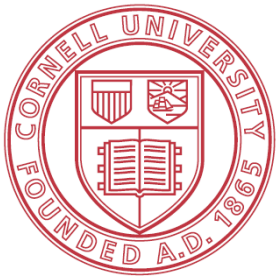

CORNELL UNIVERSITY
CLIMATE ACTION PLAN

2011 UPDATE

Prepared for

The President's Sustainable Campus Committee

CORNELL UNIVERSITY
Ithaca, NY

January 2012

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SUMMARY UPDATE

BACKGROUND

This document is the 2011 Update to Cornell's Climate Action Plan (CAP). This is the first formal update to the CAP, which was released to the public in September, 2009.

Cornell's 2009 CAP was lauded as one of the best in the nation by Second Nature, the organization that spawned the Presidents Climate Commitment. In 2010, Cornell was awarded the 1st Annual Climate Leadership Award for Institutional Excellence in Climate Leadership.

Figure 1: Vice President Kyu-Jung Whang accepts Climate Leadership Award

The CAP effort was initiated in 2007, when President David Skorton signed the Presidents Climate Commitment, a pledge that Cornell University would pursue a path towards climate neutrality. The CAP, created with financial support from the New York State Environmental Research and Development Authority (NYSERDA), was a comprehensive response to that challenge.

The web-based 2009 CAP proposed the complete elimination of net greenhouse gas (GHG) emissions required to heat, cool, and power Cornell's Ithaca campus by the year 2050. The original CAP is preserved in pdf format at the following URL: http://www.sustainablecampus.cornell.edu/climate/index.cfm. That site also links to updated information as summarized in this report.

This update does not repeat all of the initial process and analytical evaluations that

accompanied the original CAP. Instead, this 2011 Update focuses on the progress of the CAP effort in the first two years and changes that have occurred since the approval of the CAP by Cornell's leadership.

SIGNIFICANT PROGRESS OR CHANGES to the CAP

Since 2009, Cornell has reduced GHG emissions by almost 80,000 tons, an improvement of over 25%.

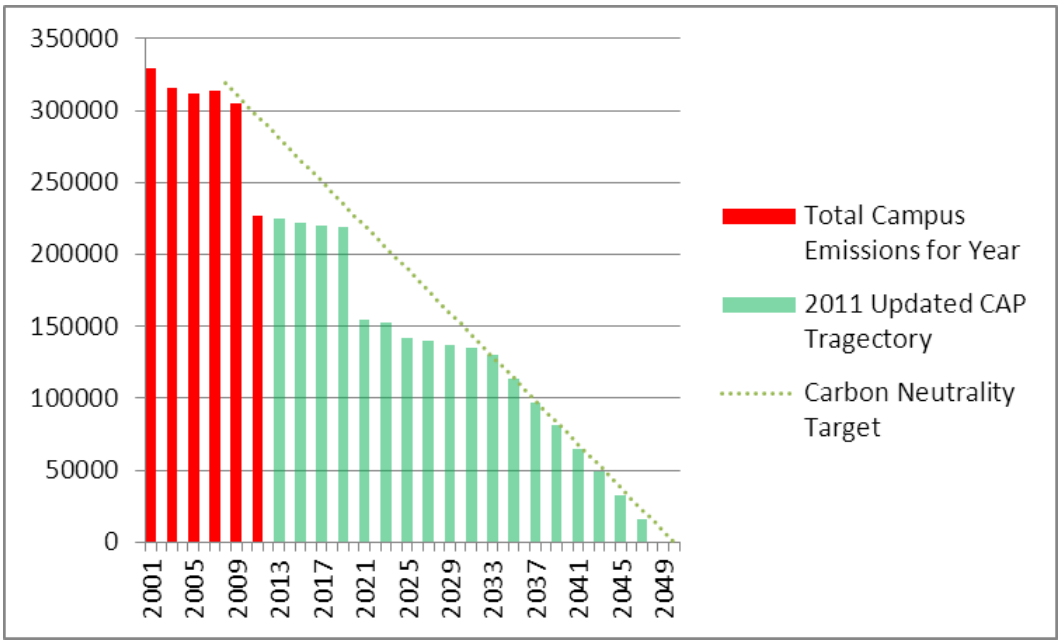


Figure 2: Cornell's Success: Ahead of Projections in 2011

This improvement was due to many factors, most significantly the high level of performance of the Cornell Combined Heat and Power Plant (which went on-line in 2010) and a decision to eliminate all coal combustion at the University. Cornell's "no coal pledge" was not an action included in the 2009 CAP but, rather, a further sign of institutional leadership; the CAP assumed that coal would not be phased-out until about 2030, when retirement of the existing coal boilers was planned.

This unprecedented 25% direct improvement is only the most visible success. Other important successes include tremendous progress in the following areas:

- Green Development (avoids future energy use)
- Energy Conservation (reduces current use)
- Alternative Transportation (reduces current and future energy use).

Together, these three highest-priority action areas have significantly reduced future

projections of energy needs for campus. This is a critically-important start for a large research campus looking to replace fossil-based energy with renewable energy, since the latter tends to be less concentrated and more difficult to harness.

Moreover, there is solid evidence that these baseline programs will continue to be effective in at least the near-term, creating a solid foundation for future achievement.

There are few significant changes to the CAP. This 2011 CAP update retains 19 Actions very similar to the original. Progress in some areas has exceeded the original goals while in other areas the actions have not progressed to the level planned, just as foretold in the 2009 CAP. Significant deviations from the original CAP Actions are as follows:

- Green Development Actions On or Ahead of Targets: Green Development Efforts (Land Use, Space Planning and Management, and Building Energy Use) have been widely embraced by Cornell planners and leadership. Generally poor economic conditions in society over the past two years have reinforced the value of planning efforts which maximize existing building and land space use and enforce low energy use standards for new buildings, all of which help to reduce the need for future energy and maintenance costs.

- Energy Conservation Goals Embraced: In the midst of reduced capital spending, Cornell has nonetheless continued to support funding for energy conservation at the highest levels. Much of this support is a tribute to the success and dedication of Cornell's Energy Management team in recent years. Over the next five years, a total expenditure of over $45M is planned to implement a broad program of energy conservation on the Cornell campus and beyond. Meanwhile, student- and department-initiated activities such as "Lights Off!" and "CALS Green" have advanced to bolster the efforts to educate campus energy users on reducing their energy usage while meeting program needs.

- Transportation Alternatives Active and Expanding: Despite challenging economic realities, Cornell continues to provide an extraordinary series of programs in Transportation Demand Management while re-vamping our fleet vehicle program with significant improvements in average vehicle mileage. In addition to on-going support for local transit, Cornell has also supported some innovative efforts, such as a highly-successful "campus-to-campus" bus service between Ithaca and New York City (Weill Medical College) that is used by

hundreds of administrators, staff, faculty, and students, replacing vehicle and airline trips along this route (the most frequent destination for Cornell business travel) and Big Red Bikes, a bike-share program hosted from Cornell's central library.

- Fuel Mix and Renewable Actions: Ramping Up Research Efforts: The Fuel Mix and Renewable Actions wedge represents actions whereby conventional energy sources (purchased electricity and fossil fuels) are replaced with renewable resources (geothermal, wind, biomass, etc). Continuing progress and evolution towards lower GHG emissions have led to elimination of one action and re-evaluation of a second action. Specifically, an action suggesting co-firing of wood with coal is no longer part of the CAP program due to the University's decision to eliminate coal, a decision now fully implemented. In its place, Cornel is evaluating direct biomass combustion (without coal). Similarly, an Action to replace a portion of steam line with better-insulated line is still being evaluated, with the evaluation now broadened to consider the possibility of converting to a hot water line, necessary for other CAP initiatives. More complete discussions of these changes are included on the individual CAP update sheets attached at the end of this summary report.

  Capital funding constraints and lower fossil energy prices have delayed a number of other action targets. Due to limited capital, poorer returns-on-investment, and more-urgent University priorities, none of the projects in this category are fully-funded under the 2011-2016 Capital Plan. While a lack of capital funding may delay development-scale implementation, research efforts in many areas have expanded. With coordination and financial seed money from the **David R. Atkinson Center for a Sustainable Future,** which **received a startling $80M endowment commitment in 2010,** researchers are focusing on plans for demonstration-scale research activities. Efforts are ongoing to identify funding sources which will allow these important initiatives to advance.

- Offsetting Actions: Exploration and Planning. As indicated in the 2009 CAP, Offsetting Actions represent the lowest hierarchy of the activities in the CAP. Cornell's Climate Focus team has yet to formally advance offsetting actions beyond the pilot stage. However, the potential here is great. Cornell continues to provide a wide range of support beyond our campus boundaries that could potentially be formalized into offset "credits". For example, Cornell Cooperative Extension (CCE) and other campus groups have continued their

long history of helping others use energy wisely, Cornell has provided some support to local "carbon credit" effort (the Finger Lakes Climate Fund) by "offsetting" travel for a 2011 conference ("Big Ten and Friends"), an action that funded local energy conservation and renewable energy projects, and Cornell's academic and research staff continue to provide state-of-the-art assessments and support for better land-use methods, supporting healthy diverse environments while sequestering carbon.

Specific Changes to Actions. Table 1 provides a high-level review of the 19 original CAP actions and changes reflected in the CAP through 2011. Details on the status of individual actions are included in the summary sheets in the appendix.

Table 1: Overall Status of 2009 CAP Actions

ACTION	ACTION STATUS
Green Development	
Space Management	On target
Land Use	On target
New Construction Energy Standards	On target
Energy Conservation	
Building Energy Conservation	On target
Conservation Outreach	Successful CALS trial; resources needed to expand
Reduce Thermal Losses	Planned; capital fund request under review
Smart Grid	Some progress; campus-wide program undefined
Alternative transportation	
Commuter Travel	On target
Business Travel	Modified; on target
Fleet Vehicles	On target; short-term goals added
Fuel Mix and Renewables	
Steam Turbine Upgrades	Planned; no capital funding yet requested
~~*Co-fire Wood in Boiler 8 with Coal*~~	~~*No Longer Needed*~~
Biomass Combustion	*New Action under consideration*
CURBI (Biomass Demonstration)	Major grant unsuccessful; research continues
Hybrid EGS	Study on-going; no implementing funds yet
Hydroelectric Upgrades	Planned; some work funded
Large-Scale Wind	Planned; no capital funding yet requested
Landfill Gas (Geneva Campus)	Planned; negotiations continue
Carbon Offsetting Actions	
Local Offset Programs	Planned; local program being developed
Global Offset Programs	Planned (future)

Section 1: Updates to the 2009 Planning Process

The 2009 Climate Action Plan included a broad spectrum of action to reduce energy growth, reduce energy use of current facilities, and move towards a replacement of fossil fuels with renewable or low/no-carbon energy sources. These activities were grouped into 19 "Actions". A functional representation of CAP options integrated into the CAP is shown in Figure 1.1. The color-coating in this chart represents the further organization of actions as discussed in the text that follows.

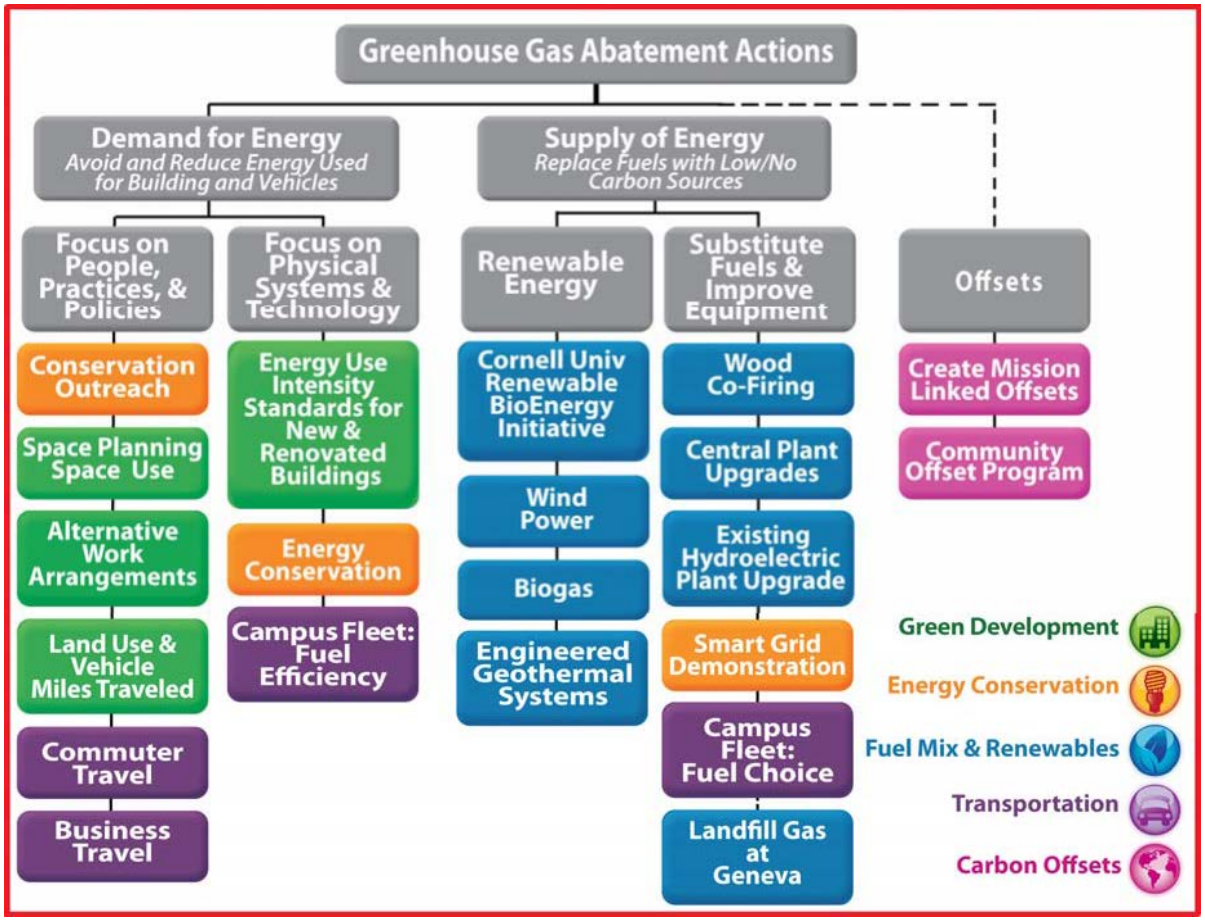


Figure 1.1: Functional Organization of CAP Options

As suggested by the color-coating in Figure 1.1, these actions were categorized into the following five groupings:

- **Green Development Actions (green)** – Actions which minimize the GHG impacts of future development of the campus.
- **Energy Conservation Actions (orange)** – Actions that reduce the energy

needs (and related GHG emissions) of the operating campus. These are also referred to as "demand-side reductions".

- **Alternative Transportation Actions (purple)** – Actions that reduce the GHG impacts of commuting, business travel, and Cornell's own fleet.
- **Fuel Mix & Renewable Actions (blue)** – Actions related to the supply of energy to campus – both on-campus combustion and purchased electricity. These actions include actions that improve supply efficiency as well as actions that substitute low carbon, or no carbon renewable energy sources for traditional fossil fuel (gas, oil, coal) sources.
- **Offsetting Actions (rose)** – Actions which offset GHG emissions from fuel and electrical use for campus activities. These include sequestration activities (within or outside campus boundaries) and programs which reduce GHG emissions in the community or broader world outside of campus.

Once organized in these groupings, teams of campus experts were assigned to evaluate potential "actions" within each group, rate them, and recommend them for inclusion into the overall CAP program, as detailed in the 2009 CAP.

This general process remains intact as of the 2011 Update. While the original "wedge evaluation" groups are no longer organized, the Actions have been dispersed to the appropriate PSCC Focus Teams for continued assessment and guidance. This constant re-assessment has led to some incremental changes within Actions, but the overall approach and evaluation process is unchanged.

Overall Energy Supply and GHG Calculations: Updated Assumptions

Implementation of the CAP will significantly impact Cornell's future energy supply and demand. The 2009 CAP utilized then-current energy "futures" pricing, campus growth projects, and other similar internal and external data to determine the most ecological and economical path to carbon neutrality, with the full knowledge that actual future conditions might be very different.

