Carbon Neutral Academic Quality Improvement Program (AQIP) Project

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Executive Summary

The Carbon Neutral Academic Quality Improvement Program (AQIP) project was developed to better integrate Michigan Tech's goals of sustainability with our education and research efforts now and into the future. The goal of this project was to develop a process, using carbon as the metric, to improve Michigan Tech's use of energy and materials and enhance our educational and research programs. We focused on infrastructure plans to reduce carbon emissions towards neutrality. This document describes a model used to estimate our carbon emissions and offsets and the detailed process by which we can begin to integrate Tech's goal of carbon neutrality into our educational programs. We also suggest certain actions that will help us achieve the final goals of carbon neutrality and, the integration of these concepts into all we do at Michigan Tech.

Introduction

Michigan Tech has long been known for its application-based education and research. These efforts began when Tech was created in 1885, educating students in mining engineering and supporting Michigan's economic development through its educational and research programs. Within the next fifty years, programs were added in other engineering areas, business, technology, arts and sciences, and forestry, all revolving around hands-on learning with application-based research and enhancing Michigan's economic development while sustaining our natural resources.

Along with these advances, Michigan Tech established itself as a national leader in research and education in sustainability. This success has been based on the achievements of our faculty, staff, and students across campus. In recognition of the principles and issues embraced by sustainability and what we have already achieved, the University in 2004 made sustainability part of our Strategic Plan (http://www.mtu.edu/stratplan/), as evidenced by the following goals:

> *Goal 2: Deliver a distinctive and rigorous discovery-based learning experience grounded in science, engineering, technology, sustainability, and the business of innovation.*
>
> *Goal 3: Establish world-class research, scholarship and innovation in science, engineering, and technology that promotes sustainable economic development in Michigan and the nation.*

As a higher education institution, we recognize that it is our responsibility to lead by example and to initiate changes in human behavior through our educational and research programs with the aim of creating a more sustainable society for future generations. The formation of the Presidential Committee

on Environmental Sustainability in 2001 with members drawn from Tech's staff, faculty, and students helped Tech begin to create a more sustainable community, to target reductions in energy use, and to change the culture of Michigan Tech's high energy use. This committee produced a comprehensive document, *Greenprint for Environmental Sustainability in Campus Operations and Activities*, in 2001 that recommended actions the University could take to reduce our energy use. Then in 2003, the Sustainable Futures Institute was formed, whose mission was centered around research and graduate education on sustainability. While both these efforts are significant and have led to many achievements, including recycling and the exchange and development of new knowledge related to sustainability, the University continues to struggle with changing its culture of high energy use. In particular, our campus does not exemplify a sustainable community, putting into practice principles taught in our classes, or the results from our research.

A major reason for this high energy use has been Tech's expansion of a "built" environment since the early 1900s. As our educational and research programs matured in the latter half of the 1900s, quality space for our programs became severely limited. Therefore, in the late 1960s and early 1970s, Tech added significant space to its campus by building new high-rises for Mechanical Engineering-Engineering Mechanics, Chemistry-Metallurgy, Biological Sciences, Electrical Energy Resource Center, Forestry, and Administration and Student Services. New residence halls and a Student Development Complex were also built to meet the needs of the number of students. These buildings were designed and engineered during a time when the first energy crisis occurred in the US and thus energy reduction efforts such as creating buildings with small windows and materials that were easily accessible and inexpensive were utilized to reduce heat demands and subsequent energy costs. Recent buildings have incorporated energy-efficient designs but continue to add to our energy footprint. At present, energy consumption and costs continue to increase with the university having no coordinated effort to reduce energy consumption or change the culture of high energy use on our campus.

We recognize that to excel in education and research in sustainability we must:
1. provide a fertile ground and an excellent test-bed for research and education in sustainability by having sustainable operations;
2. strive for sustainability as a society through our leadership in sustainability research and education;
3. "walk the talk" and demonstrate leadership in matters related to sustainability;
4. "practice what we preach" (that is practice sustainability in University operations) otherwise we are compromising our reputation among students, collaborators, and stakeholders around the world.

While most universities have taken the approach of reducing their emissions by reducing specific high emitting components, such as purchased electricity, they are not taking a holistic approach to the linking of individual decisions with the goal of reducing the university's emissions and making the campus a sustainable community. Therefore, we have embarked on a project to estimate Michigan Tech's carbon emissions and sequestration potential for various components and to subsequently develop a coordinated process to reduce our total emissions now and in the future.

This project is not only aimed at reducing the University's carbon emissions through a coordinated framework but also directed at communicating our progress and accomplishments as they occur. We believe a coordinated process for reducing carbon emissions should be embedded in all our scholarly and operational efforts. We are therefore using the Higher Learning Commission's new accountability framework, the Academic Quality Improvement Program (AQIP) to structure a more data-based and action-directed program for improvement that will help us to focus on the areas where we can make the biggest strides in accomplishing our general goal of "carbon neutrality".

What Does Carbon Neutrality Mean?

Being carbon neutral, refers to neutral (meaning zero) net carbon release or zero net carbon emissions, brought about by balancing the amount of carbon released into the atmosphere with the amount sequestered. Some consider carbon credits a means of offsetting the carbon emitted. From the standpoint of the American College & University Presidents' Climate Commitment group, climate neutrality is defined as:

> *having no net greenhouse gas (GHG) emissions, to be achieved by minimizing GHG emissions as much as possible, and using carbon offsets or other measures to mitigate the remaining emissions.*
> http://www.presidentsclimatecommitment.org/pdf/ACUPCC_IG_Final.pdf

Various groups attempt to promote the use of carbon emission reduction as a means to carbon neutrality, which is clearly not "neutral" but often a step to reduce the energy use of a community. Others have defined carbon neutrality by measuring certain parts of the carbon cycle and trying to approach net -0- emissions. Offsets are often purchased to compensate for emissions. Some have argued that the cost of offsets is not reflective of the true cost of reducing carbon emissions. Therefore, there are various ways we approach measuring carbon neutrality and these are termed "scopes". It is becoming acceptable to measure those things we can directly affect through the changing of our habits or the ease of ability to measure but not necessarily reaching true carbon neutrality.

How Do We Account for Carbon Emissions and Offsets?

The words "accounting" and "reporting" of carbon emissions are often used interchangeably. Yet, accounting is used to summarize, record, reconcile and state the complete state of affairs of a particular measurement, in this case carbon (or in most cases equivalents of CO_2). Reporting, on the other hand, is a process whereby the accounting is registered, filed or otherwise formally stated for some final goal or purpose. Carbon reporting necessitates accounting, but not visa versa.

Since 1994, reporting of greenhouse gas (GHG) emissions has been possible under the US Department of Energy "*Voluntary Reporting of Greenhouse Gas Program*". This program is often referred to as the "1605(b)" program, after the section in the Energy Policy Act of 1992 that mandated its creation. The program is voluntary and there is no requirement that carbon accounting be balanced or complete in a financial sense. Most emissions are tracked in terms of intensity, relative to some productivity measure. This is because the purpose of the program is to incentivize activities that result in reductions in greenhouse gas emissions without unduly penalizing economic activity. Between 1994 and 2004 the number of entities (companies) participating in this program increased from 100 to 226 and in 2004 alone reported reductions totaling over 390 million tonnes carbon dioxide equivalent ($MMTCO_2e$). Notably, the Energy Policy Act of 1992 established that, should mandatory greenhouse gas reductions programs be established in the future, participants in the 1605(b) program must be given credit under future programs for reductions achieved under the earlier program. Thus, reporting under 1605(b) could be viewed as a hedge against future uncertainty in more ways than one.

