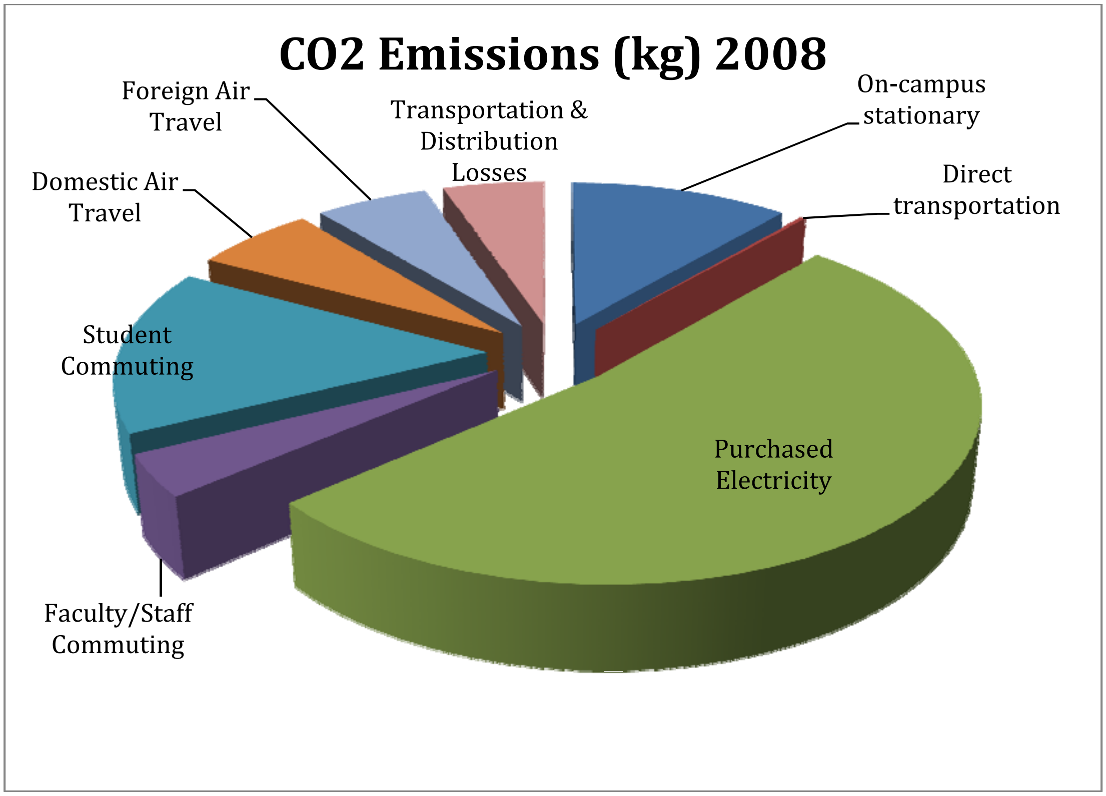


Figure 1: Distribution of carbon dioxide emissions by source

Next Steps

Our next steps are to classify and prioritize GHG reduction strategies, develop criteria for selecting reduction strategies, and analyze the feasibility of alternative emissions reductions targets. We will need to overcome any institutional obstacles that might constrain the implementation of any preferred GHG reduction strategies. The institutional obstacles that may constrain Xavier University from properly implementing a GHG reduction strategy are:

- Lack of funding in general and restrictions in the bond markets;
- The University's funding allocation, which currently does not include capital to fund GHG projects;
- Lack of a comprehensive data collection system for GHG emissions, which affects efforts to predict trends; and,
- Potential institutional inertia and focus on other priorities.

This is a substantial challenge given the current economic situation, but one that we are confident can be met because of the following potential benefits:

- Provides a cost avoidance opportunity with regard campus energy costs;
- Provides a cushion against any future climate regulations and potential utility price volatility;
- Will improve the marketability of the University and will assist in student enrollment and retention.

The Committee will now embark on a process to implement GHG reduction and reduce the University's carbon footprint by:

- Identifying low cost emissions reduction projects first
- Identifying additional cost effective projects that reduce emissions, conserve energy and thus reduce energy costs.
- Identifying alternative mechanisms to fund capital projects
- Implementing, in consultation with Executive Management, the most promising of these projects.

\- *End Executive Summary* -

OVERVIEW

Key Milestones

1. **January 15, 2008** Signatory to American College and University Presidents Climate Commitment (ACUPCC),
2. **March 18, 2008** created Sustainability Committee
3. Complete a comprehensive Greenhouse Gas Inventory by **May 15, 2009** and, using that inventory,
4. **August 30, 2009** determine interim action steps directed at reducing emissions,
5. Publish Institutional Action Plan **May 15, 2010**

Greenhouse Gas Inventory

A major initiative during the 2008-2009 academic year has been the Greenhouse Gas Inventory for the fiscal year 2007-2008. Completing the inventory has required the efforts of Committee members, faculty staff, and students. We present a summary of our methods as well as of results following this introduction.

Implementation

Having completed the inventory, we have come to realize the limitations of any such undertaking. However we have produced a basis for understanding the sources and magnitude of our institutional emissions. We now look ahead to the next stage of the committee's work:

- dissemination and campus discussion of the inventory,
- analysis of the inventory,
- development of tangible action plans designed to reduce emissions,
- subsequent development of cost-benefit analysis of each proposal, for ultimate recommendation to the President's Cabinet, and
- develop an institutional action plan for emissions neutrality, including infusion of sustainability into the curriculum.
- Assignment of resources required to collect, maintain and preserve the data necessary for a more accurate inventory

Caveat lector

In producing this inventory, we have identified two weaknesses. One lies in the quality of transportation data and the others in the inventory itself. As to the first, we require

- a better survey of commuting habits which targets all groups
- a detailed inventory of fuel consumption of the fleet extending beyond physical plant vehicles

- an estimate of reimbursed air travel, that is air travel booked outside of Xavier's travel agents
- an estimate of mileage generated through the use of rental vehicles

As to the second, the boundary between what is attributable to Xavier's carbon footprint and to other parties is not well-defined. Discussion has involved the inclusion in the inventory of green house gas emissions generated by construction projects, the growing and transportation of food served on campus, off-campus housing of students, the travel of residential students to and from campus, the travel of parents and prospective students, and travel related to Cintas events.

More problematic is the fact that moving students from off-campus to campus unambiguously reduces Xavier's carbon footprint because miles driven is reduced and utilities used by those students in off-campus housing is not. (Although in fact one would suspect that students will use fewer utilities on campus than off.) Yet the model, because of the boundary issue, requires a cancellation to some degree of the effects of reduced miles driven versus higher utilities used on campus. This means that the model in a very fundamental way is flawed as a true measure of the university's impact on the area carbon footprint.

PROCEDURES

Inventory Tool

The availability of a common tool to inventory greenhouse gas emissions permits Xavier to benchmark itself against similarly sized institutions when such data becomes available. For this reason, we have used the Clean Air-Cool Planet (CA-CP) Campus Carbon Calculator.

The latest edition of the calculator is quite comprehensive in identifying and categorizing sources of emissions. Some of the contributions to greenhouse gases pertinent to Xavier are:

1. Purchased electricity and natural gas
2. Transportation, including college fleet, business travel, commuting by students and faculty and staff to and from campus
3. Waste going to landfills
4. Fertilizer usage
5. Refrigerants

Data Collection

Data were collected from sources for each type of contribution that the CA-CP calculator requires. Below is a listing of the main sources of data for each component.

Data Need	Primary Source of Information
Student, faculty, and staff population	Decision Support
Square footage of buildings	Physical Plant
Annual operating budget	Financial Affairs Audited Report
Purchased electricity	Physical Plant
On-campus usage of natural gas in fuel fired heating equipment	Physical Plant
College fleet usage of fuel	Physical Plant
Mileage of air travel by faculty, staff, and students	Travel Authority, Program Directors & Student Life
Commuter travel of students	Decision Support, Registrar & Survey
Commuter travel of faculty and staff	Decision Support, Human Resources
Fertilizer usage	Physical Plant
Solid waste disposal	Physical Plant
Purchased refrigerants	Physical Plant

Institutional Data

Headcounts of employees and students as well as other data related to Human Resources and the Registrar were obtained from the Office of Decision Support. During the course of the academic year, there are upwards of nearly 8,000 distinct individuals on campus each week.

Purchased Electricity and Fuels

Physical Plant has the responsibility to monitor all utilities. Data related to stationary sources (equipment that use natural gas as fuel such as boilers) and purchased electricity is obtained from Duke Energy as raw data that must integrated into a database to be meaningful. During the time period for this report approximately 80 gas and electric meters were being tracked on a monthly basis. Xavier purchased over 27,600,000 kilowatt hours of electricity and 79,000 million BTUs of natural gas.

It is appropriate to mention here a significant shortcoming in producing an inventory of fuels used for direct transportation. What we may call the Xavier fleet is distributed over physical plant, as well as campus police, certain employees, and athletics in the form of owned or leased vehicles. Unless receipts of gasoline or diesel purchases are saved and recorded, it is not possible to estimate the amount of fuels used. The same holds for rental vehicles which are being used to a greater extent for travel due to the high cost of air transportation.

Air Travel

The goal here is to determine air passenger miles traveled related to university activities. Airline travel can be categorized as follows:

- Business travel by faculty and staff
- Athletics
- Study abroad and service learning by students

Unfortunately, there is no inventory of air travel. Data is available from The Travel Authority, Charter Search, Inc., credit card purchases and a list of trips related to study abroad. Reimbursed air travel is not inventoried.

For business travel by faculty and staff, we have relied solely on the air mileage provided to us by the travel authority separated into domestic and foreign travel. Since we have no information regarding the purpose of any travel, we have assumed of necessity that all foreign travel by employees is related to study abroad.

Athletics was able to supply air mileage totals related to their operations. For student travel outside of athletics, we have taken points of origin and destination as the basis of calculations. For each pair, the great circle distance has been estimated between airports.

PROCEDURES

The following table displays our estimate of air travel,

Air Passenger Miles		
Faculty/Staff	**Student**	**Study Abroad**
350,686	2,636,354	2,766,109

Solid Waste

Solid waste going to landfills results in greenhouse gas emissions in the form of methane released by the decomposition of that waste. This methane can be captured and is indeed captured at the Rumpke landfill. After some treatment, this gas is injected into the Duke Energy natural gas pipelines for distribution within their system thus reducing the overall contribution to emissions.

Fertilizers and Refrigerants

Nitrogen fertilizers applied to Xavier's landscape releases nitrous oxide (N_2O) that contributes to the greenhouse effect. Similarly, refrigerants leaking from air conditioners or refrigerators also contribute to global warming. The usage of nitrogen fertilizers and refrigerants were used as an estimate of their release into the environment. Data for these quantities were obtained from Physical Plant Grounds department.