In 2009, the campus utilized fossil fuel for the large proportion of its energy usage. Substantial reductions in coal and purchased electricity occurred in 2010 when the Cornell Combined Heat and Power project began. With the no-coal pledge, coal has now been replaced with cleaner-burning natural gas.

For 2011, we updated a tool for internal energy forecasts; this tool included estimates

of fuel use and associated carbon emissions. In addition to the no-coal action (not part of the CAP), our latest forecast reflects incremental changes in the forecasted schedule and/or impact for other projects. Our forecast will continue to change as the timetable and impact of individual actions change and as actions are added, deleted, or modified. Our goal remains net zero GHGs by 2050.

The carbon calculations in the 2009 CAP incorporated New York State's ambitious goals of carbon reduction in the electric grid supply (80% reduction by 2050). This assumption led to a planned future increase in grid electricity purchases towards the latter part of the CAP forecast, since grid electricity would be the cleanest energy then available. If NY is unable to meet that goal, Cornell might reduce GHGs further by generating more electricity using then-available technologies, rather than relying as heavily on the grid. While NY grid energy has continued to reduce GHG emissions associated with each unit of energy produced in recent years, future achievement of an 80%-lower goal remains highly uncertain. Our revised 2011 tool includes an option to model a more modest future performance of the NYS grid; for our current update we assumed a 25% reduction in GHGs per watt, to ensure we are poised to deal with a wider range of future conditions. This assumption will be re-evaluated and adjusted as appropriate during future updates.

Similarly, changes occurred in the financial assumptions used in the 2009 CAP, as discussed in Chapter 2 – Benefits. Generally, lower-than-anticipated natural gas pricing, the lack of a viable local emissions market to encourage climate action, and a tighter capital market have combined to reduce the financial benefits of many actions, especially those that are capital-intensive.

Overall, the broad assumptions used for the 2009 CAP remain in place, modified as data and circumstances change to reflect as accurately as possible current energy and economic realities.

Section 2: Benefits

FINANCIAL BENEFITS

A comprehensive financial analysis accompanied the original 2009 CAP. Based on that analysis, it was projected that Cornell would benefit substantially over time with the implementation of the CAP. The many assumptions involved in that analysis were documented as part of that original analysis. The initial CAP essentially assumed the availability of capital for cost-effective investments with positive life-cycle returns. For projects without a positive return on investment, the CAP assumed that government subsidies would be awarded to demonstrate more risky and less proven technologies.

Financial assumptions used in the 2009 CAP included detailed projections of future energy costs and carbon valuation, based on proposed regulations. Since that original analysis, many internal and external parameters used in the analysis have changed significantly. These changes have included the following:

- Energy prices have fluctuated broadly. Significantly, both electricity and natural gas prices are much lower than at the time the original assessment was done, reflecting the excess natural gas capacity available regionally in 2011. Lower external prices make it more challenging to achieve financial savings with alternatives.

- Broad economic stagnation and a reduction in regional energy use, especially in manufacturing and transportation, has substantially de-valuated the regional GHG credit market, since generous initial regional GHG targets can typically be met without credit purchases; the lack of substantive new climate-related legislation has also contributed to this market decline.

- Despite continued broad donor and grant support on many fronts, Cornell was not successful in competitive solicitations for limited State and Federal grants pursued to support some specific CAP development proposals (CURBI, Geothermal, Steam Turbine upgrades).

- The growth rate of campus facilities has been lower than projected.

- Cornell's access to financial capital has been reduced through internal policies which aim to strengthen Cornell's long-term financial standing.

The combined result of these changes is that the overall fiscal value of some CAP Actions was determined (or presumed) to be reduced. As a consequence, a number of actions, especially those that require significant capital investment, have so far been deferred beyond Cornell's current 5-year planning period. This type of continual re-assessment was anticipated in the 2009 CAP, although the degree of change in the relatively short time since 2009 is greater than was broadly anticipated.

As documented in the initial CAP, specific approval and authorization processes are required which incorporate rigorous fiscal accounting and evaluation. These processes are documented and reviewed by appropriate University administrators and trustees prior to moving forward with capital projects on campus, helping Cornell maintain fiscal discipline. As energy prices, demands, and the cost of technologies change, and as the availability of specific grant funding changes year-to-year, Cornell will continue to evaluate Actions and alternatives in an effort to minimize adverse fiscal impacts.

Institutional Benefits

There are secondary financial institutional benefits associated with the prominent research and educational programs associated with the CAP. These include the value of good will, job creation, community development, and academic growth. While more difficult to quantify, these benefits may exceed the "single bottom line" benefits presented in the 2009 CAP, given the mission and focus of the university and its means of funding.

Throughout the CAP development, the development team remained focused on enhancing not only Cornell's facilities, but also the University's primary mission. Thus, the 2009 CAP reflected a continuation of the historical transformation of the University, as the institution continues to meet the modern education, research, and outreach needs of society. Just as new facilities for multi-disciplinary nanotechnology and life sciences research ensure Cornell is poised for future advances in these areas, the CAP supports Cornell's efforts to anticipate and promote research and education that responds to all of society's grandest challenges.

In consideration of these principals, the PSCC and its working sub-committees used the following principal criteria to select actions for CAP inclusion:

- **Actions that are primarily facilities-related** should provide "single bottom line" financial benefits. These recommendations are largely under the control of Cornell's Facilities Administration or the Provost's Office. Actions that did not meet this test were not recommended. However, even for these facility-related actions, the benefits are not solely energy reduction or financial. Other identified benefits for actions are presented in **Table 2.1**.

- **Actions that provide significant research opportunities** compatible with existing or desired Cornell academic areas were recommended conditionally, based on Cornell's success in obtaining the outside research or development funding necessary to advance the action. **Table 2.2** provides a summary of the research opportunities actions included as CAP actions. **Table 2.3** provides a sampling of additional major research opportunities for which specific CAP actions have not yet been defined.

- **Actions likely to improve the community** were sometimes recommended, even when a direct financial return investment could not be reliably documented. Pursuit of these actions will require careful analysis to ensure these actions are the best use of Cornell funds. See **Table 2.4**.

- **Table 2.5** identifies **Actions that directly benefit undergraduate education**.

Table 2.1: Additional Benefits of Operations-Focused Actions

Action	Other Primary Benefits
Space Planning and Management	Sustain open space; reduce future operating costs; flexible work offers higher employee satisfaction
Building Energy Standards	Higher comfort; smaller systems
Energy Conservation	Higher comfort and HVAC control
Commuter Travel	Less campus traffic; better services
Business Travel	Improved video-conferencing capacity
Campus Fleet	Campus vehicles are visible symbols of sustainability
Upgrades to Hydro Plant	Some capital needed for maintenance in any case
Replace TG-1	Will also extend turbine life
Biomass in Boiler 8	Community economic benefit; improved fuel security
Hybrid EGS and Biogas	Regional economic benefit (jobs)/national tech interest.
Wind Power	Visible symbol of sustainability & technological acceptance.
Landfill Gas @ Geneva	Enhances reputation (*not part of Ithaca GHG inventory*).

Table 2.2: Additional Benefits of Research-Focused CAP Actions

Action	Primary Research/Education Benefits	Notes
Engineered Geothermal Systems (EGS) demonstration project	Multidisciplinary demonstration-scale research involving multiple academic departments, including earth sciences, mechanical engineering, geology, physics, chemical engineering, etc. Multiple educational interactions possible; multiple graduate student opportunities; funding through USDOE on-going.	Professor Jeff Tester leads this effort, and has a DOE funded study underway Range of GHG depends on demonstration scale, use of energy retrieved, and level of implementation of demand-conservation items.
Cornell University Renewable Biofuels Institute (CURBI) demonstration project	Multidisciplinary demonstration-scale research involving multiple academic departments, including nearly all CALS groups, engineering, planning, social sciences, etc. Multiple educational interactions; graduate student opportunities.	Professor Mike Hoffman leads this effort. It has important job-creation potential, especially for rural communities. Well suited to Cornell's land-grant mission.
Smart Grid	Multidisciplinary demonstration-scale research involving engineering, social sciences, and economics investigations. Can leverage Cornell's historical investments in smart utility infrastructure.	Professors Bob Thomas, Max Zhang, Lang Tong, Tim Mount, and others are involved in this multidisciplinary research effort. Enables energy conservation.

Figure 2.3: Additional Benefits of Future Research Options

Research-focused efforts not currently in the CAP ***These Actions may develop into CAP actions in future updates.***	
Solar Photovoltaic	Ulrich Wiesner, the Spencer T. Olin Professor of Materials Science and Engineering at Cornell, leads a team of researchers seeking a lower-cost, highly efficient material for solar photovoltaic cells. Cost and efficiency issues continue to be the primary impediments to greater solar PV use on campus; similar issues apply broadly in society.
Energy Materials Center	Co-Chaired by Héctor Abruña and Frank DiSalvo, a multidisciplinary research team is pursuing a range of research topics, including application of new materials and hydrogen delivery and storage systems that would allow for more robust, efficient, cost-effective fuel cell technology. Fuel cells theoretically allow much higher energy-to-electricity conversion rates than conventional sources and are of national and international interest as a power source for mobile or stationary applications. In a future in which biogas is available, a fuel cell might significantly extend the value of that gas.
Cellulosic Bio-fuels	Professor Larry Walker is leading a major initiative involving multi-disciplinary researchers across campus in the exploration of biodiesel generation from non-food crops grown on marginal land. This is an area of critical national and even international importance. Liquid fuels are not well addressed in the CAP – and remain a major GHG source even in year 2050. Large job-creation potential could exist for the region, provided that negative social impacts are minimized.
Carbon Sequestration Research and Demonstration	Projects of varied scale are possible. Due to the various means of carbon sequestration possible, these projects could involve soil scientists, plant scientists, chemists, chemical engineers, mechanical engineers, and others. Specific actions could be included that reflect specific faculty interest and grant funding availability. This opportunity is not yet well developed, but has a high potential as a research topic. Cornell's on-site combustion facilities provide opportunities for real- world demonstration of technologies. Success of sequestration, combined with other actions, could result in "negative" carbon emissions, by locking in GHG emissions (carbon) derived from biogas combustion.

Figure 2.4: Additional Benefits of Leadership Actions

Recommended Action	How Action Enhances Reputation or Outreach	Notes
Land Use (Tree and Trail) Programs	Trees and appropriate plantings along with pedestrian/bike amenities are highly visible and have high aesthetic, educational and ecological value while complementing Cornell's image and built environment.	Plantings and trails are popular donor projects. Program can be easily modified to fit finances.
Community Energy "Offsets" Program	Improving renewable energy use and energy efficiency in the community extends Cornell's goodwill and reputation for technical excellence. Program would be developed with community leaders.	Enhancement to existing programs within CCE; fits overall land-grant mission; high interest by active community members. Funding may be available to develop model community offsets program; future funding may be component of Cornell's traditional PILOT contributions or could result in salable offsets.

Figure 2.5: Additional Benefits of Student Education Actions

Recommended Action	Educational Value	Notes
Conservation Outreach	Educating and enabling individual users to reduce energy use could provide large life-cycle benefits for the University and educate thousands of future graduates on sustainable energy use. Student and/or staff "eco-reps" would improve value of program to directly complement overall CAP actions.	Difficult to quantify reduction in advance of application; ripe field for social and physical science study and research efforts. To be directed through academic programs and Student and Academic Services (Facilities professionals can provide feedback, training, and data availability).

Section 3: CAP Background, Governance, and Basis

Cornell's Climate Action Plan (CAP) was created in response to the American College & University Presidents Climate Commitment (ACUPCC), a national effort to highlight the leadership role of colleges and universities to address global warming. Cornell President David Skorton announced his support for the commitment in early 2007 and Cornell became a Charter Signatory in September of that year. Over 600 institutions signed the ACUPCC Pledge as of fall 2011.

ACUPCC Requirements

Details of the ACUPCC are found on the website at the following Uniform Resource Locator (URL): http://www.presidentsclimatecommitment.org/. The following italicized text is excerpted from that website:

The American College & University Presidents Climate Commitment is a high-visibility effort to address global warming by garnering institutional commitments to neutralize greenhouse gas emissions, and to accelerate the research and educational efforts of higher education to equip society to re-stabilize the earth's climate.

...

Presidents signing the Commitment are pledging to eliminate their campuses' greenhouse gas emissions over time. This involves:

- *Completing an emissions inventory*
- *Within two years, setting a target date and interim milestones for becoming climate neutral.*
- *Taking immediate steps to reduce greenhouse gas emissions by choosing from a list of short-term actions.*
- *Integrating sustainability into the curriculum and making it part of the educational experience.*
- *Making the action plan, inventory and progress reports publicly available.*

Governance

The ACUPCC mandated the creation of an institutional structure to oversee the implementation of the commitment. For Cornell, that involved the creation of a Presidents Climate Commitment Implementation Committee (PCCIC) to supplement existing University bodies and provide direction and oversight of the PCC. The PCCIC was directed by two co-chairs, representing the academic and operational components of the University, respectively:

- Tim Fahey, the Liberty Hyde Bailey Professor of Natural Resources
- Kyu-Jung Whang, Vice President of Facilities Services

After the successful generation of the CAP, the PCCIC's responsibilities began to expand beyond carbon-based emissions to encompass a broader mission of campus sustainability. To accommodate the growing roles and responsibilities of the campus, the PCICC was replaced when President David Skorton formed the 14-member President's Sustainable Campus Committee (PSCC) to oversee all aspects of sustainability in campus operations and facilities.

The PSCC includes representatives from operations and academic staff, students and faculty, will be involved across 10 areas of sustainable campus activities: energy, climate, water, food, waste, buildings, people, land, purchasing and transportation. Over the coming months, teams of staff, students and faculty will be recruited to implement actions in each of these areas. 2011 members of the PSCC include:

- Vice President for Facilities Services: Kyu-Jung Whang (co-chair);
- Liberty Hyde Bailey Professor of Natural Resources: Tim Fahey (co-chair);
- Senior Director of Energy & Sustainability: Bert Bland,
- Sustainability Office : Daniel Roth, Associate Director
- Atkinson Center for a Sustainable Future: Lauren Chamblis, Director of Communications
- Student and Academic Affairs: Dale Williams; Assistant Dean of Students for Facility and Finance;
- Student and Academic Affairs: Kent Hubble, Dean of Students
- Planning and Budget: Mary-Lynn Cummings, Director of Space Planning;
- Government and Community Relations: Gary Stewart, Director, Community Relations;
- University Communications: Tracy Vosburgh, Director of Public Affairs;
- Human Resources: Linda Croll Howell, Director of Work/Life Services;
- Agricultural Experiment Station: Mike Hoffman, Director
- Undergraduate student: Alyssa Dixon
- Graduate student: Natalie Grillon, MBA candidate, S.C. Johnson Graduate School of Management, concentration in Sustainable Global Enterprise, Roy H. Park Leadership Fellow

More information about the PSCC and its mission is included here:
http://www.sustainablecampus.cornell.edu/about/pscc.cfm

Ten Sustainability Focus Teams were formed to cover the broad mandate for sustainability at Cornell. The intention is for these teams to provide recommendations to the PSCC regarding their areas of focus. The areas of focus are as follows:

- Buildings
- Climate

- Energy
- Food
- Land
- People
- Purchasing
- Transportation
- Waste
- Water

The sustainable campus website also includes details on each of these focus teams.

Greenhouse Gas Inventory

The ACUPCC requires preparation of a greenhouse gas (GHG) inventory associated with on-site combustion of fossil fuels, purchased electricity, institution-funded air travel, and commuting. Cornell's GHG inventory, completed in fall of 2008, established the baseline for the Climate Action Plan and is shown in Figure 3.1.