The Chicago Climate Exchange (CCX) is an alternative, voluntary program that incentivizes greenhouse gas reductions. The CCX is structured as a commodity market, which works by creating an artificial scarcity. Essentially, when members join they commit to a legally-binding target emissions reduction profile for their organization. Should a member not meet a target, they may purchase excess reductions from another member or "offsets" on the exchange to meet the deficit. Offsets can take a variety of forms including forest carbon sequestration projects and avoided fossil emissions through renewable energy. The CCX is chartered to run through 2010, and reduction schedules stipulate either a 4% or 6% reduction

from a year 2000 baseline by that date, depending on when they entered the program. Current membership includes notable Michigan corporations such as DTE Energy, Ford Motor Company, and Dow Corning Corporation. Notably, Michigan State University, University of Minnesota, University of Iowa and University of Idaho are also members. Other programs are emerging at the state and regional level that will offer opportunities not provided by the 1605(b) and CCX programs. These include an independent registry run by the State of California, the Regional Greenhouse Gas Initiative that enjoys membership of 10 northeastern states, and The Climate Registry, a new national initiative under development that has been endorsed by most state governments, including Michigan.

Many universities and communities are starting to evaluate carbon neutrality through the use of carbon accounting models. One such model is the Clean Air – Cool Planet Campus Carbon Calculator (CA-CP) www.cleanair-coolplanet.org/. The CA-CP model identifies operational boundaries for institutions to 'scope' their sources of carbon and other GHG emissions in order to provide accountability for prevention of "double counting" or conversely, "double credits". There are three scopes in this model:

> ***Scope 1*** *- includes all direct sources of GHG emissions from sources that are owned or controlled by your institution, including (but not limited to): production of electricity, heat, or steam; transportation or materials, products, waste, and community members; and fugitive emissions (from unintentional leaks).*
> ***Scope 2*** *- includes GHG emissions from imports of electricity, heat or steam – generally those associated with the generation of imported sources of energy.*
> ***Scope 3*** *- includes all other indirect sources of GHG emissions that may result from the activities of the institution but occur from sources owned or controlled by another company, such as: business travel, outsourced activities and contracts, emissions from waste generated by the institution when the GHG emissions occur at a facility controlled by another company, e.g. methane emissions from landfilled waste, and the commuting habits of community members.*

What are Other Universities Doing to Become Carbon Neutral?

A number of campuses have already initiated or completed greenhouse gas inventories, many adopting the CA-CP Campus Carbon Calculator as described above. Other universities such as Harvard have chosen to use a customized GHG calculator based on the Greenhouse Gas Protocol, developed by the World Resources Institute and the World Business Council for Sustainable Development (www.ghgprotocol.org). Customized calculators with a similar base are widely used by governments and businesses. Some campuses, such as the Universities of Colorado, Vermont, New Hampshire, and Florida, Tufts University, and Middlebury College, have signed the American College and University Presidents Climate Commitment (ACUPCC) or the Talloires Declaration, set target dates for becoming carbon neutral, or joined the Chicago Climate Exchange. Of Michigan Tech's benchmark institutions, only Georgia Tech has signed the ACUPCC. Generally, schools known for their engineering programs like Michigan Tech are underrepresented. Grand Valley State University is the only Michigan university among the ACUPCC signatories (574 at this time have signed), joined by ten other colleges/universities in the state. Michigan State has joined the Chicago Climate Exchange and thus is held to its standards. More information on "point of reference" universities can be found in Appendix A.

Often universities use certain building design standards that hope to reduce emissions. A large number of universities including Michigan Tech are using Leadership in Energy and Environmental Design (LEED) standards when building new buildings or making renovations to old buildings to reduce the structure's energy and water consumption. The LEED rating system of 69 possible points addresses six areas: sustainable sites, water efficiency, energy/atmosphere, materials/resources, indoor environmental quality, and innovation in design. Updated version of these standards will most likely include a reduction in the

carbon footprint of the building while significantly reducing the GHG emissions below the baseline level of acceptability. If this occurs many more universities will be assessing their net carbon emissions.

What Are We Presently Doing to Promote Carbon Neutrality in Our Educational and Research Efforts?

Many of Michigan Tech's educational programs concentrate their instructional efforts on sustainability with emphases on carbon cycles http://www.mtu.edu/sfhi/educational/. They range from specific degree programs in sustainability to certificates in sustainability. The total list of university-specific course content that covers carbon neutrality and sustainability principles has not been compiled for Tech. Yet, an evaluation of how carbon neutrality principles can fit into our programs is the purpose of this project.

Several research centers at Michigan Tech are promoting sustainability and the education of students, research in carbon cycles, and the effect of society on this cycle. Some of the centers involved in these efforts are: Sustainable Futures Institute (SFI), Advanced Power Systems Research Center (APSRC), Biotechnology Research Center (BRC), Ecosystem Science Center (ESC), National Institute for Climatic Change Research (NICCR) , Michigan Tech Research Institute (MTRI) , Materials in Sustainable Transportation Infrastructure (MiSTI),Michigan Tech Transportation Institute (MTTI), Transportation Materials Resource Center (TMRC), Center for Structural Durability (CSD), Power and Energy Research Center (PERC), Remote Sensing Institute (RSI), Lake Superior Ecosystem Research Center (LaSER), Center for Environmentally Benign Functional Materials (CEBFM), Michigan Tech Center for Water and Society (MTCWS), and the Multi-Scale Technologies Institute (MuSTI). These Michigan Tech centers are specifically addressing, via research and teaching programs, the policy, engineering, ecological, economic, business, cultural, and sustainable community dimensions of four particular thematic areas (*Air*, *Water*, *Energy*, and *Materials*).

The "*Air*" theme deals with the sustainability of the atmosphere as a resource, with the role of the atmosphere as a key determinant of the weather, and climate and pollution transport processes through which human activities affect the sustainability of other resources. Main foci at Tech under the "air" theme are in three areas: understanding the magnitude and mechanisms of human impacts on the global atmosphere; biospheric changes and feedbacks in response to changing atmospheric composition; and developing effective and efficient policy instruments to manage atmospheric impacts. Key initiatives are the non-departmental doctoral program in Atmospheric Sciences, Northern Institute of Applied Carbon Science, and the Michigan Tech Aspen-FACE (Free-Air Carbon Dioxide Enrichment) site, a Department of Energy (DOE) User Facility and the only FACE site where open forest plots are exposed to enhanced CO_2 and O_3.

The main areas of emphasis within the "*Water*" theme include aquatic ecosystem science, physical hydrology, drinking and waste water treatment, engineered water resources systems, integrated watershed science, restoration of aquatic systems, fate and transport mechanisms in aquatic systems, water resource economics, analysis of water resource policy, and human perceptions of water resources issues. Michigan Tech's Center for Water and Society, which includes 40 participating faculty and staff from 10 academic units, acts as an umbrella for fostering initiatives that cut across disciplines. Additionally, Michigan Tech faculty and students are engaged in research and education activities in lesser-developed countries around the world, largely focused on water sustainability issues, through programs such as Environmental Engineering Peace Corps Master's, International Senior Design, and Engineers without Borders.

The focus of Michigan Tech's sustainable "*Energy*" initiative is investigations over the entire value chain for energy technology systems, including resource development, energy production, transformation, and utilization; as well as technology assessments into environmental, societal, policy and regional economic

aspects. Michigan Tech energy projects include cellulosic ethanol, fuel cells, wind and solar power, and sustainable use of fossil fuels through conservation, efficiency improvements and geological carbon sequestration. Tech has a number of active programs, many of which are associated with the Sustainable Futures Institute. The main initiatives include Wood-to-Wheels Graduate Enterprise (W2W), Power and Energy Research Center (PERC), and Advanced Power Systems Research Center (APSRC).