Commuting

Contributions from commuting to greenhouse gas emissions were difficult to estimate because it was necessary to take into consideration the behaviors of the various constituent groups. Faculty, staff and students are expected to make, on average, a different number of trips per week. Full-time employees and full-time students likely travel back and forth to campus more frequently than part-time.

A number of employees are known not to commute to campus since they are based in other cities. Students are not required to provide a local address. In some cases the only known address is hundreds or more miles distant from Xavier. Consequently, these students are omitted from the model as no one living at such a distance can be expected to commute. It is necessary to estimate:

- The number of times each group commutes on average to and from campus each week, taking into account the populations of students who are residents vs. commuters.
- The modes of transportation used.
- The proportion who carpool.
- The distance each group commutes on average each week.

We have assumed that employees travel back and forth to work alone by automobile exclusively. Some students, on the other hand, do make use of public transportation, although the number is quite small. Moreover, note that Xavier provides housing for approximately 1800 students each semester. These students do not generate any transportation mileage.

	Automobile mileage	Headcount	Average
Faculty/Staff	3,668,499	1,235	2,970
Students	14,363,744	6,610	2,173

Detailed Worksheet Inputs

In order to estimate the contribution by Xavier to greenhouse gas emissions, it is necessary to populate values in the CA-CP calculator. The following table shows the inputs with notes on the assumptions made during the process.

Excel cell number	Value populated	Notes
G29	4,194 full-time students	Average fall and spring census enrollments
H29	2416 part-time students	Average fall and spring census enrollments
I29	3,634	Census headcount enrollment for summer
J29	636	Faculty headcount both full and part-time as reported to IPEDS
K29	599	Staff headcount both full and part-time as reported to IPEDS
L29	1,769,014 sq ft	Xavier has no research building space
AF29	79,022 MMbtu	Natural gas
AP29	9,647 gal.	Gasoline fleet
AQ29	530 gal	Diesel fleet
AZ29	10 lbs	Refrigerants
BF29	98,395 lbs	Synthetic Fertilizer
BG29	17%	Nitrogen
BH29	400 lbs	Organic Fertilizer
BI29	14%	Nitrogen
BR29	27,609,563 kwh	Purchased Kilowatt hours
CC29	350,686 mi	Air employees Domestic
CD29	2,630,354 mi	Air Student Domestic
CJ29	2,766,109 mi	Air Study Abroad
CO29	2,187 short tons	CH4 recovery Rumpke

Worksheet "Input_InflAdj"

Excel cell number	Value populated	Notes
C29	$165,557,900	The year-end expenses report including financial aid
E29	$3,606,817	Actual year-end energy expenditure

PROCEDURES

Worksheet "Input_Commuter":

Excel cell number	**Value populated**	**Notes**
E28	63% students commuting by personal vehicle	In fall 2007, 72.7% of student body did not live in a residence hall. The commuting survey sent to this group found that 86.4% commute by personal vehicle. Therefore 63% of students commute in this manner.
F28	4% carpooling	From the commuting survey, 93.7% report commuting alone. Therefore 59% of students commute alone.
G28	9.06 trips/week	From the survey, the weighted average of round trips per day is 4.53/week or 9.06 trips/week.
H28	30 weeks/year	Assume each term consists of 15 weeks of 5 days.
I28	15 miles/trip	From the student census file, we extract local addresses, rejecting all students living in the residence halls and those cases for which the local address is beyond 100 miles. The zipcode of each student identifies the location of the local post office which, in turn, is converted to latitude and longitude. The great circle distance between Xavier and the post office is computed. The mean is 15.1 miles.
M28	0% taking the bus	From the commuting survey, 0.6% rode the bus. Therefore 0.44% of students commuted by bus.
N28	9.06 trips/week	See G29
O28	30 weeks/year	See H29
P28	15 miles/trip	See I29. This is likely excessive, but no other data is available.
AT28	100% using personal vehicle	All faculty are assumed to commute alone by car.
AU28	0% carpooling	See AT28
AV28	10 trips/week	
AW28	22 weeks/year	Assume full-time faculty work 150 days/academic year and adjuncts half as many, or 75 days/year. The weighted average based on headcount is 111.4 days/year. Dividing by 5 gives 22.
AX28	9 miles/trip	From the address file of faculty, the zipcode is extracted to determine the location of the local post office. As in I28, the distance is computed for each person. The weighted average of full and part-time faculty yields a mean distance of 9.2 miles.
BZ28	100%	All staff are assumed to commute alone by car.
CA28	0% carpooling	See BZ28
CB28	10 trips/week	
CC28	47 weeks/year	Staff are assumed to work 235 days/year.

CD28	8 miles/trip	From the address file of staff, the zipcode is extracted to determine the location of the local post office. As in I28, the distance is computed for each person. So few staff are part-time work schedules are so disparate, that no adjustment is made for them. The average distance is 8.4 miles/trip.

RESULTS AND CONCLUSIONS

Results

An overview of the results for FY 2008 is shown in Figure 1. Briefly, we now know that the college's total greenhouse gas emissions are at least 37,000,000 kilograms per year (abbreviated kg/yr), which come from:

- Purchased energy, which amounts to 19,500,000 kg/yr or 52% of the total emissions.
- Purchased fuels for stationary sources (heating, etc.), which amounts to 4,200,000 kg/yr or 11% of the total emissions.
- Transportation, which amounts to over 7,200,000 kg/yr or 19% of the total.
- Air travel amounted to over 5,700,000 passenger miles. About 4,400,000 kg/yr of CO_2 are emitted as a result of air travel or 12%.
- Of the *transportation* emissions, 49% is associated with student commuting, 12% with faculty/staff commuting, 38% with air travel, and 1% with fleet vehicles.
- 5% of emissions are attributed to transportation and distribution losses. These are calculations that are based on emissions factors by location, and in Xavier's case, apply only to electricity.

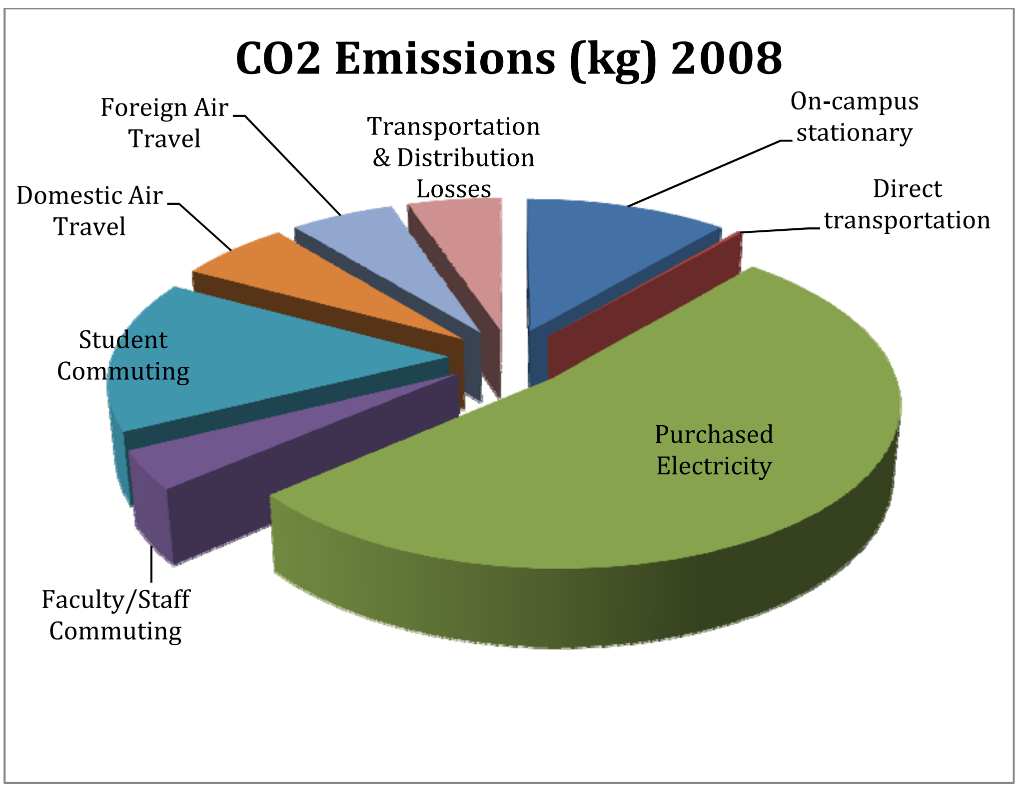


Figure 1: Distribution of carbon dioxide emissions by source

The carbon footprint of a campus is determined by many factors. Xavier burns fossil fuels in order to heat its buildings. Although housing is available for half of the undergraduate population, at least 4800 students are commuters. The athletic programs and the opportunities provided by service learning and study abroad contribute to a substantial use of air transportation.

RESULTS AND CONCLUSIONS

Conclusions

We find two significant difficulties with producing this report. On the one hand, Xavier does not have the records required to estimate its contribution of greenhouse gasses. Nor do we foresee any relief from this because of the lack of human resources to collect these data. On the other hand, for all its sophistication, the CA-CP Calculator is inadequately documented. There is, consequently, quite a bit of latitude in choosing values for inputs.

We find that Xavier's CO_2 emissions fall into four major groups with an estimate of the contribution of each. These are:

- Purchased electricity – 52%
- Commuting – 19%
- Air Travel – 12%
- Natural gas combustion – 11%

Therefore Xavier can make its greatest impact by reducing electrical energy consumption. There are many ways that this can occur. The most significant way is the construction of the new Central Utility Plant that will utilize much higher efficiency equipment. Eventually this equipment will be supplemented so that all areas of campus are served by the most efficient equipment.

Another significant contribution comes from commuting. Habits can be modified. However, Cincinnati lacks a robust transportation system. The Metro travels too infrequently and inadequately to serve our constituents.

Should another residence hall be constructed, for example, the reduction in commuting emissions will be offset by an increase in both purchased electricity and stationary combustion. An estimate of the effect of moving students to campus should be made.

As other institutions make their inventories public, Xavier will be able to make comparisons of methodology and results both with schools similar to it.

A project of this nature is highly dependent on the willingness of the dedicated staff who work at Xavier University. It is nearly impossible to thank all the individuals who have been involved, but we would like to recognize and thank the members of our committee.

