

2009 Cornell Climate Action Plan

MAKING CLIMATE NEUTRALITY A REALITY

This pdf is the original 2009 version, without updates

All future versions will be available on the Cornell Sustainable Campus website
<http://www.sustainablecampus.cornell.edu/initiatives/climate-action-plan>



About This Document

In 2007, President David Skorton represented the aspirations of thousands of students, faculty, staff, and alumni by signing the American College and University Presidents Climate Commitment, pledging Cornell University to a path toward climate neutrality. As a comprehensive response to that challenge, groups of Cornell faculty, staff, and students developed the Climate Action Plan. It promotes the education and research needed to generate solutions for the challenges of global warming – and will demonstrate these solutions in campus operations.

Completed in September 2009, the first iteration of the Cornell Climate Action Plan was unveiled as part of the Cornell Sustainable Campus website. Changing technology and circumstances require periodic modifications to the plan to enable Cornell to fulfill its ACUPCC commitment. Accordingly, the plan was updated in 2011. The original 2009 version, which has served as a resource to many other institutions, has been preserved in this pdf document. It contains valuable documentation of the process and tools used to create Cornell's Climate Action Plan, and the plan's original 19 actions.

The current Cornell Climate Action Plan will continue to be presented on the Cornell Sustainable Campus website, along with all routine ACUPCC progress reports and greenhouse gas emissions inventories.

<http://www.sustainablecampus.cornell.edu/initiatives/climate-action-plan>



Cornell Climate Action Plan

MAKING CLIMATE NEUTRALITY A REALITY

Cornell's Climate Action Plan (CAP) promotes the education and research needed to generate solutions for the challenges of global warming – and will demonstrate these solutions in campus operations.



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ACTIONS
19 INITIATIVES
TO ACHIEVE
NET-ZERO
EMISSIONS



[learn more »](#)

PROCESS
VIEW OUR
PLANNING
PROCESS
BY STAGES

[learn more »](#)

INVENTORY
ESTABLISHING
OUR CARBON
FOOTPRINT

[learn more »](#)

FORECAST
PROJECTING
GREENHOUSE GAS
REDUCTION THROUGH
2050

[learn more »](#)

CULTURE CHANGE
GET INFORMED
GET INVOLVED

CORNELL STUDENTS FAMILIES

[learn more »](#)

As the New York State land grant university and an Ivy League institution, Cornell's comprehensive plan for climate neutrality will have an impact well beyond our campus borders. From students, faculty, and staff to researchers and the administration, our actions and initiatives to eliminate greenhouse gas emissions will engage, educate, and inspire our state, our nation and our world.

Created with financial support from the New York State Energy Research and Development Authority and among the first such comprehensive programs undertaken by a major university, the Climate Action Plan (CAP) sets the goal of reducing carbon-based emissions from the Ithaca campus to net zero by the year 2050, thus achieving carbon neutrality. Recommended actions in the plan will help

A welcome message from President Skorton



the university improve the energy efficiency of its facilities, reducing operating expenses and realizing savings otherwise subject to commodity fuel cost fluctuation, projected carbon legislations, and potential capital expenditure. At the same time, the CAP will help Cornell unify research and teaching around sustainability in its broadest sense: economic strength and stability; research and teaching excellence; and outreach programs that fulfill our Ivy League and land-grant missions.

Cornell has done much—its Transportation Demand Management program, Lake Source Cooling Plant, in-construction Cornell Combined Heat and Power Plant, the Renewable Bioenergy Initiative (CURBI), a longstanding building Energy Conservation Initiative—but there is much left to do. Though the CAP provides an initial set of 19 initiatives to pursue, it is just a starting point. The opportunities represented by new technologies and circumstances of culture and economy will surely change over the course of 40 years. Accordingly, the CAP is a dynamic document and evolving initiative.

You are invited to explore the Cornell Climate Action Plan website and revisit it regularly to see what's been done, what is ongoing, and what Cornell is exploring next.

Click on the video above to play the message

NEWS

For latest news announcements and related events, please visit Sustainable Campus:

[News](#)

[Events](#)

Download the Cornell Climate Action Plan Summary:

Hi-Resolution for printing—pdf

**Suggested printing instructions:
color, double sided, staple top
and bottom.**

Low-Resolution for viewing—pdf



Making Climate Neutrality a Reality



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Our comprehensive process to engage stakeholders, cultivate ideas, analyze options, and transition to a net-zero carbon future can be explored here as a transparent and unedited example of one institution's real-life efforts to plan for climate neutrality.