The "*Materials*" theme focuses on increasing the sustainability of material acquisition, utilization, and disposal/reuse, necessitating advanced research to better understand impacts and to mitigate negative effects. This is a very active area of research at Michigan Tech, spanning multiple departments, colleges/schools, and institutes. In the last three years, almost 1000 proposals have been submitted by 200 investigators in materials-related research, culminating in over 300 awards in excess of $30M. The main areas of emphasis in this theme include nanotechnology, smart/active materials, biotic and abiotic materials, advance metallurgy, ceramics, polymers, foams, forestry products, innovative construction materials, and composites. Several centers and institutes are active within this theme, including: Power and Energy Research Center (PERC), Center for Environmentally Benign Functional Materials, Multiscale Technologies Institute (MuSTI), University Transportation Center (UTC) for Materials in Sustainable Transportation Infrastructure (MiSTI), and Institute of Materials Processing (IMP).

In addition to directing/informing campus policy, as mentioned above, Michigan Tech's Environmental Sustainability Committee (ESC) coordinates a number of community outreach and educational programs. The ESC organizes a series of seminars, lectures, and workshops for Earth Week, provides students with information about when and where they can recycle and has led several campus initiatives seeking to improve Tech's collective ecological footprint.

Use of the CA-CP Campus Carbon Calculator for Michigan Tech

We chose the CA-CP Campus Carbon Calculator to account for our carbon emissions and help us in the future to determine if we are approaching carbon neutrality by the choices we make. We are using this model largely to establish a baseline for present carbon emissions. The CA-CP Excel spreadsheet fundamentally provides a framework for summarizing, reporting and reconciling all of the scope areas and thus is an accounting system. How the Input numbers were collected is provided in the worksheets within the model.

This model had wide use by other universities as mentioned above and in Appendix A; however, other models are being developed (Appendix B) and should be evaluated in the future as to their applicability for accounting carbon emissions and to their accuracy at predicting/accounting for carbon emissions.

We evaluated Michigan Tech's carbon footprint at two levels or scopes (see Section - **How Do We Account for Carbon Emissions and Offsets** for definitions of Scopes 1, 2, and 3**)**: Scopes 1 and 2 from the CA-CP model will be the first level/scope of evaluation while the combined Scopes 1, 2, and 3 will be the second level/scope of evaluation.. Scope 3 may be very difficult for Michigan Tech to evaluate due to the lack of available data.

As with any model, there are assumptions related to the inner calculations of the model and the data input into the model. There are also model and data limitations when using a model and when collecting the data necessary for input into this model. The initial assumptions and limitations of this model and the data are described in the attached CA-CP Excel spreadsheet. If Michigan Tech is to use this model in the future to account for its carbon emissions, care must be taken to ascertain what confidence level and degree of accuracy can be ascribed to the carbon emission estimates.

At this time, we only used the following parts of the CA-CP model to estimate Techs carbon emissions (Total and Net):

- Budget (Annual)
- Actual not Budgeted
- Population
- Purchased Electricity
- Physical Size
- Purchased Electricity
- Distillate Oil
- Natural Gas
- Propane
- Gasonline Fleet
- Diesel Fleet
- Faculty/Staff Business Air Travel
- Fertilizer Application (Synthetic, % Nitrogen)
- Landfilled Waster with no CH_4 recovery
- Refrigeration and Other Chemicals HFC-134a
- Refrigeration and Other Chemicals – HFC-404a
- Refrigeration and Other Chemicals – HCFC-22
- Refrigeration and Other Chemicals – Others
- Forest Preservation Offsets

The parts of the model we did not use are colored orange in the attached Excel spreadsheet for the CA-CP model.

Initial estimates of Tech's CO_2 emissions for FY08 were estimated to be **76,904** MT eCO_2 with **6,892** MT eCO_2 sequestered. Our net CO_2 emissions for FY08 were estimated to be **70, 012** MT eCO_2. The largest contribution to our total carbon emissions is from purchased electricity – close to half of our emissions (see attached Excel spreadsheet for the CA-CP model). Further analyses of the model results and applicability to Michigan Tech's goals will be accomplished by many groups, as described below.

A Framework to Incorporate Carbon Neutrality into our Education and Research Programs

This section describes the proposed process/framework for incorporating campus carbon footprint reduction into our educational and research efforts. It begins with a general overview of the process, then provides a more detailed explanation of each of the tasks that collectively define the continuous improvement process that will be implemented annually to identify, plan, and then pursue carbon footprint reduction project activities. It also describes how students and the campus as a whole will be involved.

Figure 1 provides a general overview of the process that will be followed to continuously reduce Michigan Tech's campus carbon footprint. As is evident, the process begins with a block of tasks termed "Getting Started". This block is associated with the up-front efforts required to define and plan the continuous improvement process described in this section. It also includes the first task in the annual continuous improvement loop, where the upper administration will review and update the existing process and policy, and define improvement targets for the year's process cycle.

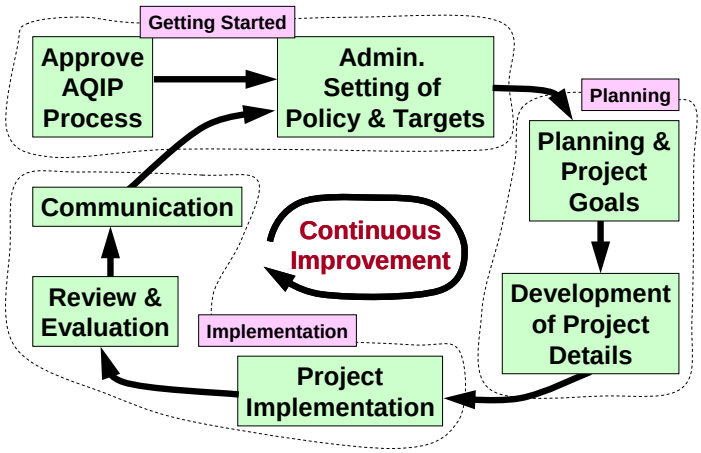


Figure 1. Overview of the Campus Carbon Neutral Process

The next block of tasks is "Planning" and addresses all the activities connected with planning improvement projects that will involve students, staff, and faculty. The planning block begins with the targets set by the administrative Executive Team (University President and Vice-Presidents), brainstorms projects within the non-academic and academic units, and then fleshes out specific objectives and resources required for each project. The last action within the planning block is for the Executive Team to identify those projects that will be implemented.

The final block of tasks to be undertaken annually is termed "Implementation." This block includes not only the project implementation efforts, but also project review and evaluation by the Executive Team and communication of the results and status of the carbon footprint project to the campus community. As is evident from Figure 1, following this block of tasks, the continuous improvement loop closes upon itself with the first step in the annual process.

A more detailed description of the tasks associated with the proposed continuous improvement approach toward campus carbon footprint reduction is provided in the following sub-sections, which have been structured according to the tasks blocks discussed above.

Getting Started

The first block of tasks to be described is associated with "Getting Started." These tasks are shown in Figure 2. The four tasks have been numbered in the figure, and it may be noted that the tasks are in different color rectangles. The legend for task colors is also shown in the figure and indicates the responsible party: Non-Academic Units (yellow), Executive Team (Red), Campus Energy Group/Committee (Light Green), Academic Units (Blue), AQIP Committee (White), and Green Campus Enterprise (Dark Green) – later one final responsible party will be introduced, the Pavlis Institute (which will have a purple color).