Sustainability Committee

Kelly Akers – *Center for Adult and Part-time Students*
Chris Barbour – *Office of Financial Aid*
James Cave - *Student*
Steven Cobb – *Department of Economics and co-author of this report*
George Farnsworth – *Department of Biology*
Pickette Harrington – *Community Building Institute*
David Lococo –*Physical Plant, co-chair of the committee*
Annette Marksberry – *Information Resources*
Douglas Olberding – *Department of Sports Studies*
Kiki Richardson – *Student*
Mary Rosenfeldt – *McGrath Health Center*
Greg Schaber – *Marketing and Printing Services*
Brett Simmons – *Student*
Caroline Solis – *Student*
Kathleen Smythe – *Department of History, co-chair of the committee*
Samantha Thomeczek – *Student*

Special Thanks

Richard Pulskamp, *Decision Support, staff to the committee and co-author of this report*.

APPENDIX C

ENERGY AND INFRASTRUCTURE

ThermalTech Engineering was hired to assist with the Energy and Infrastructure section of the report. The recommendations regarding energy and utilities resulted from their analysis. The following are processes that ThermalTech employs and insights that were gained from their efforts.

1. Process to Create ECM Recommendations:

- Use University master plan information to document the existing building areas and to estimate the future building areas.
- Use historical metered gas and electric utility data and building area to estimate the annual energy consumption of each building (not all buildings are submetered).
- Use industry building-profile data to estimate the baseline system energy use within each building by building type (education, food service, lodging, office, public assembly, service, storage) and subsystem (space heating, space cooling, ventilation, water heating, lighting, cooking, refrigeration, office equipment, computers, other).
- Identify typical energy conservation measures (ECMs) that would apply to each subsystem. Identify other ECMs that are of a broader nature, which would reduce the energy use of multiple buildings (e.g., central plant projects). Based on the experience of the engineers or from custom calculations, estimate the % energy savings that may be achieved for each ECM in each building.
- From the baseline energy use and the % savings, for each ECM calculate the units of energy savings, the dollar savings, and the GHG emission reduction.
- Based on the experience of the engineers, assign a likely simple payback period to each type of ECM. From the annual dollar savings and the simple payback period, for each ECM calculate the capital investment required.
- Total all of the energy savings, capital investments, and GHG emission reductions.

2. Utility Rates

The electric rate used in the calculations is \$0.065/kWh. This is a blended rate that includes an energy charge of \$0.058/kWh and a marginal demand charge of \$5.80/kW. The University is under contract to First Energy until mid-2012 at this rate. The rate is about 20% less than the standard Duke Energy tariff.

The natural gas rate used in the calculations is \$7.60/mmBTU. This rate reflects a \$6.00/mmBTU commodity charge and a \$1.60/mmBTU transportation charge. The rate fluctuates according to market conditions.

Using these rates and the existing building usage, the annual electric and gas cost is \$2,500,000.

3. University Energy Use

APPENDIX C

Electric energy is distributed to the University buildings by the utility company via six master meters and numerous individual-account meters. Natural gas is distributed to the University buildings by the utility company via three master meters and numerous individual-account meters. Many of the buildings served from the master meters are not submetered. One of the ECMs is to provide gas and electric submeters that are read by the University Building Management System for every building. While this will not save energy directly, meters are essential to measuring ECM performance, spotting wasteful practices, and benchmarking within the University and to similar building types.

The FY 2008 GHG emissions were calculated by XAVIER UNIVERSITY to be 19,500,000 kg/year (21,500 tons CO_2e) for purchased electricity and 4,200,000 kg/year (4,600 tons CO_2e) for stationary fuel sources, for a total of 23,700,000 kg/year (26,100 tons). Based on 2009 utility data, the GHG emissions were calculated to be 23,900,000 kg/year (26,300 tons).

There are two central utility plants on the University that provide hot and chilled water to other buildings. A third plant is under construction.

The existing central plants are metered for the electricity and gas used but not for the hot and chilled water delivered to the buildings. The new central plant will have hot and chilled water energy meters for every building that it serves.

4. GHG Emission Factors

The GHG emission factors used by XAVIER UNIVERSITY in the inventory report and in this Campus Action Plan are 116.3 #CO_2e per MMBTU of gas burned and 1.556 #CO_2e per kWh. The purchased electricity factor is an eGRID regional number. The factors for Duke Energy (the local Cincinnati utility) and First Energy (the present University electricity supplier) are higher (~1.8–2.0 #CO_2e per kWh). Higher factors would result in a need to purchase greater amounts of offset credits in order to achieve zero emissions.

The State of Ohio has legislation to require public utilities to provide up to 20% of their electricity from renewable sources. The utility companies could adopt other technologies to produce electricity (e.g., nuclear). Over a 20-30 year period, this could lower the GHG purchased electricity factor applicable to the University. We have not taken this into account in the analysis.

5. Building Inventory & Energy Use – Existing and New

The area of the existing University buildings is **1,700,000 SF** assuming Alter Hall has been removed.

The University master plan estimates that more buildings will be constructed to accommodate more students and expanded academic programs. At the time of this report, the first four buildings are under construction. The following is a projection of the possible future buildings.

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Building	Area, SF
Central Utility Plant (CUP)	20,000
Learning Commons	85,000
Williams College of Business	80,000
New Residence Hall and Dining Facility	240,000
Residence Hall Facility North of Cintas	200,000
Residence Hall Facility West of Cintas	70,000
Residence Hall Facility South of Cintas	70,000
East University	600,000
Hailstones Addition	10,000
Williams College of Business Addition	40,000
New Buildings	180,000
University Expansion to the South	100,000
Total	**1,700,000**

If all of these facilities are constructed, the new buildings represent a 100% increase in the footprint of the University. The buildings under construction and the future buildings were assumed to be more energy efficient than the average of the existing buildings. While the buildings under construction will conform to LEED Silver standards, have higher-quality envelopes and more sophisticated controls and energy systems, they will also have higher ventilation rates, tighter temperature control, better filtration, better humidity control, and more glass area – all of which increase energy use compared to the average existing building. Even with aggressive energy-reduction strategies, GHG emissions will increase when these buildings are constructed. The projected base-level GHG emissions would increase from 23,900,000 kg (26,300 tons) to 39,500,000 kg (43,500 tons) (a 65% increase).

The annual electric and gas cost is would increase from $2,500,000 to $4,200,000 at today's rates.

Energy modeling results performed by the design engineer for one of the new academic buildings estimated consumption to be 60,000 BTU/SF/year but the model appeared to be overly optimistic.

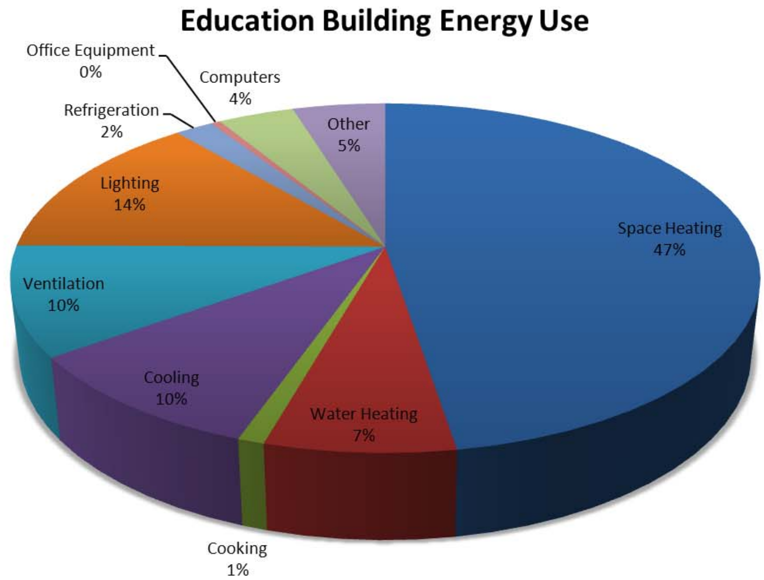
Generally, a factor of 70-75% of the University average was assumed for the new buildings. This would put the site energy intensity for new buildings at an average of 73,000 BTU/SF/year.

6. Subsystem Energy Use

Energy use within each building was estimated from the 2003 Energy Information Administration database *Commercial Building Energy Consumption Survey* for similar building types (education, food service, lodging, office, public assembly, service, storage). The subsystems included space heating, space cooling, ventilation, water heating, lighting, cooking, refrigeration, office equipment, computers, and other. For buildings served from central plants, the space heating and cooling was assumed to be the energy used by the central plant.

The following is a typical profile for one building type.

APPENDIX C



7. Energy Savings Percentages and Payback Periods

The energy savings %ages were estimated for each ECM and each building. For example, to convert from single-pane to double-pane windows, an estimate must be made as to what portion of the building envelope energy is due to the windows and then what portion of that energy would be saved by the conversion.

The simple payback period for each ECM was estimated from experience. Adjustments were made for individual buildings where knowledge of the building suggested a more appropriate value. Some of the values were based on previous calculations done for XAVIER UNIVERSITY for particular ECMs.

Adjustments were made for interaction between ECMs. If there were mutually exclusive ECMs (e.g., adding window film and replacing single-pane windows with double-pane), one of them was eliminated.

Once the electric and gas energy savings was determined, the dollar savings was computed. The result was combined with the simple payback to determine the capital investment.

8. Energy Conservation Measures (ECMs) Considered

The following general types of ECMs were included in the analysis where appropriate to a building or system. The range of simple payback periods is listed. The lower end of a broad payback range is for new construction or renovated buildings, where it is more convenient and economical to apply that ECM.

Some ECMs are assumed to be implemented purely to attain the energy savings (e.g., apply window film). They can be implemented at any time but must bear the full cost of the retrofit. Other ECMs are assumed to be an upgrade to a higher efficiency level (e.g., add more insulation when the roof is replaced). They can only be implemented when the base system or component needs to be replaced. The payback period only covers the premium cost to attain the higher efficiency level, not the cost of replacing the base system.