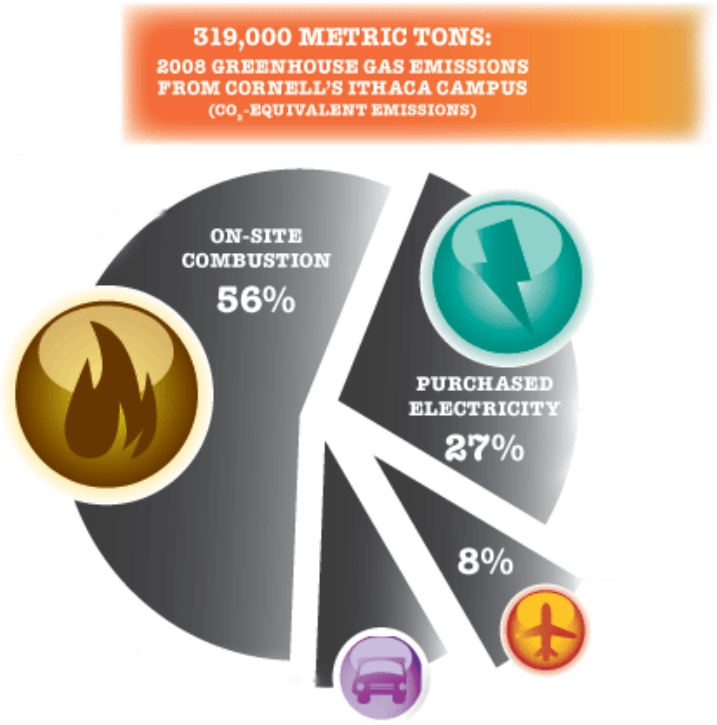


Figure 3.1 – Cornell's 2008 Greenhouse Gas (GHG) Inventory

As indicted, the fiscal year 2008 carbon footprint for the Ithaca Campus was calculated to be approximately 319,000 metric tons "carbon dioxide equivalent" (CO_{2e}) and includes carbon dioxide, nitrous oxide, and methane (the GHGs associated with fossil fuel consumption). These were composed of:

- On-site combustion (176,000 metric tons CO_{2e}; 56%)
- Purchased electricity (87,000 metric tons CO_{2e}, 27%)
- Commuting travel (29,000 tons CO_{2e}; 9%)
- Air Travel (27,000 tons CO_{2e}; 8%)

Cornell's carbon footprint has been dropping each year since this "baseline" 2008 inventory, and is now 25% lower.

General Requirements of a Climate Action Plan (CAP)

The ACUPCC requires a CAP that includes the following elements:

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.*

Cornell's 2009 CAP fulfilled these initial requirements. This 2011 Update represents a continuation of this commitment to Climate Neutrality.

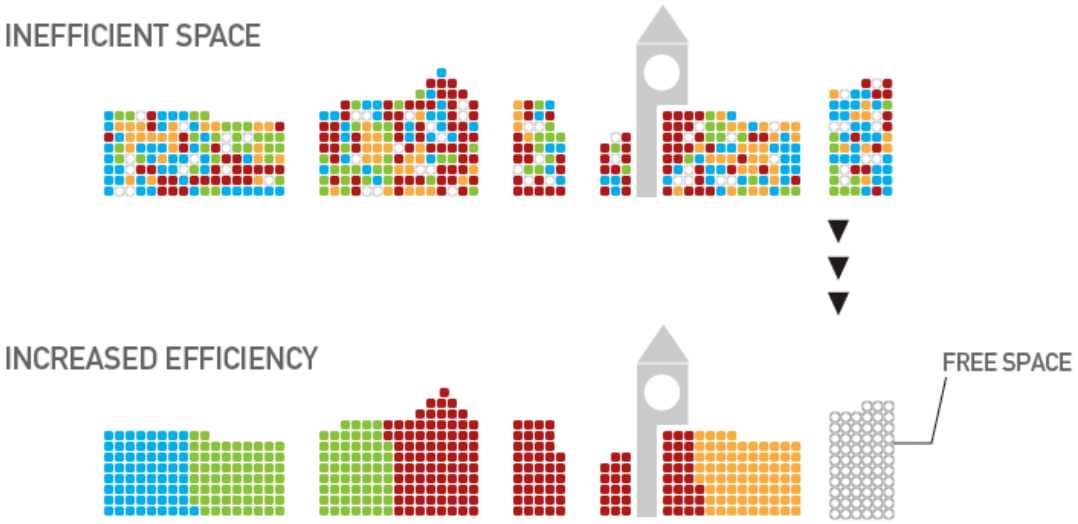
APPENDICES: Action Updates

The following Climate Action Plan (CAP) Action updates are attached:

- Space Management
- Land Use
- Energy Standards for New Construction
- Building Energy Conservation
- Conservation Outreach
- Reduce Thermal Losses
- Smart Grid
- Commuter Travel
- Business Travel
- Fleet Vehicles
- Steam Turbine Upgrades
- Biomass Combustion
- CURBI (Biomass Demonstration Technologies)
- Hybrid EGS
- Hydroelectric Upgrades
- Large-Scale Wind
- Local and Global Offset Programs

Cornell Climate Action Plan (CAP) – ACTION UPDATE: SPACE PLANNING AND MANAGEMENT

Action/Wedge: **Space Planning and Management** is a key Action of the **Green Development Wedge**, which seeks to reduce the amount of energy (and associated emissions) needed for future (planned) buildings and facilities.



Summary Description: Space Planning and Management is a centralized effort to reduce energy (and greenhouse gas emissions) associated with new building construction by reducing the amount of new space required on campus. By facilitating efficient and effective use of space on campus, both for existing facilities and new construction, future energy use can be significantly reduced.

When Initiated: Space Planning and Management is **one of the 19 initial Actions** included in the 2009 Climate Action Plan (CAP).

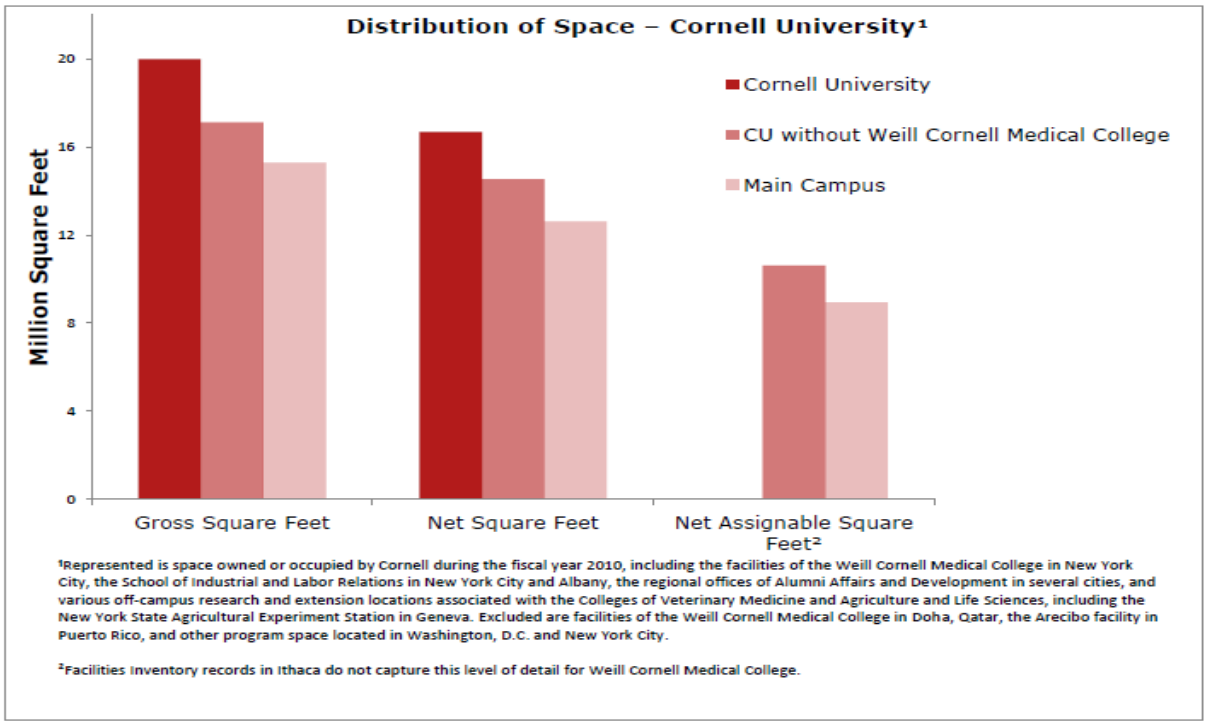
2011 Status: The formation of an operational framework for the space planning and management program at Cornell is well underway. Efforts in the period from late 2009 to early 2011 resulted in a significant amount of progress in embedding the principles of effective space planning and management into informed decision-making. The progress is in large part due to the success of a Space Use Advisory Committee (SUAC). The Committee was charged in March 2010 to:

- Develop policies, procedures and other recommendations concerning the use and renovation of space and the allocation of existing space,
- Recommend allocations of University space, including off-campus leased space, and
- Develop procedures to synchronize unit space planning during the annual capital plan development process.
- Advances in the space planning and management program include:
- The *Space Use Principles for Registered Organizations* published (October 2010)
- SUAC reviews requests for new space including the reallocation of existing space generated by new standardized request forms
- A Program Template tool was developed

- Memorandums of Understanding are developed to document space exchanges
- The University's Project Approval Request process was revised to address project space impacts
- The Capital Plan "call for projects" now asks units to identify space impacts of planned projects
- A four-year history of space distribution has been created, with written rules for pulling and analyzing data consistently through time

Key Metrics:

- Campus space growth projections used for utility planning have been reduced by half compared to projections used in the 2009 CAP (about 2M gross square feet of new space by 2040, as opposed to the former 4M gross square feet). This rapid re-calibration is mostly attributed to economic conditions. The Space Planning and Management program helps manage this slower-growth process with less impact to the campus by quantifying space needs and availability and coordinating re-purposing activities on campus.
- On average, each reduction of 1 million gross square feet (MGSF) reduces CO_2 emissions by about 13,000 tons annually and saves millions in capital and operations costs.



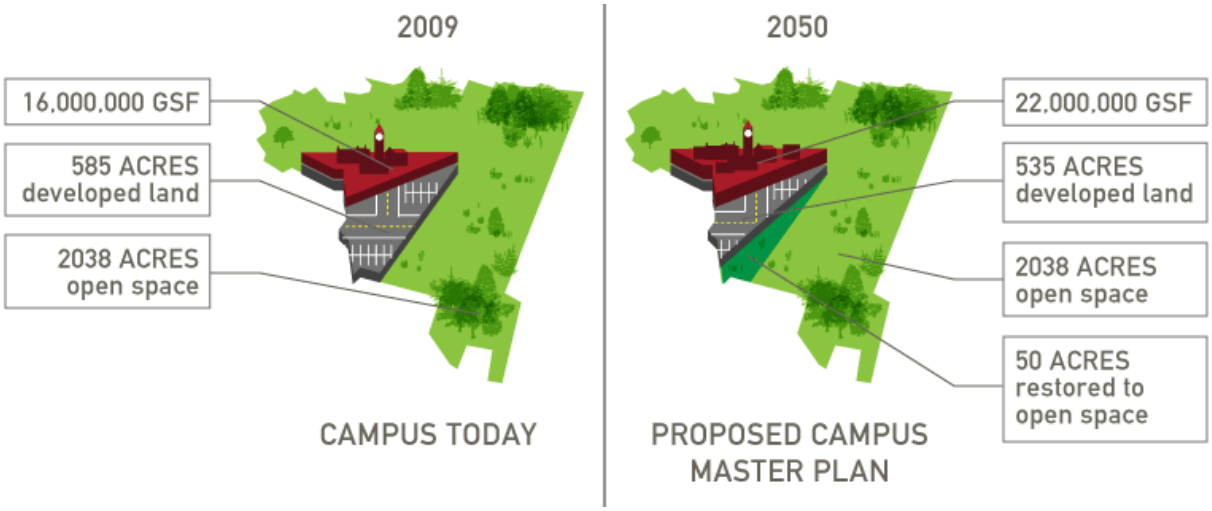
What's Next? Other activities in progress include the following:

- Space Management Operating Guidelines are under review, providing guidance to the entire Ithaca campus on issues related to the allocation and reassignment of space.
- A process for space needs studies is developing consensus. The SUAC will serve as the executive committee for such studies and interface with units to ensure collaboration. A request for proposals for a formal Ithaca campus space utilization study, to begin FY12, is in development.
- Other reports are in progress, related to leased space, classroom availability & utilization.

For More Information: Visit Cornell's Space Planning website:
http://www.dpb.cornell.edu/IP_SP_Space_Planning.htm

Cornell Climate Action Plan (CAP) – ACTION UPDATE: IMPROVED LAND USE

Action/Wedge: **Improved Land Use** is a key Action of the **Green Development Wedge**, which seeks to reduce the amount of energy (and associated emissions) from future (planned) buildings and facilities. In addition, the Improved Land Use action seeks to conserve, enhance and increase green space which can provide additional carbon sequestration and other ecosystem services.



Summary Description: **Improved Land Use** is a centralized and comprehensive effort that incorporates the guiding framework of the Cornell Master Plan to facilitate future physical development of the campus. The interlinked goals of a compact footprint and a balanced mix of land uses supported by Space Planning and Management and Commuter Travel will reduce infrastructure demands and lessen Vehicle Miles Traveled (VMT) on campus. This framework is further enhanced and implemented through better integration of building sites and campus landscape with infrastructure and naturalization efforts that improve campus aesthetics and further support CAP carbon reduction goals.

Better land use is foundational to smart growth - resulting in reduced VMT, preservation of open space and natural resources, and energy savings from buildings in compact development patterns. With less per capita energy and resource use, smart growth strategies provide permanent climate benefits including CO_{2e} reductions, better environmental quality, and long term savings in infrastructure and operational spending for a healthier community. Preservation of open space also allows room for renewable technologies, many of which require space of their own, within the future campus footprint.

When Initiated: Improved Land Use is **one of the 19 initial Actions** included in the 2009 Climate Action Plan (CAP). This program was an outgrowth of the Cornell Master Plan approved by Cornell's Trustees in 2008 and incorporates guiding principles that were developed through the Campus Planning Office.

2011 Status and Successes: The tenets of Improved Land Use are now integrated into planning decisions across Cornell's Ithaca campus. Efforts from late 2009 to early 2011 resulted in

significant progress incorporating these principles into site selection and site development guidelines formulated on a project-by-project basis. Compliance with the Campus Master Plan is now a requirement for all new capital projects and is part of their review by the Capital Planning Group and the Capital Funding and Priorities Committee. Additionally compliance with the Campus Master Plan and the embedded sustainability principles is part of the University's Strategic Plan and subsequent facility master plans and area plans for the campus.

All major Cornell projects in this time frame have represented either on-site replacement of buildings or "infill" projects within well-developed campus areas, both adding greater density to the existing development footprint, and optimizing existing utilities and transportation infrastructure. Together with the Space Planning action, Improved Land Use continues to facilitate efficient space and land use and supports efforts to avoid the types of campus sprawl that complicate efforts for alternative transportation and effective energy distribution.

Examples of recent compact development include the Human Ecology Building (with under-building parking), the Johnson Art Museum Expansion (largely sub-surface and extending the existing facility); the Combined Heat and Power Plant (built on a brownfield area where coal was formerly stored); the new Food Sciences building, under construction on the site of the former (demolished) building, the Animal Health and Diagnostic Center, on the site of several smaller and obsolete (now demolished) buildings, and several major building renovations (avoiding new construction and related space use).

Key Metrics:

- Improved Land Use is closely related to other actions (particularly Space Use Management and Commuter Transportation)), due to the better use of space, buildings and land. Good measures are the increase in overall development density, the mix of land uses and the retention of green open space in the existing campus footprint. The enhancement of open space to include ecosystem functions or green infrastructure can be an additional future metric.

What's Next?