A description of each of the numbered tasks associated with "Getting Started" is provided below.

1. **Define AQIP Process and Scope.** For this task, the AQIP committee identified a process and initial scope for the campus carbon footprint reduction activity. The committee also identified a suitable software tool, CA-CP, which could be used annually to assess the campus carbon footprint.

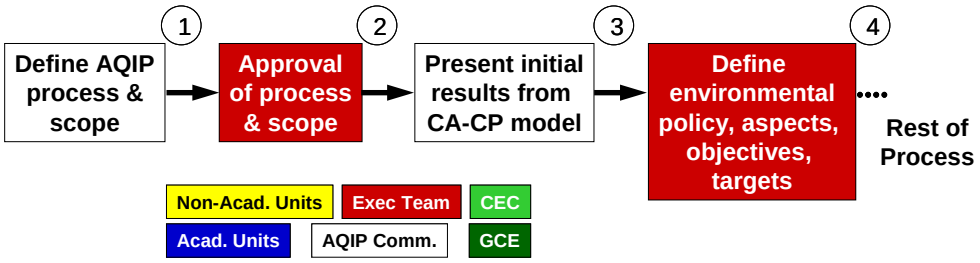


Figure 2. Tasks Associated with Initiating the Campus Carbon Footprint Reduction Initiative

2. Approval of Process and Scope. Following the completion of the first task, members of the AQIP committee met with the Executive Team. At this meeting, the Executive Team approved the process and scope described herein.

At the time of writing this report, Tasks 1 and 2 have been completed.

3. Present Initial Results from CA-CP Model. From the time the CA-CP software was identified, the AQIP committee has been working to collect and enter the required data into the CA-CP spreadsheet. Once all the data have been entered into the spreadsheet, in principle, the results can be forwarded to the Executive Team and this task could be completed. However, before moving to the next task, everything needs to be in place to conduct an annual cycle of the carbon footprint reduction process. Therefore, concurrent with this task the AQIP committee needs to formalize the organizational structure described later in this section.

4. Define environmental policy, aspects, objectives, and targets. This is the first task of the annual continuous improvement process. In this task, the Executive Team updates the environmental policy for the University (of course, such a policy must first be established) and the aspects or performance measures that will be the subject of focus. The AQIP Committee recommends that the University's carbon footprint be used as the principal performance measure of interest, and the balance of this document is structured around this assumption – this could be changed at some point in the future, perhaps to include such other sustainability measures as water consumption. In addition to revisiting the policy and aspects every year, the Executive Team must define annually the improvement targets (e.g., 5% reduction in carbon footprint) and objectives (e.g., reduce the energy losses in university housing).

Planning of Improvement Projects

The next block of tasks is largely associated with the planning of improvement projects. The planning tasks are shown in Figure 3. The block begins with the first task in the annual improvement process: Task #4 – defining the environmental policy, aspects, targets, and objectives.

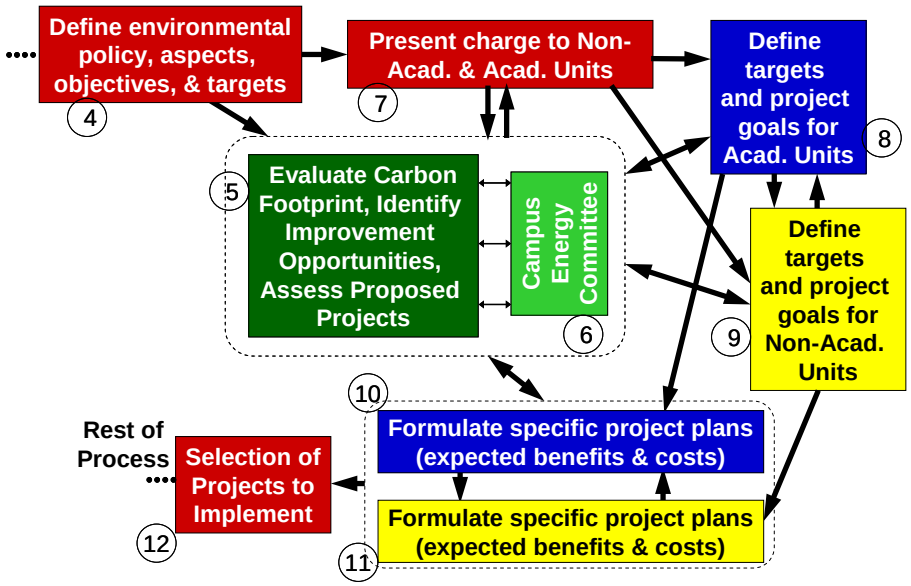


Figure 3. Tasks Associated with Project Planning for Carbon Footprint Reduction

5. Green Campus Enterprise Activities. The Green Campus Enterprise (GCE) lies at the heart of the continuous improvement process. The cadre of students participating in the GCE is charged with estimating the carbon footprint of the University, which will be done initially with the CA-CP spreadsheet model. They must secure data annually to update the model, and it is expected that they will look for other, better, models as well. As "owners" of the software tool that is used to evaluate the carbon footprint, the GCE is well positioned to provide insight into where improvement opportunities exist. The GCE responds to charges from the Executive Team, and may be considered as representing the entire campus community. The GCE will provide advice to the Executive Team on goal setting. As other campus entities begin to plan improvement projects, it is envisioned that the GCE will provide valuable feedback on the potential project benefits – using the CA-CP software they can explore a variety of "what-if" scenarios. While not displayed in Figure 3 (it will be shown later in Figure 4), it is expected that the GCE will also assist with project implementation if needed. Finally, it is expected that the GCE will assist the Executive Team in communicating on-going developments to the campus community.

6. Campus Energy Group/Committee (now called the **Energy Advisory Group** (EAG)) is an advisory body of campus energy experts drawn from the ranks of staff and faculty. These individuals are knowledgeable about how changes in technology and sociological factors can influence energy generation, energy consumption, and carbon sequestration. It is envisioned that the EAG will provide guidance to the GCE regarding their efforts and to academic and non-academic units planning improvement projects. This group will be closely working with the Executive Team on the suggestions for improvements to the University Campus.

7. Present Charge to Academic & Non-academic Units. Based on the annual updating of the objectives and tasks within Task #4, the Executive Team will charge the academic and non-academic units with goals specific to their units. Suggestions for this charge are expected to come from within the Executive Team, the GCE, the EAG, or from the units themselves. This charge may take the form of specific ideas for projects or suggested levels for carbon footprint reduction that should be achieved based on initiatives within the units.

8. Define Targets and Project Goals for Academic Units. Once the academic units have received their charge from the Executive Team, each unit will establish targets and projects to respond to their charge. For larger units, targets may be established by the larger unit that are allocated to sub-units, which in turn may propose projects to meet their targets. Smaller units may directly propose projects to meet the charge of the Executive Team.

9. Define Targets and Project Goals for Non-Academic Units. This is the same as Task #8, described immediately above, except that it applies to the non-academic Units.

10. Formulate Specific Project Plans (expected benefits and costs). Academic units will develop a plan for each proposed project. The plan should include specific tasks to be undertaken and estimates of all foreseeable benefits and costs. The method by which each project will be performed will be identified. Costs may include initial investments, long-term savings, and maintenance costs. Potential benefits may embrace less tangible issues such as University image improvement, better student/staff/faculty morale, and positive publicity, as well as more tangible outcomes such as carbon footprint reduction and positive environmental benefits. It is likely that the academic units will need the assistance of the GCE in estimating the costs and benefits.

11. Formulate Specific Project Plans (expected benefits and costs). Task #11 is the same as Task #10, described immediately above, except that it applies to the non-academic units.