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System	ECM	Payback Range, Years
Envelope improvements:		
	Implement infiltration reduction methods.	3-5
	Add internal or external shading devices to reduce solar gains during the cooling season. This applies to existing buildings. New buildings are assumed to incorporate shading devices.	10
	Add another window pane to single or double pane units.	10-25
	Add additional wall/roof insulation to existing buildings.	10-30
	Use reflective roofing materials when re-roofing or installing a new roof.	20-30
	Apply window film in existing buildings where the windows will not be replaced.	30
Electric appliances, computer equipment:		
	Power management, such as automatically powering down office equipment, vending machines, computer equipment when not in use.	2
	Use of Energy Star rated appliances, such as in residence hall rooms, laundries, and food service.	5
Lighting:		
	Use compact fluorescent lamps in place of incandescent lamps.	2
	Apply occupancy sensors in existing buildings. New buildings are assumed to already incorporate sensors.	3
	Complete the University conversion of all remaining T12 and metal halide fixtures to T8/T5 fluorescent lamps and electronic ballasts.	4
	Completely retrofit all T8/T5 fluorescent fixtures to LED when the economics become favorable. This applies to all buildings except those that may be built 10-15 years from now.	8

APPENDIX C

System	ECM	Payback Range, Years
	Apply daylighting strategies to reduce the use of artificial lighting.	10
HVAC:		
	Revise the University standards for air handler air filtration to lower the pressure drop and the life-cycle cost of filters.	0.5-2
	Lower the coil/duct/filter velocities, eliminate sound attenuators in new buildings and where HVAC systems are totally replaced (incremental cost compared to traditional).	3
	Implement improved control strategies such as supply air temperature reset, air and water loop pressure reset, and demand controlled ventilation in existing buildings.	3
	Add more variable speed drives on pumps and fans in existing buildings where not already applied.	3-5
	Recommissioning of building systems to restore the original operation, fix defects, improve control sequences.	4
	Install high efficiency motor replacements when motors burn out. Use of electrically-commutated motors in place of fractional-horsepower motors.	4
	Make natatorium upgrades: improved heating, pool cover.	5
	CUP boiler in-stack economizers when the new, larger, non-condensing boilers are installed for future buildings. The savings would be less than non-condensing economizers.	5
	Install ventilation energy recovery systems in existing buildings.	8-10
	Install chilled beam systems (as part of a new building or major renovation) in conjunction with dedicated outdoor air systems to reduce fan power.	10

APPENDIX C

System	ECM	Payback Range, Years
	Install food service refrigeration heat recovery systems.	10
Central plant:		
	Build an open-loop geothermal system coupled with heat recovery chillers in the CUP for heating and cooling. Ground water from deep wells would be pumped through heat recovery chillers to extract energy and make most of the CUP hot water. In the cooling season, the same chillers would be used to make chilled water, rejecting their heat to the geothermal loop. This ECM saves natural gas but increases electricity use. The net GHG emissions savings is relatively small. The payback period is only for the well field and part of the cost of the heat recovery chillers, not the entire cost of the chillers.	7
	CUP boiler condensing economizer when the new, larger, non-condensing boilers are installed for future buildings.	10
	Install natural gas fuel cells to produce electricity with reduced GHG emissions (only once cost-effective). As an example, the Bloom Energy fuel cell produces electricity at about half the emissions of a coal-fired power plant. The unsubsidized payback at the present time is > 40 years if no heat is recovered and > 25 years if 25% of the input energy can be recovered.	10
	Install a 500 ton heat recovery chiller in the CUP to make hot and chilled water at the same time. This ECM saves natural gas but increases electricity use.	11
	Install a cogeneration system to produce electricity and hot water from operating a natural gas reciprocating engine (size assumed to be 2,000 kW). Power would be fed into the grid to supplement all buildings. As much heat as possible would be recovered to displace the gas boilers.	12
	Install solar water heating on individual buildings.	12-20

APPENDIX C

System	ECM	Payback Range, Years
	Logan plant decommission - transfer the loads to the new Central Utility Plant (CUP).	14-19
	Replace Alumni Center boilers (assuming it is replaced purely for energy savings).	20
	Replace one Cintas chiller with a higher efficiency unit (assuming it is replaced purely for energy savings).	20
	Replace the Academic Mall underground piping due to deteriorated condition, poor reliability, and the energy losses.	20-22
	Replace Residence Hall Central Plant equipment with higher efficiency (assume it is replaced purely for energy savings).	20-25
	Replace Brockman central plant equipment (assuming it is replaced purely for energy savings).	25-35
	Submeter all individual buildings for electric power, gas (and ideally, hot water and chilled water). This saves little energy directly but is an "enabler" that helps support the overall University objectives.	--
Next-level future buildings:		
	Water conservation measures - low flow heads to reduce hot water use	5-10
	Implement additional ECMs using new or existing technology to achieve a 30% additional energy savings compared to the base usage.	7
	Create a super-insulated building envelope in all new buildings.	10-12
	Install integrated photovoltaic systems (generation capability built into exterior finishes) to create electricity from renewable energy.	10
Alternative & Renewable-energy systems:		

APPENDIX C

System	ECM	Payback Range, Years
	Install photovoltaic arrays to generate electricity from solar energy.	10-50
	Install wind turbines to make electricity.	20-25
	Install a digester to create methane fuel using University waste.	30-35

9. Additional Information on Alternative Energy Systems

There are forces at work that require all of us to seriously consider alternative energy options now rather than in the future. The following is a chart that helps summarize the options under consideration.

Technology	Nominal Size	Energy Production	Units	Capital Cost	Annual Energy Savings	Average Simple Payback Period, Years (See Note 2)	GHG Reduction, Tons/Year
Solar - PPA (See note 1)	1 MW	1,163,410	KWH	$0	$0	N/A	0
Solar - Xavier (See note 1)	1 MW	1,163,410	KWH	$4MM	$61,000	63	821
Geothermal (See Note 3)	500 Ton (300KW input))			$2.5MM	$250,000	10	500
Fuel Cell (See Notes 4 & 5)	1 MW	8,300,000	KWH	$750K	$89,727	8.5	5,400
Co-Generation (See Note 5)	1 MW	8,300,000	KWH	$900K	$63,000	14	3,700

Note 1: Need to add the cost of land if a system this size is installed
Note 2: Payback for Solar includes a reduction in cost by avoiding rate escalation
Note 3: Geothermal COP 3.3. Hot water temperatures may need to be boosted to meet equip. req's.
Note 4: Fuel cell energy savings based on 47% net electrical efficiency vs. 32% for engine generator
Note 5: Natural gas price fluctuations would need to be stabilized through a long term contract.
Note 6: All options could all increase or decrease in size. In general, as size increases the cost per unit decreases. It is strongly recommended that prior to any investment, a detailed analysis be performed to optimize the size of the final system.

10. Strategies Not Developed

APPENDIX C

Low-cost operations and maintenance items – some of these savings opportunities fall under the recommissioning task or will be achieved through educational programs and existing Physical Plant initiatives.

11. Constraints to Applying Energy Conservation Measures

Difficulties will be encountered in trying to implement every proposed ECMs in every building. For example, shading devices may not be suitable for the décor, physical space doesn't exist for heat recovery equipment, occupants are resistant to the changes (e.g., using a pool cover), occupancy sensors aren't practical in as many rooms as estimated. Some ECMs are not practical to do unless the entire building is being gutted for renovation (e.g., chilled beams).

The analysis results were interpreted to be conservative so as to not overstate the retrofit potential or understate the implementation cost. However, the entire exercise was intended to be a broad-brush indicator of the potential so changes to the plan should be expected.

12. Future Technologies and Costs

The ECMs included in the analysis are those that are available, practical, and viable today or are likely to reach such status in the next 10-20 years. For example, LED lighting was included with a simple payback period of 8 years. The payback period today is closer to 20-30 years but is expected to improve. This technology would only be adopted once the life-cycle economics are favorable, much like the application of T8 lamps over the last decade. This is one of the largest opportunities in the existing buildings.

Some ECMs, like motor replacement or roof insulation, are only economical when the component must be replaced. While a short payback period may have been used, it is for the premium cost to upgrade to a more energy-efficient level, not to replace the entire component. Working motors can't be economically replaced if they are still working. Roof insulation can't be economically upgraded until the roof membrane must be replaced.

13. Accuracy of Calculations

The methodology used in the analysis is not as accurate as if individual ECM savings and cost calculations had been performed based on measured field data and hourly computer simulation models. The estimates likely have accuracy in the range of +/-25-30%. However, they do provide a perspective on the magnitude of emissions reductions that can be economically achieved.

APPENDIX D

PV Solar

Photovoltaic (PV) Solar Electric Arrays

The amount of available sunlight is an important consideration and the justification needs to be site specific. Where there is less sun, more solar panels are needed to meet a given load. Where snow may cover panels during winter months, panels can be tilted to shed snow or PV array output can be pro-rated downward to allow for a number of weeks or months when output is reduced. The performance of grid-interconnected PV is generally measured in terms of annual power production and most PV production occurs during the sunnier summer months when days are longer and there is less cloud cover.

Assumptions and Observations

1. The Campus Master Plan's theme is a "campus in the park". While there are many reasons for this, this eliminates the installation of solar arrays in parking lots, which are scheduled for increased numbers of trees and other landscaping options.
2. Large roofs such as Cohen, Cintas Center, and the Alumni Center are limited in their ability to accommodate solar either due to their structure (Cintas), shape (Cintas, Alumni), or longevity (Cohen). This does not preclude the installation of smaller arrays, or multiple arrays on these and other buildings. Xavier has enough total roof space to host over 1 MW, assuming structural issues could be overcome economically.
3. It is desirable to locate a solar installation that maximizes the PR value of Xavier's commitment to preserving the environment.
4. Xavier is currently under contract to purchase electricity from First Energy. Part of the agreement with First Energy is that Xavier will maintain the same load profile during the term of the contract. This has allowed First Energy to price electricity without a demand component. Very often demand charges can significantly affect the payback analysis for solar installations. This analysis assumes the contract and the underlying pricing will be unaffected.

Economics

There are a variety of financial models for installing PV on campus.

1. Design, purchase and install a system with the technical assistance of a consultant or supplier, and with or without a partner. The relatively high cost and long payback of this kind of investment can be tempered by identifying incentive dollars that reduce the initial or "first cost" of the system.
2. Include the cost of the solar energy system in a larger self-financing energy conservation program and, in essence, allow the energy conservation measures (and the dollar savings they produce) to pay for the installation.
3. Engage in a power purchase agreement (PPA) with a renewable energy power provider who will install and own a PV system located on campus. A PPA will require Xavier to purchase power from the PV system for a number of years at rates established by the contract. The primary advantage of this arrangement is that the Xavier is not responsible for the installation, operation, maintenance, or cost of the

PV system. Also, this arrangement may allow the energy supplier to take advantage of tax credits which may not be available to the campus.

There are some grant opportunities scheduled to expire in 2010:

1. The current state grant program administered by the Ohio Dept of Development (ODOD) offers $3.50/watt incentive for solar PV systems. This program is available to all customers of Investor-owned utilities and hence is available to Xavier University. It requires 50% match and is capped at $150,000 for direct ownership or $200,000 for Power Purchase Agreements (PPA). The result is an economic sweet spot favoring 50 kW – 70 kW size systems. Larger systems enjoy better economies of scale but unless additional funding is leveraged their overall economics are not as favorable in Ohio, currently.
2. The American Recovery and Reinvestment Act of 2009 (ARRA) enacted a grant program for renewable energy in photovoltaic (electricity-producing) and solar-thermal (heat-producing) systems. The grant amounts to 30 percent of a solar system's cost. In order to take advantage of this grant, a tax paying entity would have to be formed.