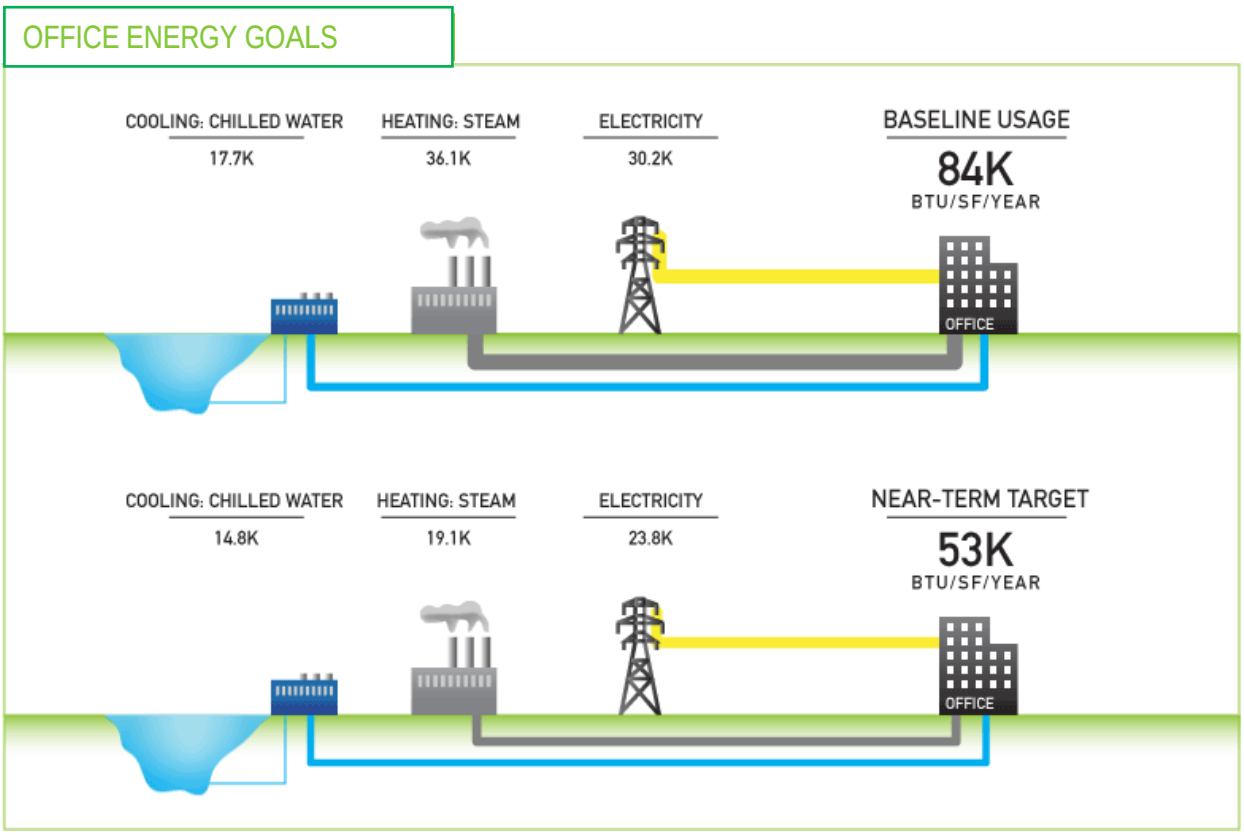
- Improved Land Use is an active collaboration across campus that will continue for decades and leave a lasting legacy for the campus and community. It involves thoughtful decisions related to each and every proposed facility construction, renovation, or land use on campus. We anticipate enhancing landscape ecosystem services on the campus as well as improving pedestrian and bike networks through physical design and planning synergies.

For More Information:

- Visit Cornell's Campus Planning Office website: http://cpp.fs.cornell.edu/cpo/main.cfm
- Read about land-related sustainable activities across campus on Cornell's Sustainable Campus (CSC) website: http://www.sustainablecampus.cornell.edu/land/

Cornell Climate Action Plan (CAP) – ACTION UPDATE: BUILDING ENERGY STANDARDS

Action/Wedge: **Building Energy Standards** is an Action of the **Green Development Wedge**, which seeks to reduce the amount of energy (and associated emissions) needed for future (planned) buildings and facilities. The creation of Building Energy Standards limits the energy required for new and significantly renovated buildings on campus.



Summary Description: The Climate Action Plan (CAP) mandates a well-defined energy modeling protocol and prescribes **Energy Use Intensity (EUI)** standards by building type to ensure future construction is optimized to Cornell's Leadership in Energy and Environmental Design (LEED) program and also achieve a minimum of a 30% reduction in building energy use as compared with the energy-code-compliant baseline (ASHRAE 90.1). Energy modeling, conducted as a part of the CAP, suggests the 50% reduction in laboratory and office energy use can be concurrently achieved with life cycle cost savings, limiting energy consumption while respecting initial capital resources. This requires new building design to ultimately limit energy usage to 50% of the baseline. These are aggressive goals that will require innovation, design discipline, and steady enforcement.

The near term target EUI called for by the CAP was established through review of recent Cornell construction projects and comparison with benchmarks used elsewhere.

When Initiated: Building Energy Standards is **one of the 19 initial Actions** included in the 2009 Climate Action Plan (CAP). This program represents a formalization of a process initiated years before as energy conservation analysis and LEED modeling efforts helped quantify the minimum energy needed to effectively heat, cool, and power buildings on campus.

2011 Status:

- Cornell's Facilities Engineering updated two campus-wide standards, "Energy Guidelines" and "Energy Modeling Guidelines" to standardize and more fully explain Cornell's EUI requirements.

Key Metrics:

- Laboratories and other high-energy-use facilities are a particular focus of the program. On average, laboratories use 5-10 times more energy than dormitories on a per square foot basis.
- Achieving a goal of 50% lower energy use effectively reduces the rate of campus growth in GHG emissions by half, even before other Green Development initiatives.
- The 50% lower energy use has proven to be a challenging but approachable goal. Examples of savings achieved during the recent past (where design just pre-dated the CAP action) include:
    - The Cornell Combined Heat and Power Plant (CCHPP) office addition uses only about 40% of the energy use than a baseline building meeting energy code standards per LEED (i.e., it saves 60%). Solar thermal heating helps reduce the building's heating needs.
    - The Physical Sciences Building achieved a 50% reduction in energy use based on the LEED calculations. The building itself used about 40% less energy; central plant efficiencies provide the remaining savings. Heat recovery, re-use of office air, and occupancy sensors were all keys to achieving this low energy use.
    - The Animal Health Diagnostic Center achieved a reduction of about 18.5%. The very strict biological safety standards in this building made reductions in airflow difficult.

What's Next?

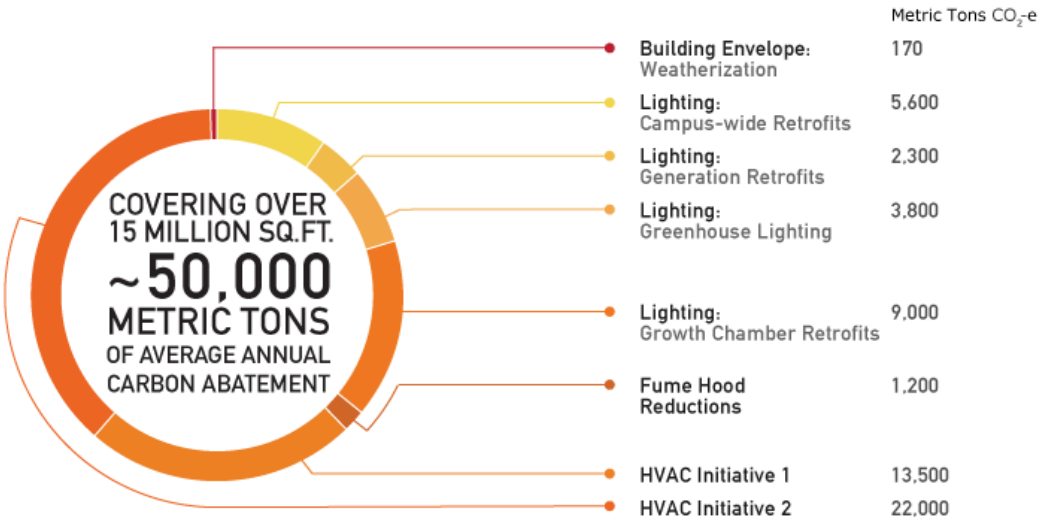
- Continued progress will require steady and consistent project-by-project oversight and diligence. While most projects can meet these goals, some continue to struggle with achieving this level of savings while maintaining other capital budget and program needs.
- Cornell has proposed to build a new campus in NYC as part of a competition. As indicated in press reports, our design proposal includes an ultra-efficient academic building that will be "energy net zero", utilizing solar power from the site and a geothermal-based heat pump system. The building, if constructed, would represent a new level of achievement in sustainable building design for Cornell.

For More Information:

- Cornell's Design and Construction Standards are found at the following URL: http://cds.fs.cornell.edu/toc.cfm
- A student group is pursuing low-energy design: http://green.mae.cornell.edu/design.html

Cornell Climate Action Plan (CAP) – ACTION UPDATE: ENERGY CONSERVATION INITIATIVE

Action/Wedge: The **Energy Conservation Initiative (ECI)** is the central Action of the **Energy Conservation Wedge**, which seeks to reduce the amount of energy (and associated emissions) needed to operate our existing campus facilities (*CO_2e estimates in figure below based on 2009 fuel mix*).



Summary Description: The **Energy Conservation Initiative** is a five-year, ~$46M program focused on reducing energy use in campus buildings. It is a comprehensive scope of work representing a broad spectrum of building studies, behavioral educations, re-commissioning, and capital improvements managed by a full-time staff of professionals dedicated to energy conservation. Programs include:

- Re-commissioning, continuous commissioning, and building control updates.
- Replacement and retrofit of lighting systems with energy-saving lighting types and controls
- Laboratory fume hood optimizing and decommissioning programs
- Reduction in ventilation rates in research spaces while maintaining safety standards
- A focused program to reduced energy use in plant growth chambers and greenhouses
- Weatherization of buildings
- Energy outreach and awareness programs partnering students, faculty, and staff
- Plug-load reduction efforts focused on purchasing and operations in offices and labs

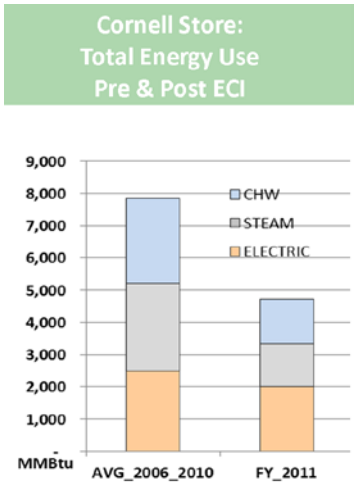
When Initiated: The Energy Conservation Initiative is **one of the 19 initial Actions** included in the 2009 Climate Action Plan (CAP). In fact, energy conservation has been going on for decades at Cornell, as documented in the original CAP and on the Energy and Sustainability website.

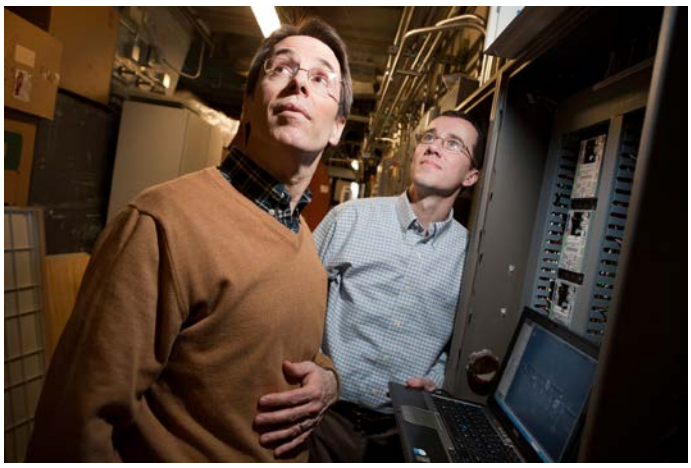
2011 Status: The current (2010) Energy Conservation Initiative expands on decades of dedicated energy conservation efforts on campus. Some highlights of work completed since the 2009 CAP and the current ECI status include the following:

- 2002-2010: Over $11M invested in energy conservation initiatives reduced annual energy bills on campus about $3M and saved 6,000 tons of greenhouse gas (GHG) emissions per year.
- 2010: Cornell Trustees approved a 5-year, $46M Plan for the ECI program including an initial allocation of $9.6M in 2010. Four conservation focused controls techs were hired, increasing the overall team to 10. Overall, ECI efforts are projected to reduce energy needs in affected facilities by up to 20 percent, reducing our GHG footprint by almost 36,000 tons annually.
- 2011: Cornell's ECI team hired an additional engineer to help manage the program, which expanded with $14.4M addition funding ($24M total). More than forty different facilities on campus are included in the current round of energy conservation initiatives.
- 2011: Cornell added a full-time lab safety specialist to create a lab risk banding program so that ventilation air flows are matched to the hazard, allowing energy savings for lower-risk hoods.

Key Metrics:

- From 1990 to 2008, ECI efforts reduced GHG emissions an estimated 35,000 tons/year.
- Since approval of the 2009 CAP, $24M in conservation program funding has been approved.
- The current (five-year) program aims to reduce the GHGs by an additional 30,000 tons per year.





Lanny Joyce, director of energy management in Cornell's Department of Energy & Sustainability, left, and Mark Howe, program manager for the Energy Conservation Initiative, examine the Cornell Store's recently updated HVAC system.

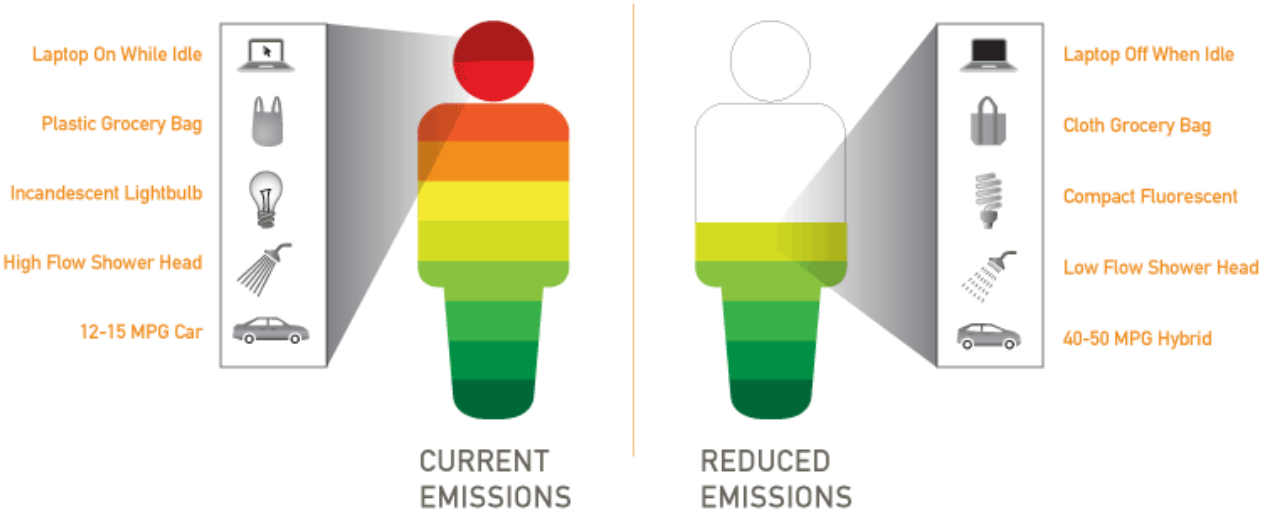
What's Next?

- The latest comprehensive Energy Conservation Initiative will continue over the next five years
- Metrics and dashboards are being developed to help communicate the program's urgency.

For More Information: Visit the Energy & Sustainability Website's Energy Conservation portal: http://energyandsustainability.fs.cornell.edu/em/energycons

Cornell Climate Action Plan (CAP) – ACTION UPDATE: CONSERVATION OUTREACH

Action/Wedge: **Conservation Outreach** is an Action of the **Energy Conservation Wedge**, which seeks to reduce the amount of energy (and associated emissions) needed to operate our existing campus facilities.



Summary Description: **Conservation Outreach** focuses on the potential for energy savings through changes in our behavior. Low-cost savings are possible through changes in the day-to-day actions of the campus community in usage of lighting, fume hoods, and electric plug load (office and laboratory equipment)—using human behavior to drive energy conservation. While difficult to quantify, the potential for cost-effective energy savings through this action is enormous. To foster change, conservation outreach is needed. The Conservation Outreach initiative envisioned a pilot program to educate users and continue to foster a culture of conservation at Cornell. The pilot would include the use of both monthly and real-time energy use and cost data. An inventory of Best Practices would be developed for each occupancy type (classroom, office, lab, residence, kitchen, etc.). Conservation representatives—"Eco-Reps"—would advise, encourage, and conduct periodic checks to ascertain whether Best Practices are being implemented.