PLANNING PROCESS BY STAGES [learn more](#)

DISCOVERY

Profile the Situation

IDEATION

Solicit Ideas:
706 Ideas Generated

ANALYSIS

Screen Ideas:
114 Themes Identified

PLAN CREATION

19 Actions Endorsed

EXECUTE

Implement the Actions

The actual process of creating our Climate Action Plan (CAP) took more than a year. From the initial activity of internally compiling our carbon inventory, to designing a project that involved external consultants, community members, subject matter experts, and a broad spectrum of Cornell stakeholders, our planning effort throughout the process has sought to engage and involve. We sought to conduct this project in a logical, ordered, and replicable fashion. As such, we have made the raw materials from early in the development of the CAP available alongside the polished finished products. We have consciously done this so that others who might seek to take on a similar challenge can benefit from our experiences and can refine the process in future iterations.

To fully trace our process, tools, and methods for creating our CAP. You can [explore the complete diagram and its associated files](#).

Project Team

PCC IMPLEMENTATION COMMITTEE

ACTION GROUP LEADERS

CONSULTANTS

Professor Tim Fahey

Dept. of Natural Resources

President's Climate Commitment
Implementation Committee (PCCIC)
PCCIC Co-Chair

Kyu-Jung Whang

VP Facilities Services

President's Climate Commitment
Implementation Committee (PCCIC)
PCCIC Co-Chairs

Robert R. "Bert" Bland

Energy & Sustainability

Steve Beyers

Energy and Environmental Engineering

Dan Roth

Energy & Sustainability

James R. Adams

Energy & Sustainability

Karen Brown

Campus Life Marketing & Communications

Mary-Lynn Cummings

Space Planning

Donna L. Goss

Manager, Strategic Communications

Linda Grace-Kobas

Strategic Communications

Daniel Grew

College of Engineering

Phil McPheron

Campus Life

W.S."Lanny" Joyce

Energy & Sustainability

Dean R S Koyanagi

Environmental Compliance
& Sustainability Office

Professor Sidney Leibovich

Mechanical Engineering

David Jay Lieb

Transportation and Mail Services

John Kiefer

Green Development
(w/Randy Lacey and Mary-Lynn Cummings)

W.S. "Lanny" Joyce

Energy Conservation

James R. Adams

Fuel Mix & Renewables

David Jay Lieb

Transportation

James R. Adams

Offsetting Actions

Robert R. "Bert" Bland

Sustainable Decisions

Robert R. "Bert" Bland

Forecast

Affiliated Engineers, Inc.