The following assumes a PPA arrangement with a third party. **The purchase of the necessary property must be added if a 1MW installation in a highly visible environment is desired.**

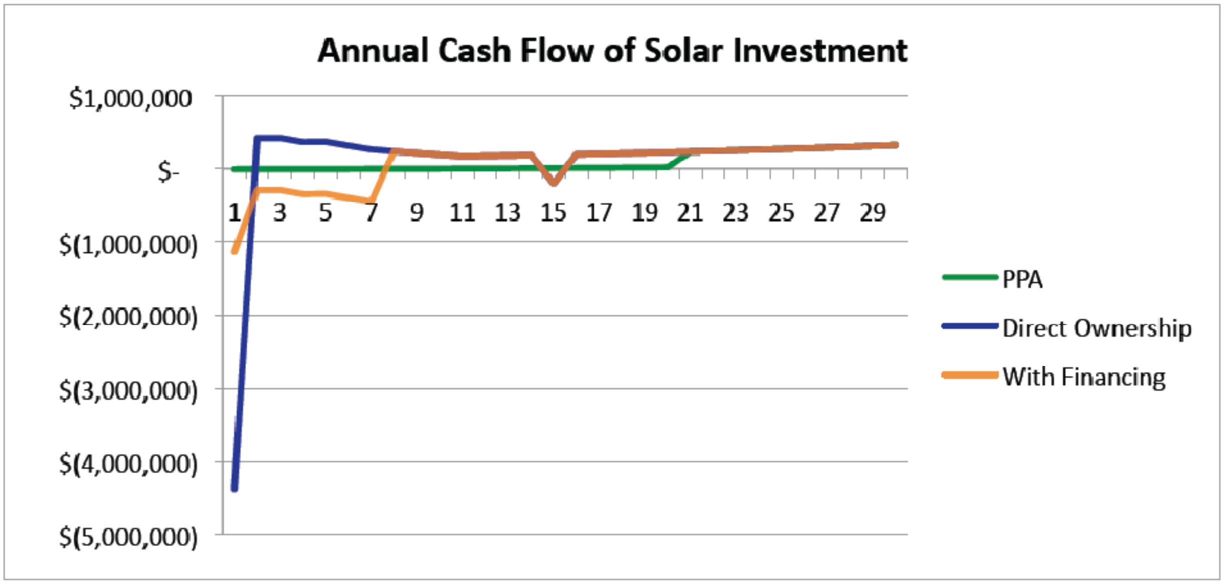
APPENDIX D

PV Solar (cont'd)

Solar PPA Economics Only	
Proposed PV System Size	**1,000.00 KW**
Annual Energy Production (first year only)	1,163,410 kWh
Approximate Solar System Value	$ 5,000,000
PPA Term	20 years
PPA Termination	Turnover to site owner
PPA Buyout option	Yes, after first 7 years
Estimated Fair Market Value in year 7 (two yrs energy production)	$ 227,240
Solar Energy Starting Rate ($/kWh):	$ 0.080
Rate Escalator	3.9%
Current Utility Energy Rate ($/kWh):	$ 0.073
Conventional Utility Cost Escalator	5.0%
Assumed Reduction in Peak Demand (% of max PV output)	0%
PPA Setup Fee	-
PPA Credit to customer	-
PPA Termination Cost	-
Utility Cost Increase (Decrease) over PPA term	$ (61,649)
Simplified Total PPA Cost (Savings)	**$ (61,649)**
30-Year Cumulative Utility Cost Increase (Decrease)	$ (2,567,656)
Post PPA O&M and inverter costs	$ 207,050
Post PPA SREC Sales (Income)	$ 514,533
Net 30-year Solar Lifetime cost/(savings)	$ (1,907,722)
25-year IRR	20%
NPV 25 yrs at 6 % discount rate	$ 339,603
Cumulative Cash flow positive in year	17

Note 1: Add property purchase to the cost of this option!!
Note 2: Very crude calculations indicate 2 to 2.3 MW could be installed on a 6.3 Ac site depending on geography and panel manufacturer.
Note 3: A pro forma for multiple smaller systems (54KW) is also available.

APPENDIX D
PV Solar (cont'd)



Critical Considerations

In order to claim GHG reductions from a campus-owned and operated PV system or from a PV PPA,

Xavier **must own the renewable energy certificates or RECs** associated with the output of the system.

In the case of a Xavier owned PV system that means not selling the REC's. In the case of a PV system installed under a PPA, to claim a CO2 emissions reduction Xavier **must buy the RECs** produced by the PV system. The REC purchase may be in addition to buying the actual power produced by the array.

In order to qualify for the Federal grant, eligible property must be placed in service in 2010. The guidelines include a "safe harbor" provision that sets the beginning of construction at the point where the applicant has incurred or paid at least 5% of the total cost of the property, excluding land and certain preliminary planning activities. Generally, construction begins when "physical work of a significant nature" begins.

APPENDIX D

Geothermal

Geothermal General

Geothermal energy for Xavier is limited to wells and ground source heat pump heating and cooling systems. Ground source heat pump (GSHP) systems rely on the more or less constant temperature of the earth below the frost line and the ability of the earth to store and release heat. Of course, these systems also rely on heat pumps which are mechanical devices that use refrigerants to move heat from one place to another. GSHP systems transfer heat in and out of the ground (depending on the season) by either an open loop pipe system that extracts and re-injects ground water or a closed loop pipe system that is sealed and contains a mixture of water and glycol to prevent its freezing.
GSHP systems require electricity to run conventional pumps, heat pumps (which contain electrically
driven compressors), and other equipment. According to the U.S. Environmental Protection Agency, geothermal systems can reduce heating energy consumption (and greenhouse gas emissions) up to 44%. And geothermal systems use 72% less energy than comparable cooling systems.

Geothermal at Xavier

A geothermal heating system and a heat recovery chiller, while having slightly better simple payback than the cogeneration system, is not as effective at reducing GHG emissions. These types of systems substitute greater use of coal-generated electricity for natural gas. A geothermal system could cost from $4,000 to $5,000/ton of cooling capacity as well as per ton of CO2e reduction. It is recommended that a vertical open-loop geothermal system be considered coupled with heat recovery chillers in the CUP for heating and cooling. Ground water from deep wells would be pumped through heat recovery chillers to extract energy and make most of the CUP hot water. In the cooling season, the same chillers would be used to make chilled water, rejecting their heat to the geothermal loop. This saves natural gas but increases electricity use. The net GHG emissions savings is relatively small.

Assumptions and Observations

There are some overriding principles guiding the installation of geothermal at Xavier.

1. An estimated 100 to 150 heat exchange wells would be required. These would need to be located near the CUP. This installation is not identified in the Master Plan and could potentially be very disruptive.
2. The CUP is not configured for a geothermal installation, but the Village, a much smaller potential user of geothermal, is.
3. Xavier is currently under contract to purchase electricity from First Energy. Part of the agreement with First Energy is that Xavier will maintain the same load profile during the term of the contract. This has allowed First Energy to price electricity without a demand component. This analysis assumes the contract and the underlying pricing will be unaffected.

APPENDIX D
Geothermal (cont'd)

Economics

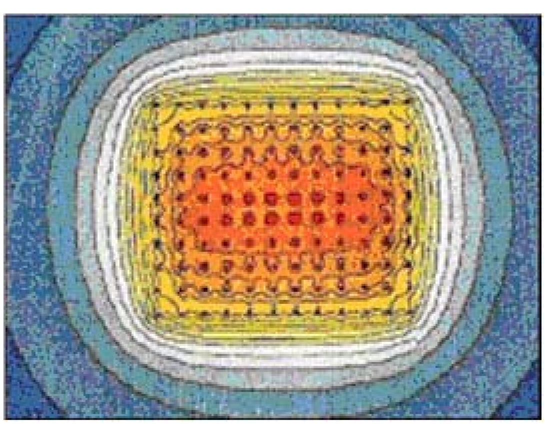
1. Systems can be costly but first costs are generally paid back within 5 to 10 years. System life of the underground components is typically 50 years or more, much longer than a comparable HVAC system.
2. Geothermal systems require less ongoing maintenance than conventional systems, making long-term savings from geothermal installations much more significant.
3. GHP heating efficiency is measured by its coefficient of performance (COP). The COP is the ratio of heat provided in Btu per Btu of energy input. Cooling efficiency is indicated by the Energy Efficiency Ratio (EER), the ratio of the heat removed (in Btu per hour) to the electricity required (in watts) to run the unit. A GHP with a COP of 2.8 or greater and an EER of 13 or greater is preferred.
4. Many schools heat with gas in the winter, but cool with electricity in the summer. Geothermal systems can do both. It's important to evaluate the cost benefits of geothermal in terms of thermal and electrical load.
5. Although additional studies are required, a 500 ton system with a heat recovery chiller is estimated to cost $2.5 MM. The payback period is anticipated to be 7-10 years depending on utility rates.
6. When performing an economic evaluation of these technologies it will be important to consider including in the analysis the dollar savings associated with avoiding future costs for RECs or carbon offset purchases.

Case Study – Richard Stockton College, Pomona, New Jersey

Richard Stockton College boasts one of the world's largest single closed loop geothermal HVAC systems, totaling 1,741 tons of installed geothermal heating/cooling capacity. The college in Pomona, New Jersey, now uses 400 heat exchange wells and water source heat pump (WSHP) units to serve the heating and cooling needs of a growing campus.

The closed loop system of wells (each 425 feet deep) are arranged in a grid at 15 ft. intervals. The majority of the wells are located under a 4-acre parking lot.

The college initially projected that a geothermal system would cost about $1.2 million more to install than a conventional HVAC system, but that it would be expected to save $330,000 in energy costs. Thus, the simple pay back of the extra costs of the geothermal system would be about 3.5 years.



Furthermore, because the reduced peak electrical demand would reduce the need for Atlantic Electric Company to install new generators, the utility offered an $800/Ton rebate for installing the geothermal system.

APPENDIX D
Geothermal (cont'd)

Since its installation, the school confirms that it has reduced its electric consumption by 25% and natural gas consumption by 70%.

However, since its initial design, the college has made changes to the system to increase its efficiency. The college operates a cooling tower in the winter months (to waste heat) in order to precondition the field for the college's increased need for summer-time cooling. Find out more about Richard Stockton's geothermal system at the Stockton College website.