12. Selection of Projects to Implement. Once project plans are defined in detail, the Executive Team will select those non-academic and academic projects that will be implemented. Resources will be identified for each project.

Improvement Project Implementation

The final block of tasks is largely associated with project implementation and these tasks are shown in Figure 4. The flow of tasks within the figure begins with the last task from the project planning block (shown in previous figure), Task #12 – Project Selection, and continues with Task #13 - Project Implementation. In considering the flow of tasks within the figure, the last primary task is Task #16 - Revival, which will be followed by Task #4 - Define environmental policy, aspects, objectives, and targets, which is the first task in the planning block of tasks, thus, closing the loop on the annual improvement process.

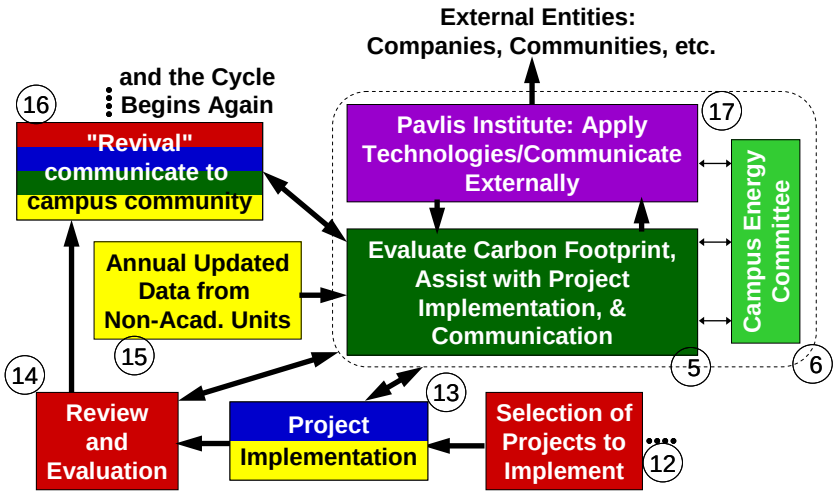


Figure 4. Tasks Associated with Project Implementation for Carbon Footprint Reduction

13. **Project Implementation.** This task is where the academic and non-academic unit projects selected for implementation are actually implemented. These projects may include efforts such as University building enhancements, alternative energy source development, and raising the awareness of the campus community to its carbon footprint. The various project implementation teams will engage the GCE as needed for assistance in project implementation efforts.

14. **Review and Evaluation.** Once a project has been implemented, it will be reviewed and evaluated by the Executive Team. It is envisioned that the Executive Team may need to call upon the GCE and the EAG for technical guidance in this review/evaluation.

15. **Annual Updated Data from Non-Academic Units.** As part of the annual updating of the Michigan Tech carbon footprint, data must be secured by the GCE from the relevant non-academic units. This updating is needed in order to evaluate the progress that is made to assess our movement toward carbon neutrality.

16. **"Revival" – Communicate to Campus Community.** Efforts and progress to impact campus carbon footprint reduction will be communicated to the campus community via a large event ("Revival") that will involve all parties. Lining up well-known speakers for the revival is recommended. This will help to generate more interest in the annual improvement process and involvement of the campus community.

17. **Pavlis Institute: Apply Technologies/Communicate Externally.** The Pavlis Institute will coordinate its activities with the GCE and EAG and will develop its own internal expertise related to assessing carbon footprints and undertaking improvement activities. The Pavlis Institute will use its knowledge and communicate the importance of carbon footprint to external entities (e.g., companies, local government entities, and international groups). Moreover, it is expected that the students of the Pavlis Institute will apply the expertise generated as part of the carbon footprint reduction process to external partners.

Recommendations

It is recommended that the following key actions be taken to make this project successful:

Action 1: Use the CA-CP model to initially account for the University's carbon emissions and offsets basing the carbon reduction goals on Scopes 1 and 2 only. Scopes 1 and 2 are defined in the model.

Action 2: Create a Green Campus Enterprise (GCE) – *Already done*. A proposal has already been developed for the GCE and has been approved by the Enterprise Program but a faculty to member needs to found to oversee this effort. A financial commitment from the Executive Team is needed to support part of the salary for the faculty member.

Action 3: Establish a named Sustainability Coordinator position at the university which would oversee the carbon reduction process. The main responsibility for the Campus Sustainability part of this project should be overseen by the Vice President of Administration, while the Provost and Vice President for Academic Affairs along with the Vice President of Research and Sponsored Programs should oversee the education/research integration portion of this project.

Action 4: Use the newly established Campus Energy Group (e.g., EAG) to provide an interface to the Green Campus Enterprise.

Action 5: Establish a sustainability website to communicate to the entire campus and to our stakeholders, the efforts that the University is undertaking to make our campus carbon neutral and sustainable and to highlight the educational and research efforts in this area. The initial website could be created through a Humanities course. This Sustainability Coordinator would oversee the website.

Action 6: Have the Provost's office monitor how individual academic units are contributing to this effort through the courses they offer and their everyday operations. This office would also make sure effectiveness reports are received annually from all groups involved.

Timeline and Challenges

The **timeline** for this process is on an annual basis. The establishment of this AQIP process has already begun with the creation of the GCE and EAG in the Fall, 2008. The first GCE will be started Spring semester, 2009 with funding from the Provost. At this time, it is thought that the EAG will function for two years as a cohesive group. After this, we are not sure what will happen with the continuous use of the EAG as advisors.

The **challenges** we face in the near and far future will be: (1) the establishment of the Revival, (2) maintaining the continuous process of communication, and (3) whether we are effectively changing our culture to reduce Michigan Tech's energy use. Annual reports from all groups on the effectiveness of their group to help with reducing our carbon footprint will be important. We may also face the challenge of how to bring other groups into this process such as other Enterprise groups, the Honors Institute, and persons teaching Sustainability principles in courses (Perspectives, etc.). Open suggestions on how we can do this should come from everyone on campus and from our stakeholders.

References

U.S. EPA, Inventory of U.S. Greenhouse Emissions and Sinks 1990-2004, Chapter 8, 2006.

IPCC, Guidelines for National Gas Inventories, Chapter 3, 2006.

Appendix A
Point of Reference Universities and Programs for Approaches to Carbon Neutrality

Greenhouse Gas Protocol (World Business Council for Sustainable Development) www.ghgprotocol.org
Offers guidelines for developing a customized greenhouse gas calculation tool for free download (13.1 MB)
www.ghgprotocol.org/plugins/GHGDOC/details.asp?type=DocDet&ObjectId=MjU1NjA

Middlebury College www.middlebury.edu/administration/enviro/initiatives/climate/carbon.htm
Based on a five-year strategic plan for advancing environmental education and campus sustainability, the Environmental Council established a Carbon Neutral (CN) Subcommittee to research and assess the possibilities for carbon neutrality at Middlebury in 2001. An extensive emissions inventory, adapting a toolkit distributed by Clean Air-Cool Planet (CA-CP), compiled campus data from 1990-2000 focusing specifically on energy use, transportation and solid waste.

www.middlebury.edu/administration/enviro/ec/ The Environmental Council (EC) is a standing committee of the College that recommends policy, undertakes assessment and projects, educates the college community and

advises the President about the sustainable campus. Comprised of a cross-section of faculty, staff and students appointed by their representative bodies, the EC has focused for the past several academic years on documenting greenhouse gas emissions and developing a process for reducing campus carbon emissions. In 2003, this effort resulted in the establishment of a separate Carbon Reduction Initiative Working Group to expand on the foundations laid by the EC. The EC is also working on policy and outreach efforts related to management of college lands, environmentally preferred purchasing, and carbon neutrality. An Environmental Grants program, funded initially by the EC budget as a pilot program and now by the President's discretionary funds, has allowed faculty, staff and students to explore over seventy campus sustainability initiatives.

www.middlebury.edu/administration/enviro/ Middlebury has an Office of Environmental Affairs, headed by a dean, and a director of sustainability integration. The Board of Trustees set a goal in May 2007 to become carbon neutral by 2016, challenging the entire College community to actively participate in efforts to achieve the new goal. The preferred approach to carbon neutrality is a combination of energy conservation and efficiency, renewable fuel sources, technology innovation, educational programming and learning, and, as a last option, purchase of carbon offsets. In 2008, the Board approved a campus master plan based on sustainability principles to guide the college's growth and development for the next 50 years.