These pilot programs would characterize potential energy savings/CO2e reductions and ascertain the most effective ways to staff, support and manage a campus-wide effort in subsequent years.

When Initiated: **Conservation Outreach** was **one of the 19 initial Actions** included in the 2009 Climate Action Plan (CAP). While some level of outreach has always been alive on campus, those efforts were

largely *ad hoc* and this action sought to formalize the program, quantify the energy savings, and expand the effort across campus.

2011 Status: Funding has not yet been allocated from central resources to fund this program as originally initiated. However, several groups have stepped forward on their own to provide early action:

- The "CALS Green" initiative through the College of Agriculture and Life Sciences (CALS)
- Several student initiatives, including the popular "Lights Out!" campaign, have demonstrated the power of student action to save energy while educating students on the impacts of waste.
- An "EcoReps" program within Campus Life, organized in 2011, includes over 24 volunteers focusing on sustainability in over a dozen residential facilities.

Key Metrics:

- CO_{2e} reduced if every student on campus used the power saver features on their computer: 1,300 tons per year (representing just over 1% of Cornell's annual electricity usage)
- CO_{2e} reduced if 1000 new office printers were energy star certified: 60 tons per year
- CO_{2e} reduced if every staff member turned off two 4' fluorescent lamps for 2 hrs /day: 120 tons per year
- CO_{2e} reduction if 1000 students used a "smart" plug strip with printers and laptops plugged in: 170 tons per year

What's Next?

Cornell groups from across campus continue to expand efforts using best practices gained from experience by others.

Natalie Zandt '11, Lights Off! President 2011

For More Information:

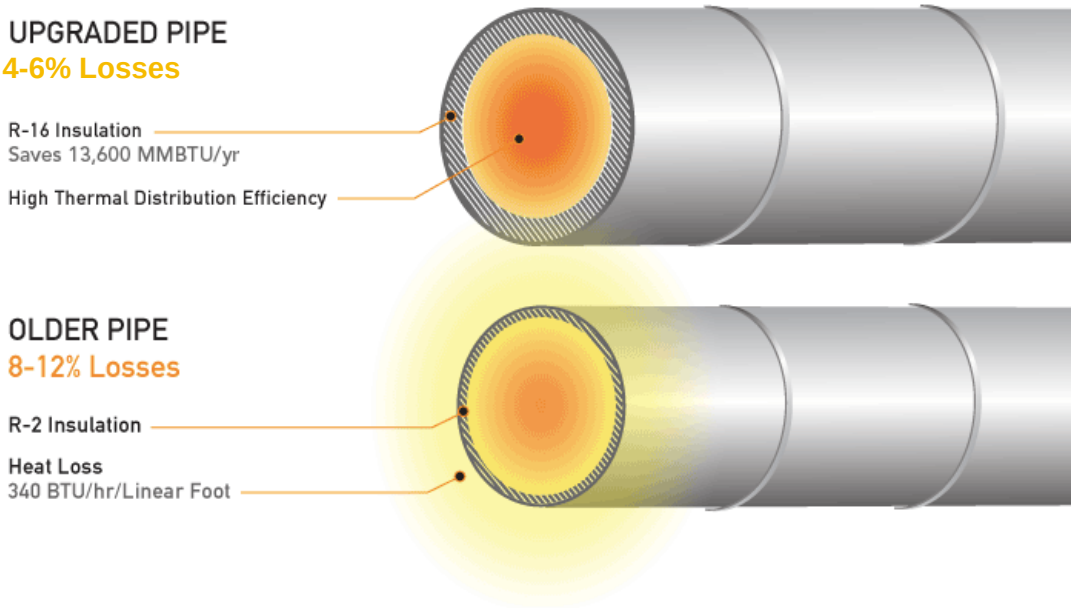
Light Out Cornell! http://energyandsustainability.fs.cornell.edu/lightsoff/faq.cfm

CALS Building Energy Contest: http://www.news.cornell.edu/stories/Sept10/CALSgreen.html

Cornell University

Cornell Climate Action Plan (CAP) – ACTION UPDATE: Reducing Thermal Losses

Action/Wedge: **Reducing Thermal Losses** is an **Energy Conservation** Action which seeks to reduce the amount of energy (and associated emissions) needed to operate our existing campus facilities.



Summary Description:

The original scope of this action was to replace one of the oldest sections of steam pipe on campus, which serves portions of the Veterinary College and terminates at the Guterman Laboratory and associated greenhouse complex (the "Guterman Line"), with a newer, better-insulated pipe. Estimates of thermal losses throughout the entire campus steam distribution system range from 10 to 15 percent; as this section has some of the lowest insulation values (about R-2) of the entire system, losses in this section are likely to be proportionally higher. During the 2009 CAP analysis, potential energy savings were estimated at 13,600 MMBtu per year.

When Initiated: Steam Line Upgrade is **one of the 19 initial Actions** included in the 2009 Climate Action Plan (CAP).

2011 Status: Capital funding has been requested for this action. It is scheduled for replacement in about 10 years.

Once funded, the first step will be a study to determine costs and potential payback for this action. In 2010, an internal "white paper" suggested upgrading this steam line to a hot water line to further reduce energy losses and begin the proposed campus-wide conversion process necessary for heat loss

reduction and broad incorporation of renewable or waste energy, as recommended in the 2009 CAP. Heat rejected by a possible future Synchrotron could be captured and delivered to East Campus Buildings via a system converted to hot water. Similarly, heat from the proposed Cornell University Renewable Bioenergy Initiative (CURBI) or a future Enhanced Geothermal System (EGS) could be delivered more readily to a hot water system, helping to enable those CAP actions.

No decision has yet been made to change the action. A future study could incorporate an analysis to determine whether replacement with steam or hot water makes more sense from an economic, environmental, and reliability standpoint. Modern hot water systems have lower energy losses than steam systems (typically less than half) and cost less to replace and maintain. Hot water system also reduce personnel hazards common with steam systems. However, the transition is very expensive. A steam-to-hot water heat exchanger would be required and, because central building systems were designed around the higher temperature steam, the change-over may involve significant modifications at many buildings. The phasing of a transition can be complicated and risky, as interruptions to service cannot be tolerated. Planning and phasing to reduce these impacts would be key requirements of any future transition approach.

Key Metrics:

- There are over 13 miles of steam piping on campus, and another 12 miles of condensate return.
- The current steam distribution system in total loses 16% of its energy from the point of production to final "sales". Replacement with new steam piping with better insulation will help reduce losses; a high-efficiency hot water system would likely reduce those losses at least in half, saving over 6,500 tons of carbon a year from reduced fossil fuel needs.

Cornell uses infrared images to help prioritize steam line insulation repairs. Lighter areas in the above image reveal heat loss from the "Guterman Line" steam piping.

What's Next?

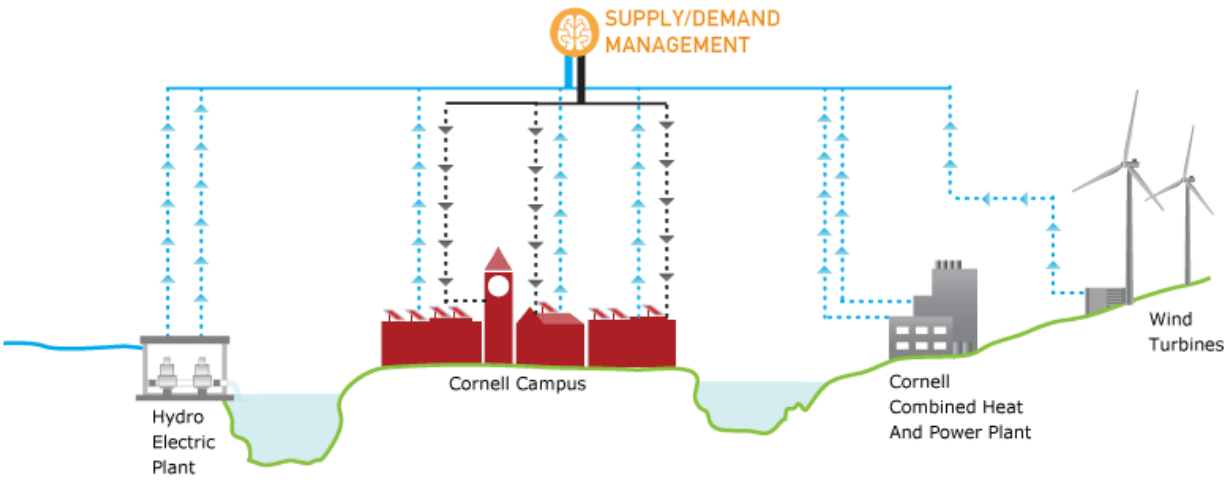
- When funded, Cornell will begin a process to plan and design for construction. Initial efforts may include an analysis to consider the overall project cost and phasing and whether a change to hot water service is financially appropriate.
- Cornell plans to replace some failing hot water piping in the North Campus area in fiscal year 2013. That project will help Cornell develop better information on the actual costs and impacts of high-performance pre-insulated piping systems.

For More Information: A description of Cornell's steam distribution system can be found at the following URL: http://energyandsustainability.fs.cornell.edu/util/heating/distribution.cfm

Cornell Climate Action Plan (CAP) – ACTION UPDATE: SMART GRID

Action/Wedge: **Smart Gird** is an Action in the CAP Wedge **Energy Conservation**, which seeks to reduce the amount of energy (and associated emissions) needed to operate our existing campus facilities. It is considered an "enabling action" because it helps facilitate the efficient use of all Cornell's resources within the campus energy system.

Summary Description: **Smart Grid** is the overarching name for a series of supply and demand management technologies and practices that are used to monitor, self-correct, and optimize the distribution and use of electrical energy within an electric grid. For Cornell, Smart Grid applies principally to the private "campus grid" owned and operated by Cornell Utilities. Cornell's electric grid is supplied by two NYSEG 115kV transmission lines feeding a 13.2kV 80MVA substation. Power is distributed to campus via a mix of 13.2kV and 2.4kV underground and overhead cable. Distribution switchgear consists of vacuum breakers, loop switches, and some air break gear. Capacitor banks maintain a power factor of 0.92 to 0.95 under typical loading. The majority of the system is configured with 400A loop capacity at 13.2kV. Loop circuits are typically loaded less than 50% so that they can be single ended for maintenance and support 100% load. Electric generation on campus from gas, steam, and hydroelectric turbines produce up to 39MW in the winter months; during this time some electricity is exported to the grid. In the summer, production averages about 14MW but can peak at 28MW. Overall, the system output is equivalent to about 85% of the campus annual electric use.



When Initiated: **Smart Grid** is one of the 19 initial Actions included in the 2009 CAP**.** Improvements to building and distribution gear instrumentation, control and data acquisition software, and control systems have been on-going for decades at Cornell. Smart Grid provided a more formal framework for the system-wide discussion and planning of these activities.

2011 Status: Since the addition of Smart Grid to the Climate Action Plan, Cornell has made the following progress towards implementing Smart Grid Technologies:

- Completed the smart-grid-ready Maple Avenue Substation and Cornell Combined Heat and Power electrical distribution system projects (2010).
- Collaborated with researchers and manufacturers to develop competitive proposals for Smart Grid demonstrations on campus.
- Incorporated Smart Grid instrumentation into planned utility and building power system improvements across campus. For example, "smart" electrical meters are being installed on buildings associated with the Energy Conservation Initiative (ECI), another CAP action.

Key Metrics:

- Annual campus usage is ~240,000,000 kilowatt-hours (KWh), so small efficiency improvements at the grid level can equate to substantial energy savings. For example, a 0.5% average improvement in distribution efficiency would save 1,200,000 kWh and reduce CO_2 emissions by over 400 tons.
- Cornell-generated electricity avoids the distribution and transformer losses required by an outside utility to produce electricity elsewhere, send the 115kV utility voltage over miles of distribution line, and then transform it to 13.2kV campus voltage. It is estimated that the average distribution loss in the U.S. is over 6% of the produced energy. A smart grid can facilitate additional internally-produced electric to reduce those external transmission losses.

What's Next?

- Cornell will continue to integrate Smart-Grid technology into transformers, switchgear, and similar distribution equipment, and work with academic and industry leaders to find opportunities to improve distribution efficiency and integrate renewable energy resources as they become available.
- Staff members from Facilities Services aligned with campus faculty and researchers recently began meeting to discuss Smart Grid initiatives as they related to campus research, system maintenance, and renewal efforts. Specific goal and objectives for Cornell's program are now being defined.

For More Information:

- Learn more about the central electrical utilities at the following URL: http://energyandsustainability.fs.cornell.edu/util/electricity/distribution/default.cfm.
- Information on academic studies involving Smart Grid technologies can be found at this link: http://energyandsustainability.fs.cornell.edu/util/electricity/distribution/smartgrid.cfm
- Cornell Researchers are involved in funded Smart Grid work: http://cornellsun.com/section/news/content/2011/10/14/cornell-researchers-explore-smart-grid-technology

Cornell Climate Action Plan (CAP) – ACTION UPDATE: COMMUTER TRAVEL

Action/Wedge: **Commuter Travel,** an Action in the CAP Wedge **Alternative Transportation**, seeks to reduce the energy (and associated emissions) required for daily transportation to and from campus.

Summary Description: Commuter Travel focuses on the potential for energy savings through changes in our means of commuting to and from work each day. This action promotes the use of less carbon-intensive travel modes, from zero-carbon biking and walking to lower-carbon vanpooling, bus trips, and carpooling. Education and awareness are central components, although market-pricing parking also encourages the University community to consider the available options.

When Initiated: Commuter Travel was **one of the 19 initial Actions** included in the 2009 Climate Action Plan (CAP) but a broad and far-reaching effort substantially pre-dated the CAP program. Cornell's Transportation professionals had already developed an award-winning Transportation Demand Program that includes sub-programs addressing all of these alternative modes of transportation.

2011 Status and Successes: Cornell's greenhouse gas (GHG) emissions associated with commuting are lower, although Cornell has not yet formally measured the reduction. In the period 2008-2010, local bus ridership improved, individual parking permits are down, a new Big Red Bike rental program has developed, two van-pools have sustained service, and the community continues to take advantage of support programs like the free "Car Share" memberships and "emergency ride" programs to balance work and life needs while reducing individual commuting impacts. Meanwhile, the broader University recognizes that technology allows many people to occasionally or often work from home – and has developed formal policies to support this practice.

Key Metrics:

- The average vanpool rider emits 3.5 times less CO_2-e than the typical Tompkins Consolidated Area Transit (TCAT bus) rider and 10 times less than an average SOV commuter.
- Working from home 1 day a week reduces one's transportation carbon footprint by 20 percent.
- The typical Tompkins County household makes nearly 6 vehicle trips daily. Eliminating just 1—by sharing a ride, walking, or chaining trips, for example—saves about 350 trips per year, about 3,000 miles of travel, and over 1-1/2 tons of CO_2-equivalent.
- Over 700 Cornell-affiliated members now take advantage of free Ithaca Carshare memberships, giving them access to over a dozen fuel-efficient cars (and one pick-up truck) – a great start to going car-free (or reducing the number of household vehicles).
- Ithaca Carshare passed the 1,000 member mark in 2011.

What's Next?

- In 2011-2012, Cornell continues to offer the free Car-Share membership, a Bus-pass program, Emergency Riders, and other amenities for those seeking alternative commuting programs.
- Cornell continues to offer and expand efforts to support alternative community methods through a broad range of supporting projects, which are adjusted continually to better meet campus needs (see links below).
- Beyond these transportation-focused efforts, Cornell also has continued to develop policies and practices that encourage employees to work from home (when possible) and efforts to develop affordable housing within walking or biking distance from campus.

For More Information:

- For more information on Cornell's broad-ranging transportation demand management programs, see: http://www.transportation.cornell.edu/tms/parking/commuting/
- More information on Cornell's policy on workplace flexibility can be found here: http://www.dfa.cornell.edu/treasurer/policyoffice/policies/volumes/humanresources/flexibility.cfm
- A Transportation Focus Team covers a wide range of education, research, and demonstration efforts on campus described here: http://www.sustainablecampus.cornell.edu/transportation/

Cornell Climate Action Plan (CAP) – ACTION UPDATE: BUSINESS TRAVEL

Action/Wedge: **Business Travel** is an Action in the CAP Wedge **Alternative Transportation**, which seeks to reduce the energy (and associated emissions) required for University-related transportation.