APPENDIX D
Cogeneration/CHP

Cogeneration General
Cogeneration is the use of an engine to simultaneously generate both electricity and useful heat. It is one of the most common forms of energy recycling. Conventional power plants emit the heat created as a by-product of electricity generation into the natural environment through cooling towers, flue gas, or by other means. By contrast CHP captures the by-product heat for domestic heating purposes. By-product heat at moderate temperatures (212-356°F/100-180°C) can also be used in absorption chillers for cooling. A plant producing electricity, heat and cold is sometimes called trigeneration or more generally a polygeneration plant. Cogeneration is a thermodynamically efficient use of fuel. In separate production of electricity some energy must be rejected as waste heat, but in cogeneration this thermal energy is put to good use.

Cogeneration at Xavier
Cogeneration at Xavier can be realized by employing a system to produce electricity and hot water from operating a natural gas reciprocating engine (size assumed to be 1,000 kW). Power would be fed into the grid to supplement all buildings. As much heat as possible would be recovered to displace the heating output of the gas boilers.

Assumptions and Observations
1. The CUP is not configured for the installation of a cogeneration system. Additional engineering and/or space may be required.
2. The primary use of heat during the summer months is for dehumidification. This limits the overall summertime effectiveness and leaves open the question of how much heat can really be recovered from a cogeneration system?
3. A geothermal heating system and a heat recovery chiller, while having slightly better simple payback than the cogeneration system, is not as effective at reducing GHG emissions. These types of systems substitute greater use of coal-generated electricity for natural gas. The cogeneration system produces electricity from natural gas which results in a large reduction in GHG emissions. As long as a significant portion of the waste heat can be used, cogeneration is a better choice.
4. Effective operation of a cogeneration system could:
   - Improve energy efficiency
   - Reduce consumption of fossil fuel
   - Reduce emission of CO2
   - Reduce the cost of electrical energy
   - Improve security of supply
5. Natural gas costs can be highly variable and volatile. The trend toward increased use of natural gas by large utilities places upward pressure on cost. The requirement of shale gas leaseholders to produce gas or lose the lease places downward pressure on gas. The combination of the current economic conditions in the US and the high volume in storage has resulted in unnaturally low natural gas commodity prices.

APPENDIX D

Cogeneration/CHP (cont'd)

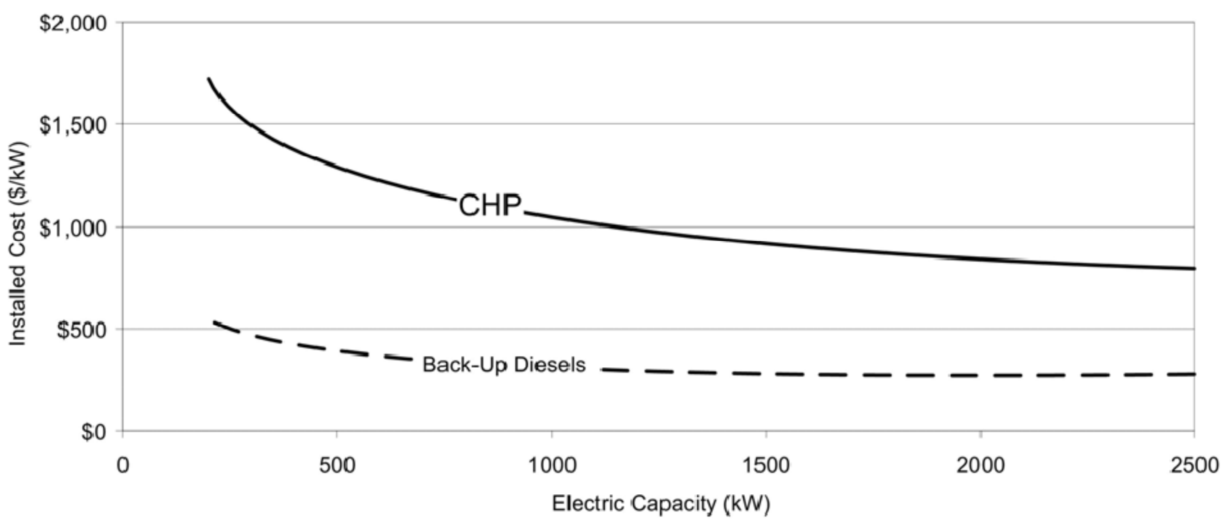
6. Xavier is currently under contract to purchase electricity from First Energy. Part of the agreement with First Energy is that Xavier will maintain the same load profile during the term of the contract. This has allowed First Energy to price electricity without a demand component. This analysis assumes the contract and the underlying pricing will be unaffected.

Economics

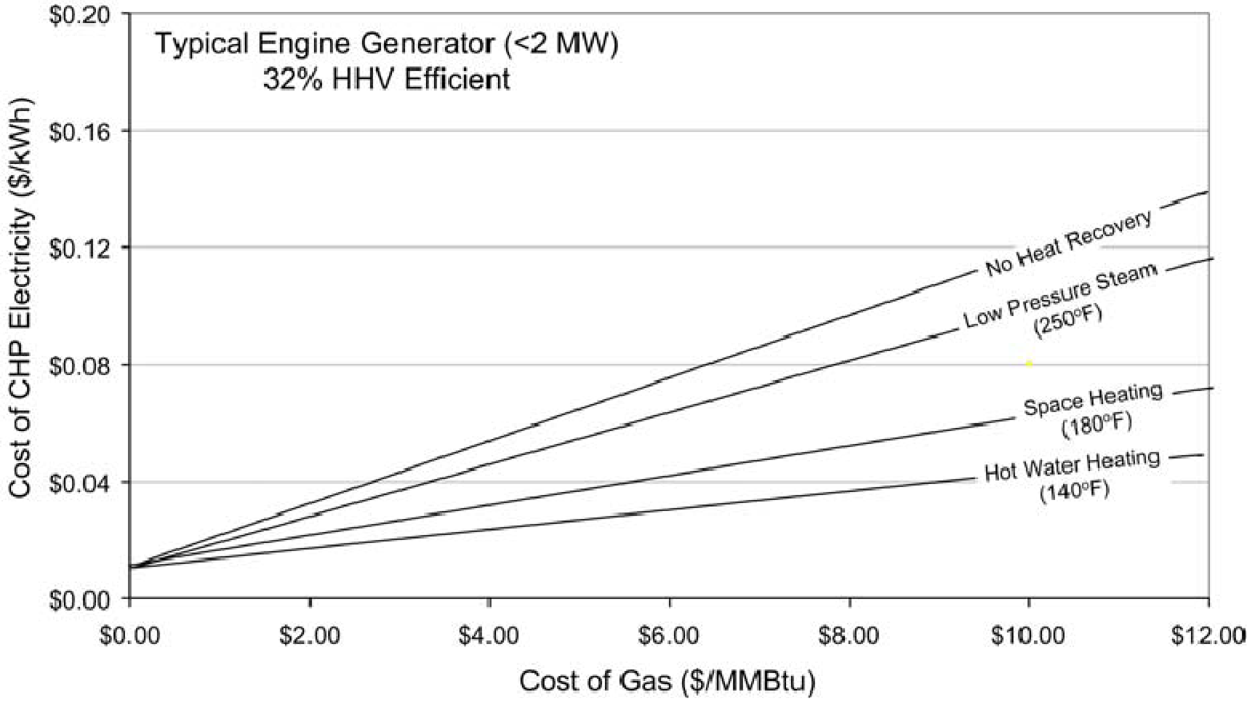
1. If the allowable marginal payback period is extended to about 14 years, a natural-gas-fired cogeneration system can be included in the CUP. This would increase the emissions reduction to 45-50%. .
2. The cogeneration system costs about $275/ton of GHG emissions saved. For comparison purposes, the geothermal system costs $5,000/ton and the heat recovery chiller costs $1,500/ton.
3. Although additional studies are required, a 1MW system is estimated to cost $900K. The payback period is anticipated to be 14-15 years depending on utility rates. Utility cost savings are estimated to be $63,000/year
4. Implementation of the cogeneration system increases the University site-energy intensity to about 65,000 BTU/SF/year but decreases the overall GHG emissions. When performing an economic evaluation of these technologies it will be important to consider including in the analysis the dollar savings associated with avoiding future costs for RECs or carbon offset purchases.

Cogeneration Cost Data

The following is from the University of Illinois at Chicago in conjunction with the Midwest CHP Application Center.



APPENDIX D
Cogeneration/CHP (cont'd)



APPENDIX D

Fuel Cells

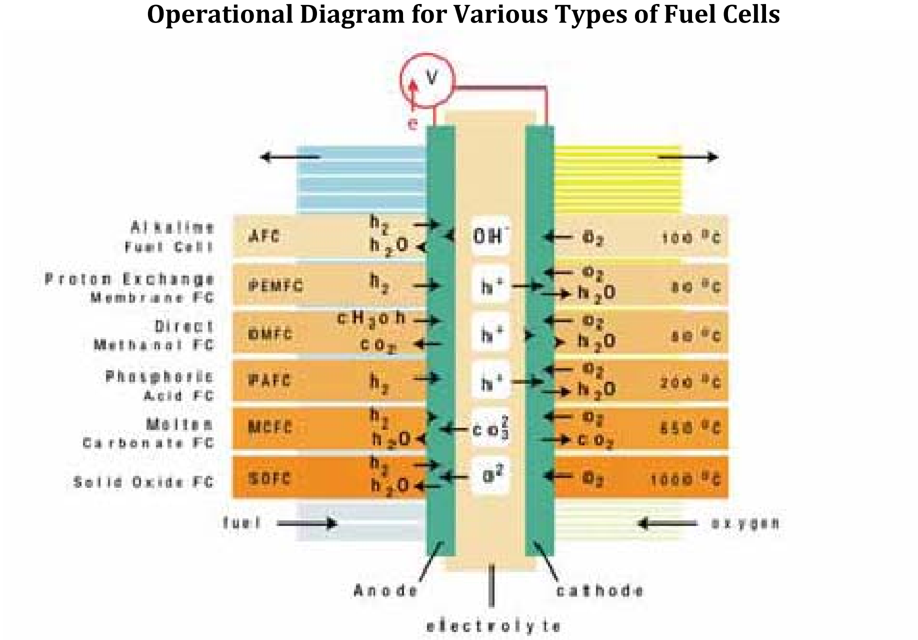
Fuel Cells

Fuel cells operate much like a battery, using electrodes and an electrolyte to generate electricity. Unlike a battery, however, fuel cells never lose their charge. As long as there is a constant fuel source, fuel cells will generate electricity. There are five primary types of fuel cells, which are differentiated by the type of electrolyte they use. The specific characteristics of each—such as operating temperature and type of fuel consumed—may make one a better fit for some applications than others. For a facility's power needs, the three fuel cell types most often used are: Proton Exchange Membrane (PEM), Molten Carbonate Fuel (MCF), and Solid Oxide Fuel (SOF). These technologies can be used by facilities for both backup and primary power needs (continuous or not).