The MiddShift Implementation Working Group (MSIWG) recently produced a "Guide to Carbon Neutrality at Middlebury College" with an overview of the College's carbon footprint, its goal to be carbon neutral by 2016, why it set this goal, and how it will develop a roadmap for implementing the goal. Students in the 2003 ES 010 class "The Scientific and Institutional Challenges of Becoming Carbon Neutral," created a 200-page report with fifty strategies to minimize campus climate impact (http://community.middlebury.edu/~cneutral). A sub-group of these and other strategies were synthesized into an initial carbon reduction portfolio targeting heating and cooling, electricity use, transportation, the generation of waste, and offsets and sequestration.

www.middlebury.edu/administration/enviro/initiatives/climate/Snow+Bowl+Goes+Carbon+Neutral.htm Middlebury downhill and cross country facilities have gone carbon neutral by purchasing offsets from Native Energy. A ZipCar car-sharing program was added for 2007-08 (www.middlebury.edu/administration/enviro/).

Tufts University http://sustainability.tufts.edu/index.htm
The Sustainability Office grew out of the Tufts Climate Initiative (TCI),which launched the Tailloires Declaration in 1990 and pioneered climate change mitigation at institutions of higher learning. Today, campus sustainability is part of the fabric of university life: an electric tractor mows the organic baseball field; water use is down 10% since 1990; students can rent electric and hybrid vehicles as part of a shared vehicle program; dining services offers organic and local foods and buys high efficiency appliances; renewable energy powers the new residence hall (a LEED Silver building, topped with photovoltaic and solar hot water systems); the library roof is turf; recycling is a part of everyday life; and student learning is integrated into these many initiatives through undergraduate and graduate student research, class projects, and internships. Tufts won the prestigious EPA Climate Protection Award in 2005 and was #10 on *Sierra* magazine's 2008 list of greenest schools. Tufts is committed to meeting or exceeding the Kyoto target, the goals of the New England Governors and Eastern Canadian Premiers, and the Chicago Climate Exchange targets (first university to join the CCE).

University of New Hampshire www.sustainableunh.unh.edu/index.html
Since 1997, the University Office of Sustainability—the oldest endowed sustainability program in higher education in the U.S.—has united faculty, staff, and students to facilitate the integration of sustainability across the UNH's CORE (Curriculum, Operations, Research, Engagement). UNH's Climate Education Initiative (CEI) is actively engaging the university community in integrating the ethics, science, technology, and policies of greenhouse gas reductions into the university's identity and practices. UNH joined Presidents Climate Commitment in 2007 and was one of 11 campuses to earn the highest "green rating" on the Princeton Review 2008 survey. The 1990-2003 greenhouse gas inventory report and 2004-05 update are available online www.sustainableunh.unh.edu/climate_ed/greenhouse_gas_inventory.html Sources of GHG emissions for 2005: 48% stationary sources (e.g. heating); 35% electricity; 17% transportation; less than 2% from

agriculture, solid waste disposal, and refrigerants. Despite a 5% reduction from 2004 to 2005, net emissions increased 25% from 1995-2005.

University of Vermont www.uvm.edu/climatechange/
After signing the ACUPCC in June 2007, UVM is updating their 2000-05 greenhouse gas emissions inventory, available in September 2008 from the Office of Sustainability www.uvm.edu/~sustain/ An environmental studies course, "Managing the Sustainable Campus," examined mitigation strategies for UVM's greenhouse gas emissions, which will help develop the University's Climate Action Plan (the final class presentation and recommendations are online). A group of graduate students proposed a university policy of proactive voting on climate-related shareholder resolutions at corporations in which the endowment is invested, and as a result, the Board of Trustees adopted new climate proxy-voting guidelines in May 2008 and the treasurer's office began voting in favor of resolutions asking corporations to reduce greenhouse gas emissions.

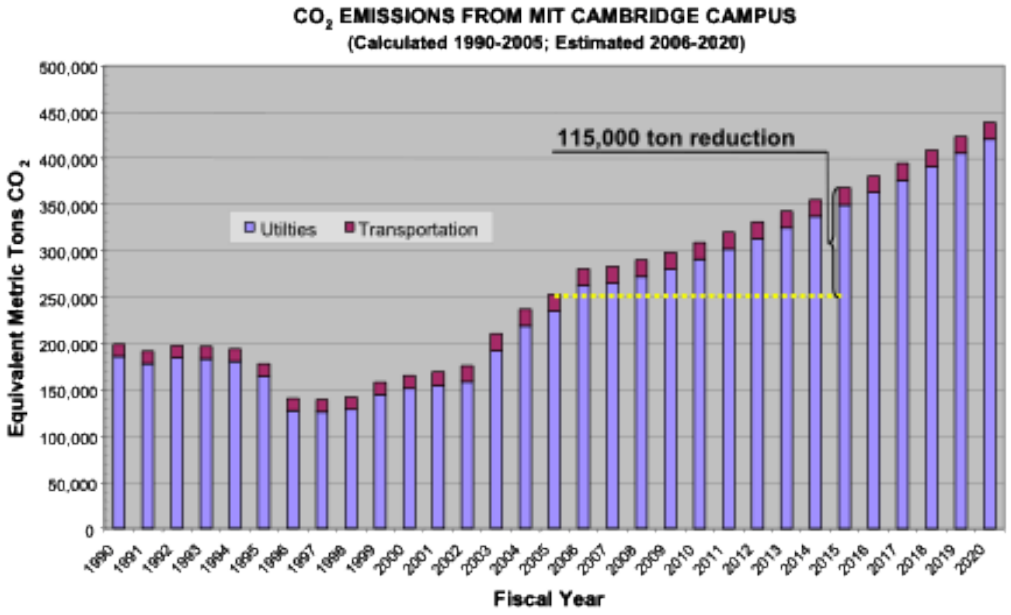
Campus Sustainability Assessment Database http://csap.envs.wmich.edu/pages/res_csa.html
Contains links to CA-CP greenhouse gas inventories for Bates College, Middlebury College, University of New Hampshire, and University of Vermont. Western Michigan University maintains the database.