Summary Description: **Business Travel** focuses on the potential for energy savings through changes in our means of travel. This action promotes the use of less carbon-intensive travel modes for business trips. Education and awareness are central components. With a high reduction goal, this would also include a portal to assist in finding/booking lower-carbon travel. A vital component would be increased use and availability of teleconferencing tools and facilities. The current fiscal environment creates an incentive to reduce costs through substituting teleconferencing tools for travel where appropriate.

When Initiated: Business travel was one of the **19 initial Actions** included in the 2009 Climate Action Plan (CAP). While Cornell's Transportation and Mail Services division had already developed robust programs for reducing single-vehicle commuting and was involved in improving fleet vehicle efficiency, business travel was not a primary focus of any specific university department in 2009.

2011 Status: Funding has not yet been allocated from central resources to fund all portions of this program as originally initiated in the CAP. However, the success of the Campus-to-Campus bus service, which provides an alternative to the University's highest-frequency destination (New York City), has resulted in an expanded service that now operates 20 round-trip routes per week serving up to 32 passengers per trip. This expansion resulted in increased passenger loads and even better mileage on a per-passenger basis. Some of these trips replace travel by private or fleet car while others replace airline trips.

Meanwhile, telecommuting remains broadly supported at Cornell and additional telecommuting facilities have accompanied new construction projects. Cornell will update its overall business travel estimates in 2011 to assess the overall impacts of our efforts.

Key Metrics:

- The Campus-to-Campus bus now boasts an amazing 140 miles-per-passenger-gallon – better than the best 2-passenger hybrid! Midway through 2011, ridership was up 40% over 2010.
- Greenhouse gases from flying are even higher than driving; if four people carpool to a conference 250 miles away instead of flying, they'd save roughly 1.2 tons of $CO_{2\text{-}e}$ (and roughly $1,000). If their destination is NYC, the Campus-to-Campus bus reduces emissions even more!
- The $CO_{2\text{-}e}$ associated with business travel at Cornell (about 26,000 tons per year) is roughly equal to all of the commuting GHG impacts of Cornell faculty, staff, and students.
- One full Campus-to-Campus bus load replacing (say, on average) 16 car trips with two passengers each, would save about 2.5 tons of CO_2. The roughly 1000 trips per year could save about 2,500 tons (some of this might not qualify as "business travel", but is it still saved CO_2!). If some of those people would have flown or driven single-occupant vehicles, savings are higher.

What's Next?

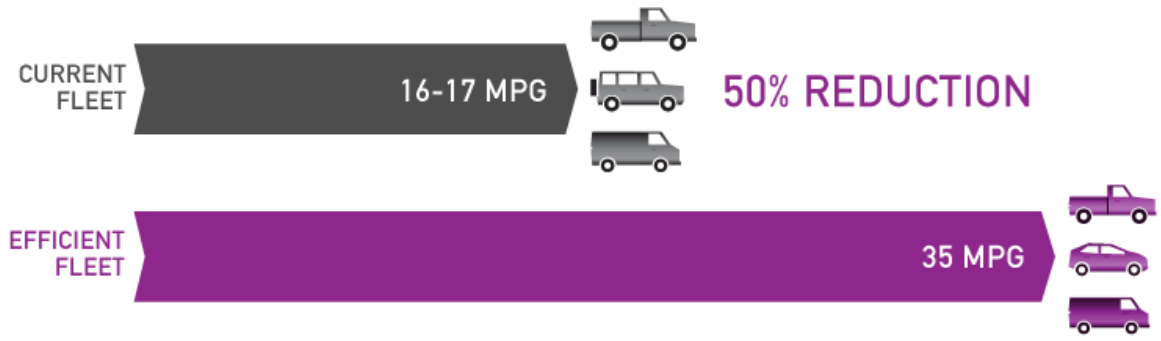
- Cornell is currently exploring the feasibility of adding a direct bus connection to Washington, D.C., another high-frequency destination for Cornell business travel.
- Cornell staff area gathering data on Business Travel with a goal of being able to update Cornell's GHG estimate by end of summer, 2011.
- Cornell continues to explore many areas of reducing the cost and energy use of business travel within departments across the campus.

For More Information:

- Read more about the Campus-to-Campus service here: http://www.transportation.cornell.edu/tms/coach/index.cfm
- For more information on teleconferencing in the College of Human Ecology: http://www.human.cornell.edu/administration/computing/teaching/vtc.cfm
- The Transportation Team's webpage describes a wide range of education, research, and demonstration efforts on campus: http://www.sustainablecampus.cornell.edu/transportation/

Cornell Climate Action Plan (CAP) – ACTION UPDATE: CAMPUS FLEET: REDUCING FUEL CONSUMPTION

Action/Wedge: **Campus Fleet,** an **Alternative Transportation** CAP Action, seeks to reduce the fuel energy needed to operate the fleets required for day-to-day travel within and beyond campus.



Summary Description: The **Campus Fleet** CAP action includes two main components. First, it was desired to incorporate higher fleet fuel efficiency standards for fleet vehicles generally, to reduce fuel consumption by university-owned vehicles. One method of accomplishing this was to improve the mix of available fleet vehicles, allowing users to rent smaller or hybrid vehicles as appropriate. The second component was in the considering alternative fuels. As technology develops and becomes standardized, alternative fuel vehicles could be incorporated at a higher level. Together, these goals of improved fleet fuel efficiency (average miles-per-gallon across the fleet) and incorporation of proven alternative-fuel vehicles can substantially reduce greenhouse gas (GHG) emissions associated with fleet vehicle fuel use.

In 2008, as the CAP was being developed, average fuel economy for the overall fleet was below 18 mpg. The long-term goal of the CAP was an improvement in the average fuel economy to about 35 mpg, which would result in nearly a 50% reduction in fuel consumption, and thus greenhouse gas (GHG) emissions, for these vehicles. As corporate average fuel economy (CAFE) standards will be rising at the same time, achievements beyond the base case would come from an accelerated schedule of reducing fuel usage as well as the subsequent establishment of a fuel standard that exceeds the national fleet average. Achieving these improvements in fuel economy would be accomplished through purchase policies that encourage higher efficiency vehicles, often smaller vehicles, and fewer SUVs and pickup trucks.

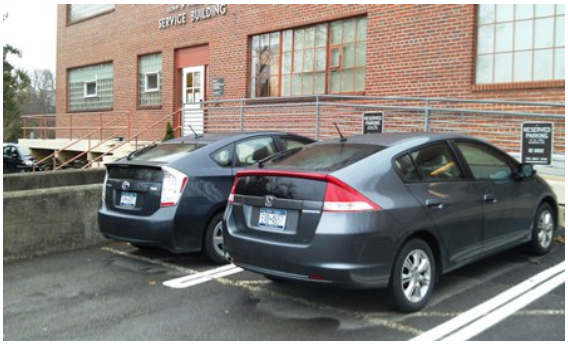
A secondary approach to achieving carbon reduction from fleet services operations would lie in the pursuit of alternative fuel sources with lower carbon footprints. While there is some current use of compressed natural gas (CNG), on-campus vehicle availability and filling requirements make a wholesale conversion impossible at present. Electric vehicles should be considered where appropriate and where they can satisfy the needs of the users. Conversion to a bio-fuel may be possible as the fuel supply infrastructure develops sufficiently to make a substantial impact. The current approach combines some “early adopter” testing to guide future policies which may take longer to fully implement, as relevant technologies are still further matured.

When Initiated: **Campus Fleet** was one of the 19 initial Actions included in the 2009 Climate Action Plan (CAP). Prior to that period, vehicular mileage and/or fuel source were factors in fleet vehicle purchases, but not major considerations.

2011 Status and Successes: As an interim goal, Cornell has set a short-term (within 5 years) goal of reducing the campus fleet by 30% while improving the fleet average miles-per-gallon by 30%. Since 2009 Cornell has added both high-efficiency vehicles, including gas-electric hybrid vehicles and a recent (October 2011) all-electric vehicle, to the campus fleet on an incremental basis. This improvement is reflected in the overall GHG emissions associated with on-campus liquid fuel use, which dropped from about 3,500 tons (2008) to about 3,300 tons (2010); further reductions are anticipated when 2011 totals are calculated. Many older vehicles with poor mileage are being phased out and careful assessment of vehicles needs has allowed many of these vehicles to be replaced by smaller, lighter vehicles that require less fuel.

Key Metrics:

- In 2009, the average fuel economy for the campus fleet was estimated at less than 18 mpg. Many of the passenger vehicles in the fleet at that time were large sedans or vans.
- A goal of this Action was to improve the average efficiency of the fleet to 35 mpg, for fuel savings of up to 50% over the pre-CAP fleet. The most recent measurement (October 2011) is about 22 mpg for the fleet average.
- GHG emissions associated with on-site fuel use dropped from about 3,500 to about 3,300 tons in 2010 (2011 final figures not yet available).
- Fleet vehicles are typically turned over every 4 years on average. This replacement rate (over 25% each year) provides a ready opportunity for continuous improvement in mileage standards.



Insight and Prius: available for use by Cornell staff

What's Next?

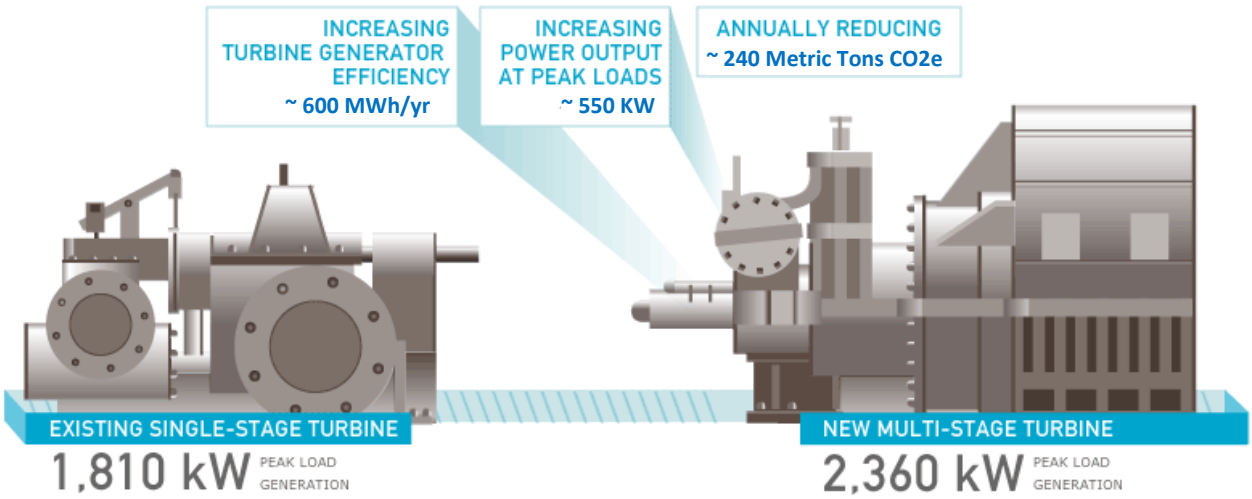
- Cornell is continuing its program of considering vehicle sizes and types to improve the energy economy of our fleet, including introducing alternative-fuel vehicles. A feasibility study for a new natural gas fueling station is underway and electric charge stations were added to the new (2011) Human Ecology Building.
- Cornell continues to track and explore changes in technology and fuel options as the market creates these options.

For More Information:

- For more information on Cornell's broad-ranging transportation programs, see: http://www.transportation.cornell.edu
- The Transportation Team's webpage describes a wide range of education, research, and demonstration efforts on campus: http://www.sustainablecampus.cornell.edu/transportation/

Cornell Climate Action Plan (CAP) – ACTION UPDATE: Turbine Generator Replacement

Action/Wedge: **Turbine Generator Replacement** is an Action of the **Fuel Mix and Renewables Wedge**, which include strategies to replace fossil fuel use with renewable energy sources



Summary Description: Steam turbines accept high-pressure steam produced in the Cornell Energy Plant and produce electricity. The power output of Cornell's Cogeneration facility could be increased by approximately 550 kilowatts (kW) at peak load conditions with a more efficient backpressure steam turbine generator (TG-1). A new TG-1, currently rated at 1,810 kW, would deliver up to 2,360 kW. The new turbine's higher full and part load efficiency would increase annual generation by approximately 600 megawatt hours (MWh) per year based on current operations, an increase of about 20%.

The ability to pass additional steam through a more efficient generator will result in slightly lower energy ("cooler") steam being exported to campus for heating during the winter month. Although still adequate for campus needs, slightly more steam would be needed to meet the same campus heat demand. The CAP cost savings estimate, downgraded from the 2009 estimate to match recent performance data, accounts for the slight additional fuel needed to deliver the total energy for this revised co-generation process (slightly increasing gas use to significantly reduce electrical imports).

When Initiated: **Turbine Generator Replacement** is one of the 19 initial Actions included in the 2009 Climate Action Plan (CAP).

2011 Status and Successes: Cornell applied for Federal Funding in 2009 to help pay for this action, but was unsuccessful in that application. While there is no funding available in the current Capital Plan for this action, it remains a planned improvement as capital funds become available and it will be re-assessed as the turbine ages.

In late 2009, Cornell upgraded its other steam turbine (TG-2) to improve its efficiency. Although that action was pre-approved prior to the CAP and so not considered a "CAP action", it did result in improved co-generation capacity for campus.

Key Metrics:

- This action will reduce Cornell's GHG footprint by about 240 metric tons of CO_2 per year, or about 0.1% of the total campus emissions.
- The projected 600 MW-hr per year that would be produced represents the equivalent of the electricity used in about 50 average U.S. homes.

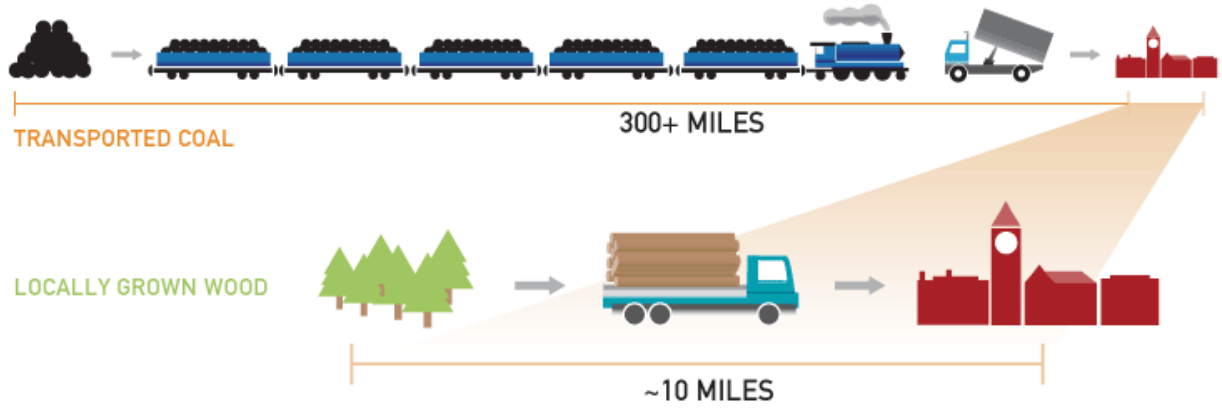
What's Next?

- This Action will continue to be evaluated periodically based on energy prices and estimated replacement cost; funding will be requested when the project is financially viable.
- When it is time for a generator replacement or significant rebuild, a more efficient multi-stage generator will be considered.

For More Information: A description of Cornell's electrical production systems, including the steam cogeneration, can be found at the following URL:
http://energyandsustainability.fs.cornell.edu/util/electricity/production/default.cfm

Cornell Climate Action Plan (CAP) – ACTION UPDATE: BIOMASS COMBUSTION

Action/Wedge: **Biomass Combustion** is an Action in the CAP Wedge **Fuel Mix and Renewables**, which seeks to reduce the fossil-fuel energy needed for campus heating, and electricity with energy from renewable resources. The original 2009 Action, as noted below, highlighted the difference in transportation impacts between the then-current combustion of coal versus combustion using locally-sourced wood. Cornell ended all coal combustion in March 2011.