Stationary fuel cells which generate electricity and heat powered by natural gas – which is now the norm – are neither renewable nor carbon-free. Having said that, when hydrogen and oxygen are combined in a fuel cell, water and electricity are produced, with the resulting air polluting emissions at close to zero. In its "2010 Industry Overview" report, the U.S. Fuel Cell Council (USFCC) stated that a fuel cell power plant running on natural gas may create less than one ounce of pollution per 1,000 kilowatt (kW) hours of electricity (as compared to 25 pounds of pollutants from conventional combustion systems). Nitrogen oxide emissions, for instance, are 97% lower than those from a conventional coal fired power plant. To use a fuel cell to produce GHG emission-free electricity and heat, a carbon-free source of hydrogen would be required. That could come from a hydrolysis process (which splits water into hydrogen and oxygen) that is powered by renewable, carbon-free electricity from either wind turbines or PV panels.

Heightened efficiency is another way fuel cells reduce environmental impact. The USFCC states that high temperature fuel cells deliver at least 47% net electrical efficiency; that figure rises to 80% and higher when waste heat is captured for further use.

Operational Diagram for Various Types of Fuel Cells



APPENDIX D

Fuel Cells (cont'd)

Assumptions and Observations

1. The CUP is not configured for the installation of a fuel cell. Additional engineering and space will be required.
2. Fuel cells produce both electrical energy and heat. The ability of Xavier's energy profile to utilize the excess heat is limited.
3. Xavier is currently under contract to purchase electricity from First Energy. Part of the agreement with First Energy is that Xavier will maintain the same load profile during the term of the contract. This has allowed First Energy to price electricity without a demand component. This analysis assumes the contract and the underlying pricing will be unaffected.

Economics

1. The U.S. Department of Energy's Office of Fossil Energy is partnering with several fuel cell developers to develop the technology for the stationary power generation sector with a goal of producing a solid-state fuel cell module that would cost no more than $400/kW. At this price, fuel cells would compete with gas turbine and diesel generators. Currently fuel cells cost $750/kW. By contrast, a diesel generator costs $800 to $1,500 per kilowatt, and a natural gas turbine can be $400 per kilowatt or even less.
2. The fuel cell stack deteriorates with use.
3. When performing an economic evaluation of these technologies it will be important to consider including in the analysis the dollar savings associated with avoiding future costs for RECs or carbon offset purchases.
4. A 1MW installation would cost $750K not including infrastructure or additional space costs.

Case Study – Richard Stockton College, Pomona, New Jersey

Stockton wanted to evaluate the suitability of fuel cell technology for a medium sized campus. Anticipated advantages of operating a fuel cell on campus included:

- Avoiding cost of power delivery
- Reducing peak electrical demand
- Reliability and support of emergency power needs
- Educational value as demonstration project
- Utilization of "waste" heat

In 2002, the College conducted a feasibility study and decided to install a gas fired fuel cell. It was brought on line in March of 2003 and taken out of service in May of 2008. The fuel cell was purchased with financial support from the NJ Board of Public Utilities, the US

APPENDIX D

Fuel Cells (cont'd)

Department of Energy and NJ HEPS (Higher Education Partnership for Sustainability). Gas fired fuel cell technology was supported by NJ and the federal government as an early part of the projected future "hydrogen economy" and as part of a move towards distributed (rather than centralized) generation of electricity.

The first step in fuel cell operation is to "reform" natural gas into hydrogen. Carbon dioxide is a by-product of the hydrogen generation. Hydrogen then combines with oxygen to produce electricity, heat and water vapor. Some of the heat is captured for boiler and domestic hot water use, but not all of it. The best heat utilization will be attained if a fuel cell is designed into the associated buildings before construction. This project was a retrofit, and the location was selected based on visibility to the public as well as on proximity to heat using equipment. AC power was connected to campus distribution system through an inverter. Availability (on a quarterly basis) ranged from 73% to 98.7%, averaging about 90%. This was less than anticipated.

Lecture tours for classes and a student internship have been offered. Public education programs associated with the fuel cell included an inaugural event with a technical session and luncheon which was attended by 120 people from NJ government agencies, architectural & engineering firms, other colleges and universities, and the general public. Architects received AIA credit for attendance. Additional less formal visits were hosted later.

The fuel cell was not used for emergency electrical power because stringent measures would have been needed to prevent feedback into the campus grid during an outage. Again, this would have been easier if the fuel cell was part of the original construction plans.

Stockton's fuel cell was sold back to the manufacturer. The relative prices of gas and electricity had changed, reducing the financial advantage. The annual maintenance contract cost more than tripled since the fuel cell went into service. Rebuilding the reformer ("stack") at the five or six year mark would have been very costly. Major construction and expansion is planned for the College and some of that activity is already underway. A 150,000 GSF Campus Center is being constructed where the fuel cell stood. Moving the fuel cell to another location on campus would have cost more than $100,000.

In summary, the College did not fully achieve the projected cost savings due to lower availability than expected, a change in relative prices of energy, limited heat recovery and high maintenance costs. The future of this technology will depend on relative fuel costs and major reductions in capital and maintenance costs. Gas fired fuel cells will continue to be purchased by users (like biotechnology centers or emergency command posts) with exceptional needs for non-interruptible power.

APPENDIX E

Ecological Footprint Proposal

Background and Purpose
In 2008, Fr. Mike Graham pledged Xavier to create a campus-wide greenhouse gas inventory and, from this inventory, develop a Campus Action Plan (CAP) to achieve climate neutrality. Xavier fulfilled part of its pledge in February of 2009 when members of the Xavier community completed the greenhouse gas (GHG) emissions inventory. While the inventory successfully demonstrates the sources and extent of GHG emissions on campus, it is limited in demonstrating the total environmental effect of the Xavier community because it focuses attention solely on GHG emissions. While GHG emissions do account for a large amount of the environmental impact of Xavier, an Ecological Footprint Assessment (EFA) would take into account other environmental factors, such as water usage and the amount of landfill space used, in addition to GHG emissions.

The development of an EFA would correspond with the University's Jesuit, Catholic identity. The Jesuit mission and Catholic philosophy asserts we are stewards of the planet. Stewardship necessitates a holistic understanding of the impact different actions and policies have on the planet. While there are limitations with any assessment, the EFA would be an opportunity for the University community to understand our impact on the environment within a framework that comes closer to resembling the complexity of our interaction with the environment. While incomplete, the EFA will assist the Xavier community in working towards a more complete analysis of campus sustainability.

Process
Mathis Wackernagel and William Rees at the University of British Columbia originally developed the concept of the EFA in 1996. Since 1996, some universities have adopted the EFA as their primary means of analyzing sustainability on their campus. According to an extensive report written by students at the University of Toronto at Mississauga (UTM), an ecological footprint measures "the biologically productive land and water area required to provide resources consumed and assimilate waste produced." The EFA determines the amount of earth's surface required to support an entity's current consumption patterns. Expressed in hectares, this measurement can be compared to the amount of hectares the entity actually holds to analysis the current sustainability of the entity.

The EFA is measured through a conversion process for different consumed goods and waste products. For instance, the impact of commuting is measured by multiplying the amount of commuter miles traveled and the hectare conversion impact of one mile traveled. The hectare conversion for each input represents a scaled area of land required for different uses and the land's productivity. Again, for commuting this would represent the area of land needed to consume GHG emissions and other adverse environmental effects.

APPENDIX E

An example of the UTM basic EFA follows:

Waste Audit	Waste produced (type)	**Value**	**Conversion Factor**	Footprint (hectare years)
	Paper (kg)	19460	0.0028	**54.488**
	Glass (kg)	3736	0.001	**3.736**
	Aluminum (kg)	2313	0.0094	**21.7422**
	Plastic (kg)	9554	0.0036	**34.3944**

Data
The students at UTM developed a basic EFA calculator to assist other schools in moving toward EFA calculations. The majority of the data needed for the simple EFA calculator could be taken largely from the data collected in the Clean Air-Cool Planet (CA-CP) Campus Carbon Calculator (Version 6.1) used for the GHG emissions report. Additional data could be collected through metering if the school invests in the current metering proposal. Surveys could assist in estimates for other data. Although surveys may not contribute the most accurate data, it would serve as a starting point for the EFA.

A Note on Sources
In the process of developing ways to measure the effectiveness of different sustainability initiatives, Heriberto Cabezas, acting director of the Environmental Protection Agency's Sustainable Technology Division recommended examining EFAs as they are the EPA's recommended sustainability measurement. Initial research involved reading EFAs for American schools as well as a Chinese schools per recommendations made by EPA employees. Final resources came from student research done at UTM. These resources were compiled as a resource for students and researchers at other institutes. Resources from UTM can be found at:

http://geog.utm.utoronto.ca/conway/ecofoot/mainframe.htm

http://geog.utm.utoronto.ca/ecofootprint/index.html

APPENDIX F

Glossary of Terms

Alternative Energy: Energy sources different from those in widespread use at the moment, which are referred to as conventional. Alternative energy sources include solar, wind, wave, tidal, hydroelectric, and geothermal. Although each has its drawbacks, none of these energy sources produces significant air pollution, unlike conventional sources.

ASHRAE EQ: As state, local and federal governments look at reducing national energy use and curbing greenhouse gas emissions and building owners look to save money, an easily understood, yet technically sound, tool for understanding a building's energy use and identifying opportunities to reduce that use is needed. One such tool, the Building Energy Quotient, or Building EQ, currently is being piloted by the Atlanta-based American Society of Heating, Refrigerating and Air-conditioning Engineers with a widespread launch planned for late 2010.

Biodiesel: A type of biofuel that can be used in place of diesel fuel in modified engines. Biodiesel (fatty acid alkyl esters) is a cleaner burning diesel replacement fuel produced (by transesterification) from natural, renewable sources such as new and used vegetable oils and animal fats. A common form of biodiesel is rapeseed methyl ester (RME), which is derived from rapeseed oil.

Biomass: Refers to living and recently dead biological material which can be used as fuel or for industrial production. Most commonly, biomass refers to plant matter grown for use as biofuel, but it also includes plant or animal matter used for production of fibers, chemicals or heat. Biomass may also include biodegradable wastes that can be burnt as fuel.

British Thermal Unit(BTU): Any of several units of energy (heat) in the HVAC industry, each slightly more than 1 kJ. One BTU is the energy required to raise one pound of water one degree Fahrenheit, but the many different types of BTU are based on different interpretations of this "definition". The power of HVAC systems (the rate of cooling and dehumidifying or heating) is sometimes expressed in BTU/hour instead of simply watts.

Carbon Footprint: Total set of greenhouse gases (GHG) emissions caused by an organization, event or product. For simplicity of reporting, it is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted.