Harvard University www.greencampus.harvard.edu/ggi/
Harvard was one of 11 campuses to earn the highest "green rating" on the Princeton Review 2008 survey. T***he Harvard Green Campus Initiative has inventoried the University's greenhouse gas emissions annually since 2000; data is available back to 1990.*** Harvard replaced the Clean Air-Cool Planet Inventory tool with its own GHG calculator in an effort to comply with the WRI/WBCSD Greenhouse Gas Protocol, which is the most standardized, internationally accepted methodology (www.greencampus.harvard.edu/ggi/methodology.php). HGCI recently completed the FY07 Greenhouse Gas Inventory. There have been several changes since FY06 in response to new developments and the emergence of best practices in the field of GHG measurement (specifically, the emergence of The Climate Registry as a national GHG registry). These changes are summarized below:

- **Electricity** is treated using a regional average emission factor, as opposed to a state-specific factor. This results in an overall lowering of emissions for all data years, because the New England grid is "cleaner" than the Massachusetts grid.
- **REC**s are shown as "adjusted emission reductions" as opposed to being deducted directly from the emissions total. This provides more transparency and is a policy-neutral treatment of RECs until a clear solution for assessing the GHG impact of RECs is available.
- **The Longwood Campus**, home to the Medical, Dental, and Public Health Schools, is not included in the FY07 analysis due to a lack of data from the Longwood Energy Plant.
- **Emissions** are expressed according to Scope 1 (direct on-site combustion) and Scope 2 (indirect emissions from purchased energy).
- **New emission sources** have been added to the inventory, including the Harvard fleet, refrigerant micro-releases, solid waste disposal, commuting, and air travel.

Harvard's GHG Emissions: Page Last Updated: August 15, 2007 to reflect better electric conversion factors. University-wide, greenhouse gas emissions have continued to skyrocket upwards, growing by 66% since 1992 and by 2.0% since FY05. Harvard's emissions are approximately equal to those of the entire island nation of Samoa (1) and our per capita GHG emissions are more than double the world average of 4.2 MTCDE/person (2). The major drivers of this increase are rising demand for electricity and steam.

Massachusetts Institute of Technology http://web.mit.edu/mitei/campus/projects.html
Campus greenhouse gas emissions are an important measure of MIT's energy and environmental impact, originally conducted as an MIT graduate thesis (http://web.mit.edu/mitei/campus/tiffany-groode-thesis.pdf). The inventory, completed in 2003 and updated in 2005, allows for striking forecasts of future emissions and highlights the importance of taking action now to reduce greenhouse gases. Thesis was response to City of Cambridge Climate Protection Plan to reduce emissions by 20% from 1990 levels by 2010.



Lighting retrofits, continuous commissioning of buildings, fume hood sash controls, and coil and filter upgrades are the focus of an initial $500,000 allocated for energy conservation. Many other projects and outcomes, including financial and carbon emission savings, are listed on the projects pages. Also, sustainability success stories: http://sustainability.mit.edu/Campus_Sustainability_Success_Stories

University of Colorado at Boulder http://ecenter.colorado.edu/greening_cu
The “Blueprint for a Green Campus” pledges to make the campus “carbon neutral” by 2025, reducing emissions, improving air quality and implementing sustainable habits and practices. CU will reduce its energy consumption through energy conservation programs like the Buff Energy Star, energy efficiency upgrades to buildings, efficient building design and construction, and campaigns like “When not in use, turn off the juice” which reminds people to turn off lights when they leave the room. CU is also investing in renewable energy on campus, such as solar power, and all new buildings will be offset with wind power. A 2000 carbon emissions inventory is currently being revised http://ecenter.colorado.edu/energy/projects/emissions/inventory.html

The chancellor has signed the Presidents Climate Commitment. Two new campus buildings have achieved LEED “gold” status. A Bike Station provides free minor bike maintenance. Activities are coordinated by the Environmental Center, which was established in 1970 and has seven permanent staff. CU Boulder signed the Talloires pledge in 1997. Students started purchasing wind power credits in 2000, then switched to the new Colorado Carbon Fund in 2008 to purchase Colorado-based offsets for campus carbon emissions. CU was #2 on *Sierra* magazine’s 2008 list of greenest schools

The CU Live Green Pledge: I pledge to live green by informing and educating myself on decisions I make that impact others and the environment. I will strive to increase my understanding of environmental consequences of my behavior and seek sustainable options to create a better world.

University of Florida www.sustainable.ufl.edu/
One of 14 guiding principles of the campus-wide Office of Sustainability (created in 2006): Monitor and minimize energy consumption, reduce and offset greenhouse gas emissions, and promote the development and use of renewable energy sources. President Lombardi signed the Talloires Declaration in 1994. President Machen was first to sign College and University Presidents Climate Commitment in 2006. Development of an action plan to achieve carbon neutrality by 2025 is underway, according to the 2008 "Vision for a Sustainable UF" report (www.sustainable.ufl.edu/documents/sustainability-vision.pdf). UF received 97 of 99 points in Princeton Review's first green campus rating in 2008, UF hosted the NCAA's first carbon-neutral football game in 2007; a nonprofit Neutral Gator group will offset all seven 2008 home games (www.neutralgator.org).

Cornell University www.sustainablecampus.cornell.edu/energy/climateneutral.cfm
Cornell's president signed the ACUPCC in 2007, committing to achieving a climate-neutral campus. The campus sustainability coordinator compiled the 2006 Green Report (pp. 20-21 on carbon emissions) www.utilities.cornell.edu/utl_firstgreen%20report.html Cornell reduced carbon dioxide emissions through energy efficiency by 50,000 tons per year between 1980 and 2000 at a cost savings of $7 million.Energy upgrades include lake-source cooling, a new cogeneration plant, and an Energy Conservation Initiative that has reduced CO2 emissions 15% since 2000 (www.sustainablecampus.cornell.edu/energy/energy.cfm). Facilities Services has a Sustainable Computing Guide with electronics purchasing, energy management, and recycling guidelines **(**http://computing.fs.cornell.edu/fsit/Sustainable/FSSustainableComputingGuide.pdf). KyotoNOW! began as a project of the Cornell Greens in 2001 and became an official student organization after the U.S. government pulled out of the Kyoto Protocol. Students who wanted Cornell to commit to the goals of the protocol convinced the University to create the Kyoto Task Team and several projects and initiatives that allowed Cornell to reach the Kyoto goals. www.rso.cornell.edu/kyotonow/history.html and www.sustainablecampus.cornell.edu/getinvolved/Staff%20orgs/kyototeam.cfm.

Virginia Tech www.facilities.vt.edu/sustainability
VT established an Energy & Sustainability Office and coordinator in 2007. *VT* will develop a **climate action commitment and** campus sustainability plan**,** aimed at reducing global warming emissions in everyday campus operations, by the end of the **spring** 2009 **(***www.vtnews.vt.edu/story.php?relyear=2008&itemno=374***)**. A *GHG inventory* is *not mentioned*, but ***Virginia Tech*** and surrounding communities **are converting their diesel fuel-powered public works and facilities vehicles and power equipment to B20 *biodiesel fuel*** to reduce their greenhouse gas emissions **(***www.vtnews.vt.edu/story.php?relyear=2007&itemno=233***).** VT *received an overall grade of C- from the Sustainable Endowments Institute in 2008 but an A for its alternative transportation program (www.endowmentinstitute.org/sustainability).*The state of Virginia has a plan to reduce Virginia's carbon emissions 30% to 2000 levels by 2025 (www.via.vt.edu/fall07/feature1.pdf).
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Georgia Institute of Technology www.sustainable.gatech.edu/campus
The Institute for Sustainable Technology and Development has links to resources for green purchasing, photovoltaic research (www.sustainable.gatech.edu/faculty/profiles/rohatgi.php), and integration of sustainability into campus master plan (www.space.gatech.edu/CPSM_Folders/masterplan/Sustainability.pdf). Facilities Management has links to energy conservation (www.facilities.gatech.edu/om/conservation.php). Article "Tech earns low campus sustainability grade" from the Sustainable Endowments Institute: http://nique.net/issues/2007-02-09/news/1 is no longer on the website (GT's 2008 grade was a C). National Wildlife Federation's Campus Ecology recognized GT in 2008 for several exemplary programs, but not for energy efficiency and conservation. It was one of 11 campuses to earn the highest "green rating" on the Princeton Review 2008 survey. Searches on "greenhouse gas," "carbon emissions," and "carbon footprint" turned up nothing, except in facilities design standards (www.facilities.gatech.edu/dc/GTSPECS.pdf)—interesting because they have signed the Presidents Climate Commitment (also not found).