Summary Description: **Biomass Combustion** is the utilization of renewable biomass resources (wood or non-food agricultural products) as a combustion source in existing solid-fuel boilers, replacing the coal once used at the Central Energy Plant. Principal challenges include managing the transportation and materials handling needs for biomass, which is a much less concentrated energy source than coal, and modifying the energy plant as necessary to maintain safe operations and clean emissions. There is also a parallel need to understand the social and environmental impacts of more intense biomass production, an area of interest for both academia and the broader public.

When Initiated: This is a **proposed new Action** in the CAP, replacing the 2009 CAP action "Wood Co-Firing". Wood Co-Firing was an effort to co-fire 10-20% wood with coal in our existing solid fuel boiler. Since the time of the original 2009 CAP, Cornell has completely eliminated coal combustion and no longer stores coal on site. Biomass Combustion – using 100% biomass – has emerged as a potential opportunity to utilize the capacity of Cornell's functional solid fuel boiler ("Boiler #8").

2011 Status: Cornell completed an initial study in 2011 to verify the functionality of the current materials handling (conveyors and hoppers), boiler, and emissions-control equipment for wood combustion. This study identified improvements needed in the areas of storage and materials handling. Some of these improvements would be needed just to safely conduct a test-burn to verify the technical and economic feasibility of this action and document emissions that would result. The preliminary internal study also concludes that biomass combustion would be significantly more expensive than natural gas combustion.

If storage and handling deficiencies can be overcome, Cornell's investigation concludes that boiler #8 has potential to combust 100% solid biomass fuel. Pilot testing is needed to confirm that boiler #8 could supply a minimum steam flow of 60,000 lbs per hour for the winter months, displacing natural gas that would have been fired in either duct burners or package boilers. This steam would provide heat and co-generated (using existing steam turbines) electricity for campus needs.

Cornell has received tentative permission from the New York State Department of Environmental Conservation (NYSDEC), which regulates Cornell's combustion sources, for a test-burn, removing one potential barrier. Assuming no changes in the NYSDEC's approach; the main barriers to moving ahead are capital funding and the increased operational costs. In parallel, Professor Tim Fahey and researcher David Weinstein prepared a study which demonstrated that adequate sustainably-harvested biomass exists for this conversion, but education and development efforts would be needed to ensure the work was done sustainability and with acceptably low impacts to the environment and community.

Without wood biomass capability, the Central Energy Plant needs to rent two large oil-fired boilers during the winter months to ensure adequate support for peak winter steam (heating) demands, with the assumption that primary plant equipment, though very reliable, may be down for maintenance or repair from time to time. Should wood prove to be a feasible alternative, one or possibly both rental boiler purchases could be deferred in future years, because wood would be available as a back-up fuel. In the longer term, economic evaluations will consider the total cost (capital and operating) of installing a new permanent gas boiler versus the total cost for a biomass system.

Key Metrics:

- Combusting 32,000 tons of biomass in place of natural gas would reduce CO_2 emissions by 11,000 metric tons on an annual basis.
- Combusting biomass to generate 60 klbs/hr of steam flow would require approximately 270 tons/day of 45% moisture biomass (raw wood chips); 32,000 tons over the 4-month time period.
- Biomass is labor-intensive: the equivalent of 8 additional full-time staff may be needed over the 5-month prime heating season to support the round-the-clock operation of a solid fuel boiler, including materials staging and handling, boiler operation, ash handling, and maintenance.

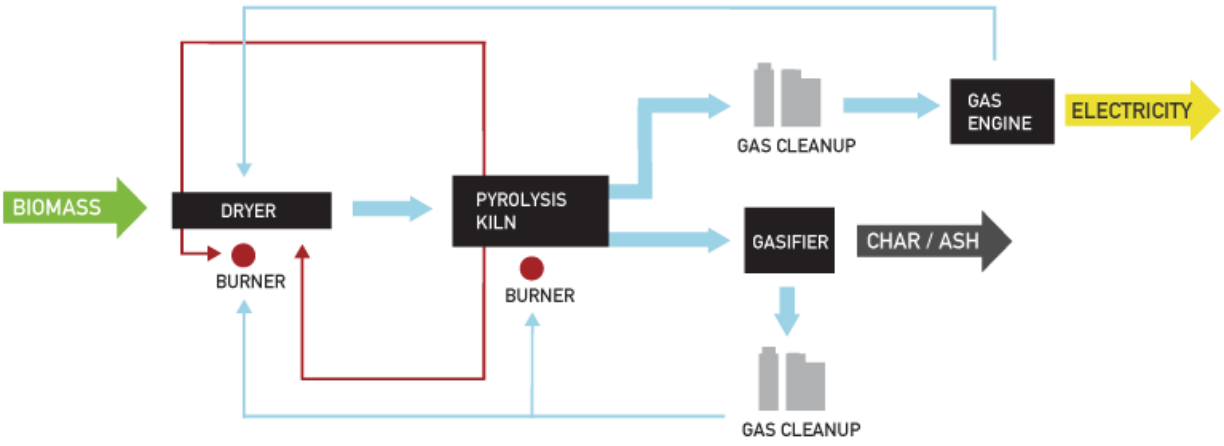
What's Next?

- Because some improvements are needed to allow a test burn, further advancement of this proposal will not occur until the financial efficacy of this Action can be demonstrated.
- Cornell staff continues to track energy costs to assess whether biomass may become more economical in coming years, and to identify potential biomass sources for the long term.

For More Information: Learn more about Cornell's Central Heating Plant at the following URL: http://energyandsustainability.fs.cornell.edu/util/heating/production

Cornell Climate Action Plan (CAP) – ACTION UPDATE: CURBI

Action/Wedge: **CURBI** is an Action in the CAP Wedge **Fuel Mix and Renewables**, which seeks to reduce and replace the fossil-fuel energy needed for campus heating, cooling, and electricity with energy from renewable resources.



Summary Description: **The Cornell University Renewable Bioenergy Initiative (CURBI)** was conceived as a research and operations platform to be used for the demonstration of the conversion of biomass into energy for the Cornell Ithaca campus using multiple technologies. A feasibility study for CURBI, managed by Cornell's Ithaca Agriculture Experiment Station (AES) and funded in part by the New York State Energy Research and Development Authority (NYSERDA), was published in January 2010. The study provided a detailed plan for converting the more than 50 campus biomass and waste streams into renewable energy for the University and confirmed the technical and operational feasibility of technologies that would be both comprehensive (designed for a wide range of input materials) and stackable (interlinked such that the waste from one process could become a feedstock for another).

Key technologies envisioned for CURBI include:

- Anaerobic Digestion
- Dry Fermentation
- Biodiesel conversion
- Combustion
- Pyrolysis & Torrefaction
- Biomass Gasification

These technologies would be linked with common biomass management and handling systems; syngas utilization equipment (creating combined heat and power), and an operations control building.

When Initiated: CURBI is **one of the original 19 CAP Actions.** Although biomass field and energy-conversion research has long been active at Cornell, the goal of CURBI was to develop a more formal interdisciplinary model for operations-scale research with real-world outputs, joining researchers and facilities professionals.

2011 Status: Since the addition of CURBI to the Climate Action Plan, Cornell has made the following progress towards implementing CURBI:

- Completed the CURBI feasibility study (published January 2010)
- Achieved a formal concept ("Project Plan") approval within the University (Summer 2010)
- Completed a site selection study and approval, designating a location on campus for the future CURBI support building (Fall 2010)
- Utilized the CURBI concept in securing donor support for the first CURBI-related technology, a 100 pound/hour Pyrolyser unit located on central campus to be utilized in research by Professor Johannes Lehmann. The action of converting biomass to biochar through pyrolysis holds the potential for biologically locking carbon in soil while improving agricultural output, essentially creating a "carbon-negative" (sequestering) agricultural option.

Despite these successes, Cornell had not yet been successful in securing funding for the full CURBI initiative and no funding for this project is included in Cornell's current Capital Plan.

Key Metrics:

- The feasibility study estimates that Cornell's available feedstocks could produce over 2,600 megawatt-hours of electricity and over 29,000 MMBtu of thermal energy each year. While this is small compared to campus loads (1% of electricity and 2% of heat, respectively) it is large enough for demonstrating energy production at farm or small commercial scale.

What's Next?

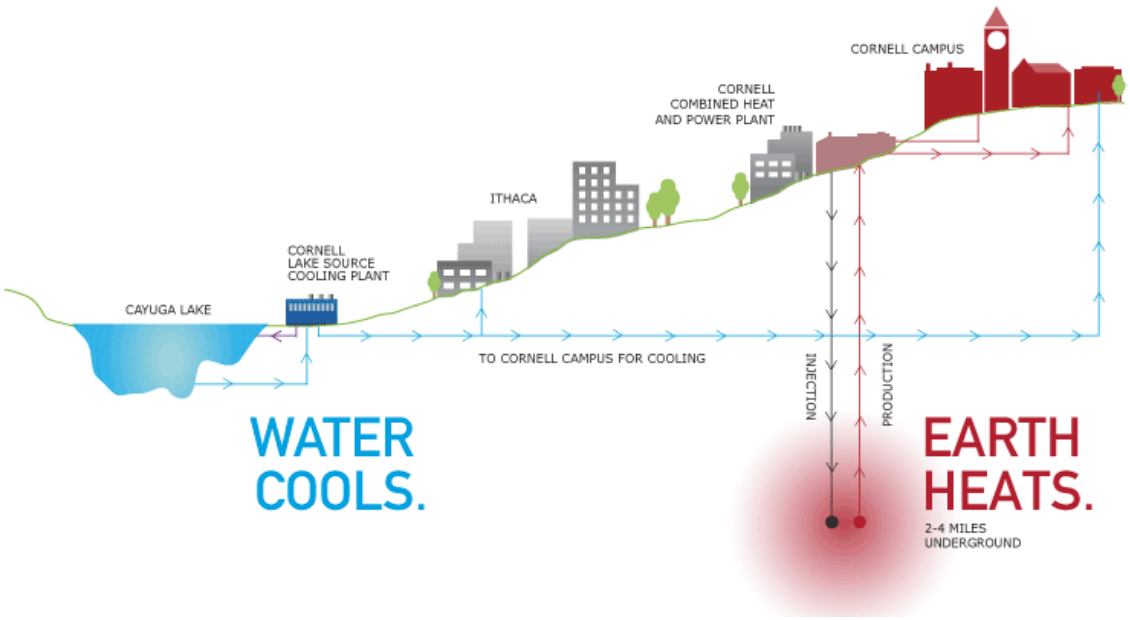
Cornell has not yet been successful at funding the overall CURBI facility. A number of proposals have been submitted for projects which involve CURBI-related technologies, but primary funding will be needed to develop the comprehensive CURBI concept represented by the feasibility study.

For More Information: Learn more about CURBI and the work of the Agriculture Experiment Station at the following URL: http://www.cuaes.cornell.edu/cals/cuaes/ag-operations/curbi

Mike Hoffmann, director of Cornell's Agricultural Experiment Station in Ithaca, works with the Climate Action Plan team to integrate campus priorities into actions.

Cornell Climate Action Plan (CAP) – ACTION UPDATE: HYBRID Enhanced Geothermal System (EGS)

Action/Wedge: **Hybrid Enhanced Geothermal System (EGS)** is an Action in the CAP Wedge **Fuel Mix and Renewables**, which seeks to reduce and replace the fossil-fuel energy needed for campus heating, cooling, and electricity with energy from renewable resources.



Summary Description: **Hybrid EGS** represents a strategic combination of two distinct potential actions. The first, illustrated above, is the use of deep (2-4 mile) geothermal wells to extract heat from the earth to provide heat and power for campus. This heat would come from bedrock deep within the earth; the "enhanced" (or, sometimes "engineered") term refers to the need to fracture this rock to create pore space whereby water can pass to collect this energy. The second technology is the use of biomass to create a hydrogen-rich gaseous fuel ("syngas" or "bio-gas") to provide heat and power during peak heating times. This combination of EGS and bio-gas production allows both systems to be appropriately sized – the geothermal system sized to take advantage of the steady "baseline" heat of the earth during normal periods and the bio-gas system sized to accommodate peak heating needs. By joining these two together, Cornell seeks to minimize capital investment while maintaining a sustainable rate of resource extraction.

When Initiated: This is **one of the original 19 Actions** in the 2009 CAP. The great potential of EGS was documented in a 2006 USDOE study "The Future of Geothermal: Energy Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century", written by an interdisciplinary panel chaired by Professor Jeff Tester, who has now joined the faculty at Cornell.

2011 Status: Cornell has actively pursued Federal and State funding for development-scale EGS or Bio-gas work since 2009, but has yet to secure funding at a level necessary to initiate the full-scale energy development project envisioned in the CAP. Meanwhile, EGS research efforts continue at Cornell, with two specific teams of graduate and post-graduate scholars involved in a multi-institutional USDOE-funded collaboration exploring the Hybrid EGS concept. The focus of this work at Cornell incorporates both the subsurface EGS resource potential as well as the at-surface energy utilization potential for that resource. These efforts will continue for several years while Cornell continues to monitor the availability of funding for development-scale work on campus.

Key Metrics:

- The USDOE estimates that, with proper investment, EGS could provide over 100 GW (gigawatts) of cost-competitive generating capacity in the next 50 years. By comparison, the total generating capacity of nuclear power in the United States in 2010 was also about 100 GW. This nuclear power accounted for almost 10% of total U.S. electrical generating capacity and, because of its steady, baseline operation, about 20% of total U.S. generated power in 2010.
- Hybrid EGS is by far the largest single energy action proposed in the CAP. Successful implementation of hybrid EGS would provide for nearly 113,000 tons (CO_2 equivalent) of average annual carbon abatement—more than 40% of the total campus footprint in 2010.

What's Next?

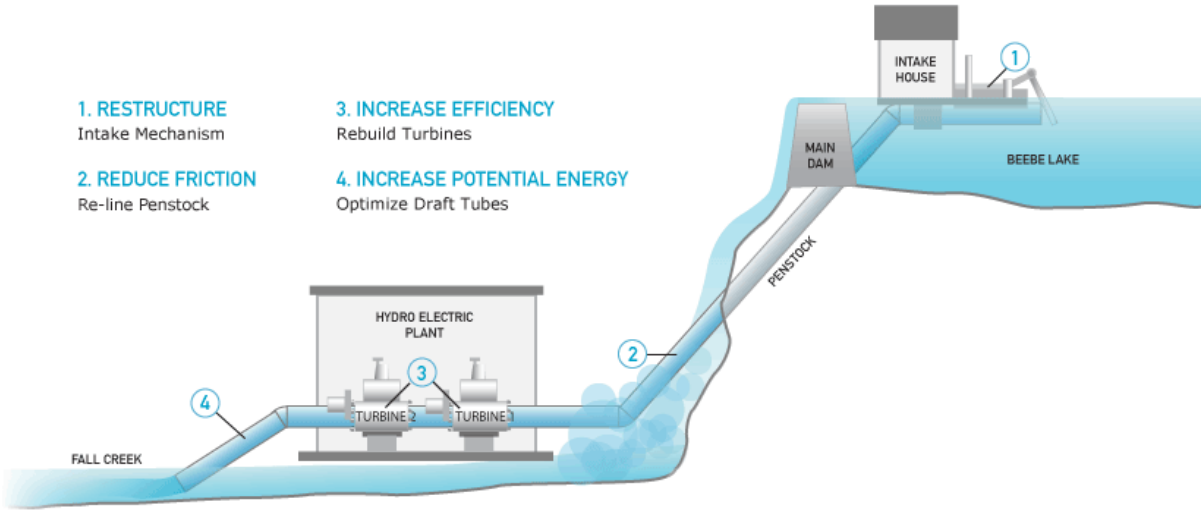
Cornell continues to seek opportunities for Hybrid EGS – either a bio-gas plant or an EGS installation, and eventually for both. However, while there is fully-funded on-going research work, there is no funding in the current 5-year Capital Plan for on-campus implementation of these technologies.