Chiller: A device that removes heat from a liquid via a vapor-compression or absorption refrigeration cycle. This cooled liquid flows through pipes in a building and passes through coils in air handlers, fan-coil units, or other systems, cooling and usually dehumidifying the air in the building. Chillers are of two types; air-cooled or water-cooled. Air-cooled chillers are usually outside and consist of condenser coils cooled by fan-driven air. Water-cooled chillers are usually inside a building, and heat from these chillers is carried by recirculating water to outdoor cooling towers.

Composting: The controlled aerobic decomposition of biodegradable organic matter, producing compost. The decomposition is performed primarily by aerobic bacteria, helped by larger creatures such as ants, nematodes and oligochaete worms.

Controller: A device that controls the operation of part or all of a system. It may simply turn a device on and off, or it may more subtly modulate burners, compressors, pumps, valves, fans, dampers, and the like. Most controllers are automatic but have user input such as temperature set points, e.g., a thermostat. Controls may be analog, or digital, or pneumatic, or a combination of these.

Ecological Footprint: A measure of human demand on the Earth's ecosystems. It compares human demand with planet Earth's ecological capacity to regenerate. It represents the amount of biologically productive land and sea area needed to regenerate the resources a human population consumes and to absorb and render harmless the corresponding waste. Using this assessment, it is possible to estimate how much of the Earth (or how many planet Earths) it would take to support humanity if everybody lived a given lifestyle. For 2006, humanity's total ecological footprint was estimated at 1.4 planet Earths - in other words, humanity uses ecological services 1.4 times as fast as Earth can renew them.[1] Every year, this number is recalculated - with a three year lag due to the time it takes for the UN to collect and publish all the underlying statistics.

Energy Audit: A survey that shows how much energy is used in a facility. It helps identify inefficiencies and ways to use less energy. A energy audit will pinpoint where a facility is losing energy and determine the efficiency of a
facilities heating and cooling systems.

Energy Certificates: Renewable Energy Certificates (RECs), also known as Green tags, Renewable Energy Credits, Renewable Electricity Certificates, or Tradable Renewable Certificates (TRCs), are tradable, non-tangible energy commodities in the United States that represent proof that 1 megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource (renewable electricity).

These certificates can be sold and traded or bartered, and the owner of the REC can claim to have purchased renewable energy. While traditional carbon emissions trading programs promote low-carbon technologies by increasing the cost of emitting carbon, RECs can incentivize carbon-neutral renewable energy by providing a production subsidy to electricity generated from renewable sources. It is important to understand that the energy associated with a REC is sold separately and is used by another party. The consumer of a REC receives only a certificate.

In states that have a REC program, a green energy provider (such as a wind farm) is credited with one REC for every 1,000 kWh or 1 mWh of electricity it produces (for reference, an average residential customer consumes about 800 kWh in a month). A certifying agency gives each REC a unique identification number to make sure it doesn't get double-counted. The green energy is then fed into the electrical grid (by mandate), and the accompanying REC can then be sold on the open market.

Energy Efficiency Rating (EER): EER is an abbreviation for **E**nergy **E**fficiency **R**ating. The Air-Conditioning and Refrigeration Institute standardized this rating, which reports central air conditioning efficiency at 80 degrees F indoors and 95 degrees F outdoors. This rating measures steady-state efficiency -- that is, the efficiency of the air conditioner once it is up and running.

EnergyPlus: Mission: To provide businesses and consumers with electricity that is competitively priced, PLUS meaningful value-added benefits and services.

Envelope of Building: A **building envelope** is the separation between the interior and the exterior environments of a building. It serves as the outer shell to protect the indoor environment as well as to facilitate its climate control. Building envelope design is a specialized area of architectural and engineering practice that draws from all areas of building science and indoor climate control. Building envelope design includes four major performance objectives: Structural integrity; Moisture control; Temperature control; Control of air pressure boundaries of sorts. Control of air includes air movement through the components of the building envelope (interstitial) itself, as well as into and out of the interior space, which affects building insulation greatly. The physical components of the envelope include the foundation, roof, walls, doors and windows. The dimensions, performance and compatibility of materials, fabrication process and details, their connections and interactions are the main factors that determine the effectiveness and durability of the building enclosure system.

eQuest: QUick Energy Simulation Tool.

Ethanol: Also known as *ethyl alcohol* or *grain alcohol*, a colorless liquid that is produced by the fermentation and distillation of starch crops, such as corn, barley, that have been converted into simple sugars. Its chemical formula is C2H5OH. Ethanol can also be produced from cellulosic biomass such as trees and grasses and is called bio-ethanol. It is most commonly used to increase octane and improve the emissions quality of gasoline and is also used as an alternative fuel.

GHG Offset Credits: A **carbon offset** is a financial instrument aimed at a reduction in greenhouse gas emissions. Carbon offsets are measured in metric tons of carbon dioxide-equivalent (CO_2e) and may represent six primary categories of greenhouse gases. One carbon offset represents the reduction of one metric ton of carbon dioxide or its equivalent in other greenhouse gases. There are two markets for carbon offsets. In the larger, compliance market, companies, governments, or other entities buy carbon offsets in order to comply with caps on the total amount of carbon dioxide they are allowed to emit. In 2006, about $5.5 billion of carbon offsets were purchased in the compliance market, representing about 1.6 billion metric tons of CO_2e reductions.

Geothermal Energy: Heat from the Earth's interior that is a potential source of energy. The most common way of capturing the energy from geothermal sources is to tap into naturally occurring hydrothermal convection systems where cooler water seeps into the Earth's crust, is heated, and then rises to the surface. When heated water is forced to the surface, it is straightforward to capture that steam and use it to drive generators.

Geothermal Heat Pump: A type of heat pump that uses the ground, ground water, or ponds as a heat source and heat sink, rather than outside air. Ground or water temperatures are more constant and are warmer in winter and cooler in summer than air temperatures. Geothermal heat pumps operate more efficiently than conventional or air-source heat pumps.

Greenhouse Gases: Those gases, such as water vapor, carbon dioxide, tropospheric ozone, methane, and low level ozone that are transparent to solar radiation, but opaque to long wave radiation, and which contribute to the greenhouse effect.

Green Power: A popular term for energy produced from clean, renewable energy resources.

Green Roofing: A **green roof** is a roof of a building that is partially or completely covered with vegetation and soil, or a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems. The term "green roof" may also be used to indicate roofs that utilize some form of "green" technology, such as solar panels or a photovoltaic module. Green roofs are also referred to as eco-roofs, vegetated roofs, living roofs, and greenroofs.

APPENDIX F

HVAC: An acronym that stands for "**heating, ventilation, and air conditioning**". HVAC is sometimes referred to as "climate control" and is particularly important in the design of medium to large industrial and office buildings such as sky scrapers and in marine environments such as aquariums, where humidity and temperature must all be closely regulated while maintaining safe and healthy conditions within.

Kilowatt (kW): A standard unit of electrical power equal to 1000 watts, or to the energy consumption at a rate of 1000 joules per second.

Kilowatt Hour (kWh): A unit or measure of electricity supply or consumption of one thousand watts acting over a period of one hour. The kWh is a unit of energy. 1 kWh = 3600 kJ =3412 Btu.

Leadership in Energy and Environmental Design (LEED): A list of standards and certification scheme for environmentally-sustainable construction developed by the US Green Building Council (USGBC). The Leadership in Energy and Environmental Design (LEED) Green Building Rating System is presently the most popular and respected guide for green building in the United States. It evaluates environmental performance from a whole-building perspective over a building's life cycle, providing a definitive standard for what constitutes a "green building."

Light Emitting Diode (LED): A semiconductor light source. LEDs can produce a very bright light for a small amount of power. They are used in many applications e.g., car break lights, traffic lights, but white colored LEDs are a relatively new technology.

Long-term: Goals identified in this plan that are anticipated to be completed in five to ten years.

Low embodied energy: The total amount of energy required to manufacture a product should be as little as possible. This includes considering resource excavation and extraction from the Earth, use of manmade materials in production, and complexity of manufacture. The simpler the process, the less harm done to the environment.

Low emissivity (low-E) Glass: Glass that has a low-emissivity coating applied to it in order to control heat transfer through windows. Windows manufactured with low-E coatings typically cost about 10–15% more than regular windows, but they reduce energy loss by as much as 30–50%.

Methane: A colorless, odorless, tasteless gas composed of one molecule of carbon and four of hydrogen, which is highly flammable. It is the main constituent of natural gas that is formed naturally by methanogenic, anaerobic bacteria or can be manufactured, and which is used as a fuel and for manufacturing chemicals.

Mid-term: Goals identified in this plan that are anticipated to be completed in three to five years.

Photovoltaic: Pertaining to the direct conversion of light into electricity. The word "photovoltaic," first used in about 1890, is a combination of the Greek word for light and the name of the physicist and electricity pioneer Allesandro Volta. So, "photovoltaic" can be translated literally as "light-electricity." The conversion of sunlight to electricity using photovoltaic (PV) cells, also known as solar cells, is based on the photoelectric effect discovered by Alexander Bequerel in 1839. The photoelectric effect describes the release of positive and negative charge carriers in a solid state when light strikes its surface.

Renewable Energy: Energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). In 2006, about 18% of global final energy consumption came from renewables, with 13% coming from traditional biomass, which is mainly used for heating, and 3% from hydroelectricity. New renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels) accounted for another 2.4% and are growing very rapidly.[1] The share of renewables in electricity generation is around 18%, with 15% of global electricity coming from hydroelectricity and 3.4% from new renewables.[1]

Retrofit: The improving of existing buildings with energy efficiency equipment.

Short-term: Goals identified in this plan that are anticipated to be completed in one to two years.

Solar Water Heating System: Solar water heating systems include storage tanks and solar collectors. There are two types of solar water heating systems: active, which have circulating pumps and controls, and passive, which don't. Most solar water heaters require a well-insulated storage tank. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank.

Value Engineering: A systematic method to improve the "value" of goods or products and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value can therefore be increased by either improving the function or reducing the cost. It is a primary tenet of value engineering that basic functions be preserved and not be reduced as a consequence of pursuing value improvements.

VOC-emitting: According to one study, 96% of volatile organic compounds (VOC) found in a large office building following construction resulted from materials used to construct and furnish the building. Thus, there is increasing awareness and emphasis on reducing the chemical emissions gained from the use of building materials.

Wind Turbine: A wind energy conversion device that produces electricity; it typically has one, two, or three blades. Wind turbines can be classified into the vertical axis type and the horizontal axis type. Most modern wind turbines use a horizontal axis configuration with two or three blades, operating either upwind or downwind.