Carnegie Mellon University www.cmu.edu/greenpractices
Campus energy projects on CMU's Green Practices Committee website mention a student intern conducting a greenhouse gas inventory **(**www.cmu.edu/greenpractices/get_involved/energy_projects.html) but hasn't been updated since FY03.

Carnegie Mellon researchers told federal officials in Washington, D.C., that carbon dioxide emissions from electric generation plants can be reduced and eliminated without damaging the economy [June 2005]. Their report, commissioned by the Pew Center on Global Climate Change, also stressed that rapidly establishing a clear timetable for reducing carbon dioxide emissions from power plants will result in lower costs than waiting to do so. In addition, the report recommended that government officials and the $250 billion electricity industry focus resources on developing "promising technologies that do not require fundamental breakthroughs," like carbon capture from new types of clean coal generators called coal gasification plants. For more, visit http://www.cmu.edu/PR/releases05/050615_greenhouse.html.

August 2007: Pittsburgh aims to reduce its carbon emissions, with Clean Air-Cool Planet directing a task force. CMU students compiled an inventory for the city www.post-gazette.com/pg/07229/810242-53.stm Also Pittsburgh Climate Protection Initiative www.pittsburghlive.com/x/pittsburghtrib/s_522932.html

Rensselaer Polytechnic University www.rpi.edu/dept/ess/greening/
Found nothing on campus GHG inventory. The Greening of Rensselaer Initiative, started by the EcoLogic student group in 1995, includes energy conservation (link broken). RPI has a Center for Future Energy Systems with an online tutorial: www.rpi.edu/cfes/edu_tutorial.html Research on GHG emissions in China. RPI President Jackson addressed the National Science Foundation on innovation and energy security in April 2007 http://www.rpi.edu/president/speeches/ps042307-nsfmathscience.html and later, the Washington Post: www.rpi.edu/president/speeches/The_Energy_Question.pdf

Lehigh University www.lehigh.edu
Didn't find anything on greenhouse gas emissions. The only hits on "sustainability" were for Dining Services (www.lehigh.edu/dining/about_sustainability.html). Research on carbon accumulation in Canadian peatlands and a website for the Environmental Change Group are within the Dept. of Earth and Environmental Sciences: www.ees.lehigh.edu/EESdocs/environmental_change.html

Missouri University of Science & Technology (formerly University of Missouri Rolla) www.mst.edu/
Didn't find anything on campus greenhouse gas emissions other than reference to EMS. Little mention of campus sustainability on website in the past other than research on internal combustion engine controls to reduce emissions and improve energy efficiency; more promotion of nuclear energy and exploration for fossil fuels. A speaker will address climate change in September 2008 during first-ever Greenfest event: "The purpose of the event is to celebrate Missouri S&T's commitment to becoming a green campus that is focused on environmental sustainability and energy conservation" (http://news.mst.edu/events/2008/greenfest.html

Michigan State University www.ecofoot.msu.edu
MSU is committed to reduce greenhouse gas emissions 15% below 2000 baseline within 10 years through the Chicago Climate Exchange, as discussed in the 2007 Campus Sustainability Report (www.ecofoot.msu.edu). "Footprints" newsletter from Office of Campus Sustainability has articles on carbon offsets, winning the 2007 AASHE Campus Sustainability Leadership Award, etc. www.ecofoot.msu.edu/newsletters/footprints.09.07.pdf In its Campus Environment 2008 Report Card, the National Wildlife Federation found that MSU not only has the greatest number of "exemplary programs" among colleges and universities within the state of Michigan, but it is also one of the top five campuses in the nation for such programs (http://news.msu.edu/story/5634).

University of Michigan www.umich.edu
The 2004 Environmental Task Force Advisory Report www.umich.edu/pres/committees/envrpt/ proposes measuring GHG emissions as one of their environmental performance indicators. It doesn't say how they will be calculated, but references the state inventory project below, which used **"**methodologies outlined by the U.S. EPA's State and Local Capacity Building Branch and the Emission Inventory Improvement Program (EIIP). The State Greenhouse Gas Inventory Tool (SIT) was used to calculate emissions for these gases from energy related activities (stationary and mobile combustion of fossil fuels and fugitive emissions), industrial processes (non-energy related activities), agricultural activities, land-use change (carbon sequestration resulting from land-use change, excluding forestry) and waste (solid waste and wastewater management

activities). The Center for Sustainable Systems conducted a greenhouse gas inventory for the State of Michigan (2005) and 2007 update www.snre.umich.edu/newsroom/2007-05-23/reducing-greenhouse-gas-emissions-can-boost-michigans-economy

Appendix B
Other Models for Carbon Accounting

CoolClimate Calculator is a campus/community carbon footprint calculator that University of Calilfornia, Berkeley developed. It is set up for individuals/households like other carbon calculators and would have to be customized for other applications: http://berkeley.edu/news/media/releases/2008/02/28_carboncalc.shtml and http://bie.berkeley.edu/calculator.html

Zerofootprint Universities http://www.zerofootprint.net/general_articles/universities (Wackernagel is an advisor.) Must purchase software, but allows individual/aggregate measurement and reduction goals based on the Greenhouse Gas Protocol. "You can customize Zerofootprint Universities to your requirements. We co-brand the application, and link it to your website, with your university's logo appearing on all pages. You can tailor the questions in the carbon footprint calculator to suit your community, and we program in the appropriate emissions factors for your location which will be used for all the calculations. You can adapt the 'Community' section of the application to allow challenges between your departments, classes or other groups."

Green Student U: www.greenstudentu.com/carbon_footprint_calculator.aspx Links to various online calculators and other resources, aimed at college students

E-Redux www.eredux.com/states/ State-by-state per capita and total carbon footprint and ranking (Michigan is 9th highest in total emissions, but 31st per capita; Vermont ranks 50th in both; Wyoming is #1 per capita and 31st overall; Texas is #1 in total, 10th per capita)

Nature Conservancy (individual/household vs. US and world averages; home based mostly on #BR) http://www.nature.org/initiatives/climatechange/calculator/

Carbon Footprint Ltd. (UK, individual vs. US, industrialized, world averages; allows exact heat and elec. data for home, specific cars) http://www.carbonfootprint.com/

BP Carbon Calculator (allows credit for green electricity) http://www.bp.com/extendedsectiongenericarticle.do?categoryId=9015627&contentId=7029058

EPA Personal Carbon Calculator www.epa.gov/climatechange/emissions/ind_calculator.html

Climate Crisis www.climatecrisis.net/takeaction/carboncalculator/ An Inconvenient Truth website

Safe Climate Calculator www.safeclimate.net/calculator/ World Resources Institute

BeGreen www.begreennow.com/calculator?source=0I0909 Sells Green Mountain Energy carbon credits

Global Footprint Network (published ecological footprint standards; calculates acres rather than carbon; number of earths if everyone lived as calculated) www.footprintnetwork.org/gfn_sub.php?content=calculator

EnergyStar Home Energy Yardstick
www.energystar.gov/index.cfm?fuseaction=home_energy_yardstick.showStep2

Low Impact Living www.lowimpactliving.com/scores

Consumer Consequences (American Public Media, using data from Redefining Progress):
http://sustainability.publicradio.org/consumerconsequences/