Jeff Tester, The Croll Professor for Sustainable Energy Systems, leads an effort to evaluate whether engineered geothermal systems could be developed in the Ithaca

For More Information: Learn about Cornell's EGS explorations here:
http://www.geo.cornell.edu/eas/energy/research_front_page/geothermal.html

Cornell Climate Action Plan (CAP) – ACTION UPDATE: UPGRADED HYDRO CAPACITY

Action/Wedge: **Upgraded Hydro Capacity** is an Action in the CAP Wedge **Fuel Mix and Renewables**, which seeks to replace the fossil-fuel energy needed for campus heating, cooling, and electricity with



energy from renewable resources.

Summary Description: **Upgraded Hydro Capacity** is a proposal to improve the efficiency of the hydropower plant such that more energy is generated from the same water resource. This action combines four separate upgrades, specifically:

1. Restructure the Intake: Although it has been updated since the hydroelectric plant was originally constructed in 1953, the intake structure was designed for lower flows than currently required for optimum output. Nearly 4 percent of system pressure is lost from the trash rack to the penstock. Reconfiguring the bell-mouth entrance and replacing the entrance gate within the existing intake structure could eliminate just over half of this pressure loss.

2. Re-line the Penstock: Relining the existing penstock to create a smooth interior surface would reduce pressure loss due to friction.

3. Rebuild the Turbines: The turbines currently operate at about 65 percent efficiency—considerably lower than their rated efficiency of 80 percent as a result of guide vane and turbine runner wear on both turbines. Complete renewal of the turbines would return them to their rated efficiency.

4. Optimize Draft Tubes: Connecting tubes to the turbine exits and extending them below the tailwater surface may help to increase the total water pressure by 5 percent providing additional driving head for the flow.

When Initiated: Up-grading Hydro Capacity is **one of the original 19 Actions** in the 2009 CAP.

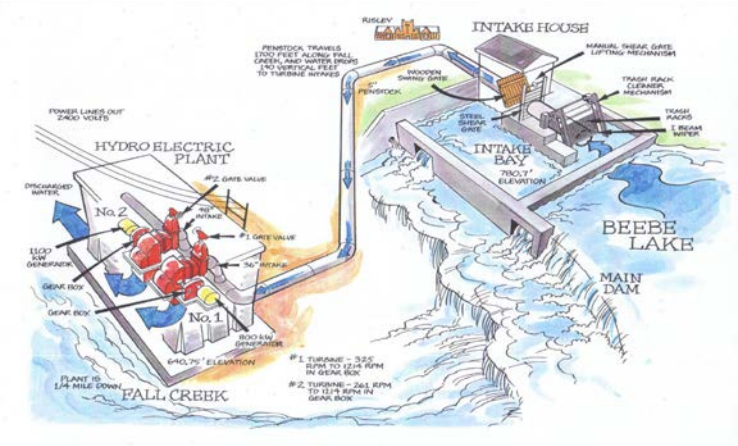
2011 Status: Since the 2009 CAP publication, Cornell maintained the integrity and improved the performance of the hydroelectric plant by replacing the roof and upgrading controls. Control upgrades such as automating the trash rack and improving turbine sequencing have increased production by 20%.

Key Metrics:

- The facility generates an average 5,000 MWh (5 million kWh), enough for 600 homes.
- Improvements in four areas could result in an additional 1,800 MWh production from the same water resources and reduce GHG emissions by a corresponding 730 metric tons CO_2 per year:
  - Restructuring the intake would add 300 Mwh per year.
  - Relining the penstock would provide a 4.2 percent improvement or 250 MWh per year.
  - Turbine upgrades could create another 900 MWh per year in additional output.
  - Extending draft tubes could increase output from the plant by 350 MWh per year.

What's Next?

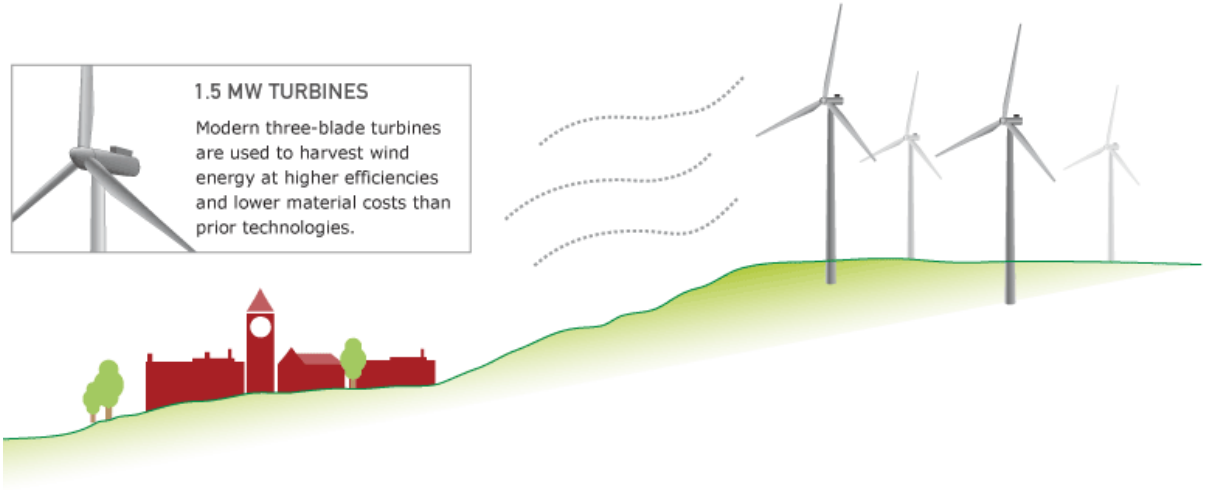
- The University's current capital plan includes funding to rebuild one turbine in 2013 and the second in 2014.
- Funding for other potential elements of this Action, including a rebuild of the intake structure and relining of the penstock, is being considered in balance against other University priorities.
- Energy & Sustainability staff members are working with faculty and students within the College of Engineering to investigate the potential for incorporating micro-turbine energy production along Fall Creek. If this is shown to be feasible, it could represent a new CAP Action.



For More Information: Learn about the hydropower plant at the following URL:
http://energyandsustainability.fs.cornell.edu/util/electricity/production/hydroplant.cfm

Cornell Climate Action Plan (CAP) – ACTION UPDATE: HARNESSING WIND ENERGY

Action/Wedge: **Harnessing Wind Energy** is an Action in the CAP Wedge **Fuel Mix and Renewables**, which seeks to reduce and replace the fossil-fuel energy needed for campus heating, cooling, and electricity with energy from renewable resources.



Summary Description: **Harnessing Wind Energy** is a proposal for harnessing "utility-scale" wind power. The CAP-proposed wind power project included eight wind turbines rated at 1.5 megawatt (MW) each, for a combined rated capacity of 12 MW, connected directly into the Cornell electric system.

Wind power has the advantage of directly generating electricity, the energy of highest value for Cornell's campus. Wind turbine generator and control technology continues to advance and is characterized as the most cost effective large scale renewable electricity energy source available.

A technical challenge for wind power is to match generation capacity to power needs. In Ithaca, the majority of wind energy production will occur during October through April when Ithaca experiences the most wind, the same time period that the Cornell Combined Heat and Power Project can provide the most electricity. Cornell's need for a broad portfolio of "stored" and "naturally fluctuating" energy resources reflects the challenge of broader society. Cornell seeks to optimally create models for "on-demand" energy (geothermal and stored biomass) and "as supplied" energy resources (wind, solar, and conventional hydropower) to demonstrate broad-based solutions that address this challenge.

When Initiated: This is **one of the original 19 Actions** in the 2009 CAP.

2011 Status and Successes: In the spring of 2005, Cornell announced plans to begin a feasibility study for generating utility scale quantities of electricity using wind energy on nearby university property on

Mt. Pleasant in the Town of Dryden, NY. Early investigations suggested that the site was the best option within a range that could directly supply campus, even though the wind resource at this site is only rated as "marginal" on standard wind industry maps. Then, a number of public meetings were held and university officials met with homeowners in the vicinity of the proposed site. As a result of concerns addressed at homeowner meetings, very restrictive local zoning laws, the identification of technical and financial challenges associated with the construction and operation of a wind farm, and other institutional priorities, the university halted the feasibility study at that time. However, a 2009 survey showed that the overall community was more supportive of wind power than any other renewable energy option.

Although wind power remains one of the most cost-effective technically-proven options available for the production of electricity, a wind project near Cornell is not expected to have a reasonable payback without substantial grant or donor funding based on current electric rates. A site such as Mt. Pleasant is currently more expensive than co-generation using fossil fuels or electric grid prices.

Cornell is also investigating smaller-scale wind applications for the Ithaca campus and for other sites. A small turbine design for Cornell's Lake Erie Research and Extension Laboratory (Portland, NY) has been proposed. Cornell already operates a small turbine at the Shoals Marine Laboratory, located on Appledore Island off the coast of Maine. No other new projects have yet met the University's financial criteria based on capital costs and anticipated energy savings. Cornell continues to review opportunities, which may be more viable if energy prices increase or greenhouse gas emissions taxes are implemented.

Key Metrics:

- The U.S. Department of Energy is pursuing plans to obtain as much as 20% of the nation's electricity from Wind by 2030.
- New York State's Renewable Portfolio Standard sets the bar at 25% renewable energy by 2013. Wind Power has the highest renewable energy growth potential in the portfolio.
- Assuming a capacity factor of 29 percent, annual output from eight (8) 1.5 MW-rated wind turbines would total about 30,500 MWh, or almost 15% of campus annual usage.

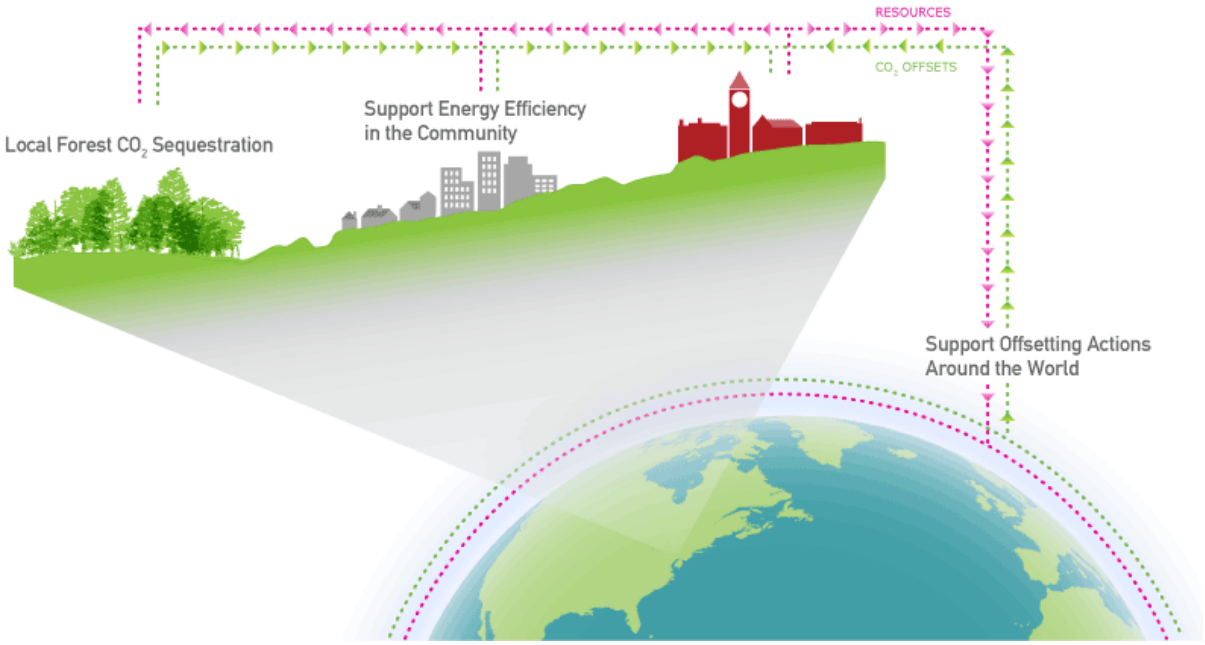
What's Next?

Cornell continues to seek opportunities for implementing wind power for education, research, demonstration, and full-scale utilization. However, present economics and available local wind resources do not support substantial wind development without further economic incentives.

For More Information: Learn about Shoals Marine Lab, which is partially powered by wind and solar: http://www.sml.cornell.edu/sml_welcome.html

Cornell Climate Action Plan (CAP) – ACTION UPDATE: OFFSETTING ACTIONS

Action/Wedge: **Offsetting Actions** make up the final CAP Wedge. The positioning is intentional; Cornell seeks to avoid, reduce, and replace its GHG emissions to the extent practical before calculating any "credits" for actions occurring outside of campus. Nonetheless, Offsetting Actions acknowledge the interdependence between Cornell and surrounding communities and the potential positive impacts Cornell can have based on its management of lands and sharing of knowledge and resources.



Summary Description: CAP **Offsetting Actions** represent three distinct areas of focus, namely:

- **Direct Mission-Linked (Land-Use Related) Offsetting Actions:** These actions involve the care of lands under the stewardship of Cornell in a manner that will improve the carbon stored in these lands and includes the following three separate activities:
    - **Afforestation:** Converting idle pasture or cropland to forest land by planting and actively managing the land to grow mature trees can enhance carbon sequestration by allocating lands to forest cover that has higher carbon storage potential.
    - **Forest Management:** Active forest management on over 6,600 acres of Cornell University owned forestlands can increase the carbon-storage capacity of these lands.
    - **Biochar:** Land application of biochar (charcoal produced from the slow pyrolysis of organic biomass) has been proposed as an effective method for long-term capture and sequestration of carbon in the earth.
- **Undefined Offsetting Actions:** Cornell research and outreach spans many fields, from energy systems to agriculture to human behavior, all central to our broad educational mission (teaching, research, and outreach). As the impacts of our actions become better defined and

measured, Cornell may seek to document positive impacts (GHG reductions) which directly result from these mission-linked activities and which would not occur without these activities.

- **Community Offsetting Actions:** Cornell is an integral member of the broader community. A local carbon offset initiative, the Finger Lakes Climate Fund, was launched by local environmental leaders whereby "credits" can be purchased and the money used to fund energy conservation and renewable energy projects in the local area. Faculty, students, Cornell Cooperative Extension staff, and Facilities staff have long been involved in assisting community members in expanding renewable energy and conservation efforts. With appropriate auditing and structure, initiatives like these could generate third-party-verified carbon offsets.

When Initiated: The three types of Offsetting Actions were included among **the 19 initial Actions** in the 2009 Climate Action Plan (CAP).

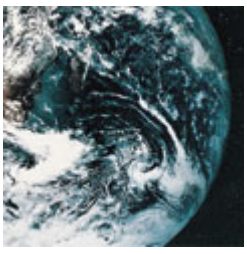
2011 Status and Successes: Cornell researchers continue on-going efforts to understand and quantify the short- and long-term effects of various land use strategies. A "pyrolysis" kiln has been donor-funded and is expected to be commissioned in 2012 for the further generation and study of biochar and its potential benefits for carbon sequestration (although this research-scale effort itself will not yield carbon-negative results). Cornell has engaged with the local Tompkins County Climate Fund, purchasing informal "offsets" to cover traveler's emissions to Cornell for a spring 2010 energy conference.

Key Metrics:

- Cornell estimates that mission-linked land use actions on Cornell lands could sequester about 20,000 tons of CO_2 beyond current sequestration levels.
- A working community offset program could reasonably eliminate about 3,000 tons of carbon emissions across the local community through coordinated action.

What's Next?

- Cornell's Natural Resources faculty continue to refine estimates for the carbon-capture potential for Cornell lands and are seeking grants to demonstrate these improvements.
- A biochar kiln to be installed in 2012 will greatly increase the availability on campus of biochar, allowing Cornell to quantity the real-world potential of biochar for carbon sequestration: a field unit in Kenya aims to produce both biochar and local energy (butane) from local biomass.
- The Presidents Sustainable Campus Committee (PSCC) Climate Team will evaluate and recommend next steps to develop an effective local offset program.



For More Information:

- The Finger Lakes Climate Fund: http://www.tccpi.org/Climate_Fund.html
- Cornell's work on Biochar: http://www.cuaes.cornell.edu/cals/cuaes/ag-operations/curbi/biochar.cfm
- Cornell Environmental and Natural Resources information: http://cce.cornell.edu/Environment/Pages/EnvironmentandNaturalResources.aspx