Mike Walters

Green Development

Stan Wrzeski

Energy Conservation

Jerry Schuett

Fuel Mix & Renewables

John Carter

Fuel Mix & Renewables

Energy Strategies

Nick Travis

Sustainable Decisions

Robert McKenna

Forecast

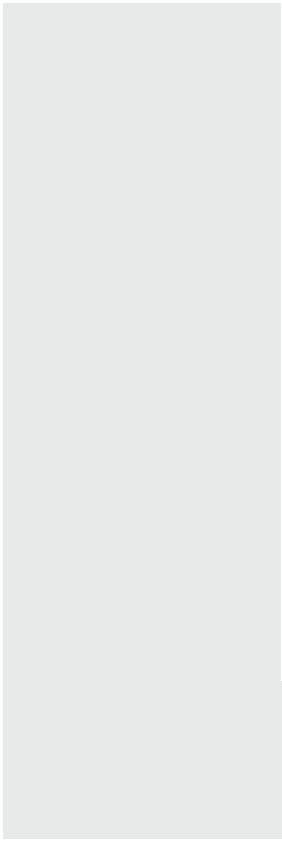
Jeff Burks

Carbon Offsets

Martin/Alexiou/Bryson

Nathaniel Grier

Transportation



Karen Muckstadt

Campus Life

Shane Rothermel

Student, College of Engineering

Dennis W. Stein

PawPrint

Professor Jeff Tester

Chemical & Biomolecular Engineering

Mike Walsh

Trustee Student Representative

David Weinstein

Department of Natural Resources

CAP Planning Process by Stages

Key Stakeholders Interviewed Consultants Hired	Faculty, Staff, Student Working Group Participants Enlisted Students & Community Solicited	Trustee Briefing Internal / External Experts Contacted	Stakeholder Reviews Committee Reviews Public Educational Sessions	Pilot Projects Continued Campus Education Website Development
Discovery	Ideation	Analysis	Plan Creation	Execute
Profile the Situation	Solicit Ideas: 706 Ideas Generated	Screen Ideas: 114 Themes Identified	19 Actions Endorsed	Implement the Actions
Inventory & Forecast Model The Forecast model, built from the Greenhouse Gas (GHG) Inventory, was a critical tool in our CAP planning process. The model became a consistent, robust vision of a Business-as-Usual Cornell from which all incremental decisions (CAP Actions) were assessed. The forecast model evolved throughout the planning process and is used as a measuring stick for GHG abatement, operating costs, potential capital investment, and many other important considerations. For a complete review of the CAP assumptions please refer to the Basis Notes document .	Wedge Groups Formed Green Development >> Energy Conservation >> Fuel Mix & Renewables >> Transportation >> Carbon Offsets >> Idea Brainstorming & Collection (Idea Collection Tool Template) At the project outset potential CAP ideas were solicited from the entire Cornell community and the Ithaca community through the use of a Web-based form. Click here to view the tool used and the 706 ideas generated! A brochure (pdf) was used to encourage new ideas. Idea Screening Ideas were initially screened to determine if they aligned with the University Mission and fundamental boundary conditions and then were: accepted into a "theme" for future analysis, eliminated and placed in the "compost," parked for future consideration in the "bike rack," or identified as a potential research or	Technical Brief Development Technical Briefs offer detailed descriptions of the potential CAP actions with specifics relating to scale of implementation, carbon abatement potential, first cost, operating cost, and qualitative reviews of Environmental (beyond carbon), Economic, Social, and Institutional considerations (Triple Bottom Line Plus or TBL+). Technical Briefs were used as the input documentation for technical and financial assessments. Green Development: Energy Use Intensity Standards Space Planning and Management Land Use Energy Conservation Fuel Mix & Renewables: All w/o Biomass Large Scale Biomass Transportation: Commuter Travel Fleet Services Business Travel	Portfolio Analysis Actions passed from the analysis stage were then considered together as an investment portfolio so interrelationships could be identified and optimized. The portfolio is comprised of specific near-term actions that merit immediate approval for implementation, mid-term actions that are recommended but do not require immediate approval and should be subject to periodic review, and long-term opportunities that should be monitored and assessed over time. Download the Cornell Climate Action Plan Summary: Hi-Resolution for printing—pdf Suggested printing instructions: color, double sided, staple top and bottom. Low-Resolution for viewing—pdf	Feasibility Studies Grant Proposals Project Development Summary Report: Community Attitudes toward Cornell University's Climate Action Plan

development opportunity and included in a CAP "test tube rack."

[See our Idea Screening Tool](#)

[See our Theme Screening Tool](#)

[See our Stage 1 Summary Report](#)

Offsetting Actions:

[Afforestation](#)

[Anaerobic Digestion](#)

[Biochar](#)

[Forest Management](#)

[Soil Tillage](#)

[Third Party Offsets](#)

Climate Action Decision Tool

This [comprehensive analytical tool](#), created as an Excel spreadsheet, was used to review the actions. The spreadsheet calculates emission improvements and financial data utilizing of each proposed actions independently and interactively against a Base Case scenario.

Metric Brief Development

[Metric Briefs](#) were used throughout the project as a tool to quickly convey key characteristics of proposed actions in a consistent format.

Detailed Financial Analysis

Financial models and interactive tools were used to determine the financial impact of actions. Commodity price forecasting was completed as documented in the [Basis Notes](#). Financial Assessments for each action, based on specific action sets, were documented for review by the Climate Action team.

[Internalized Cost of Carbon](#)

[Internalized Cost of Carbon - Supplement
Capital and Operating Expenditures
Estimate](#)





Greenhouse Gas Inventory

[HOME](#)

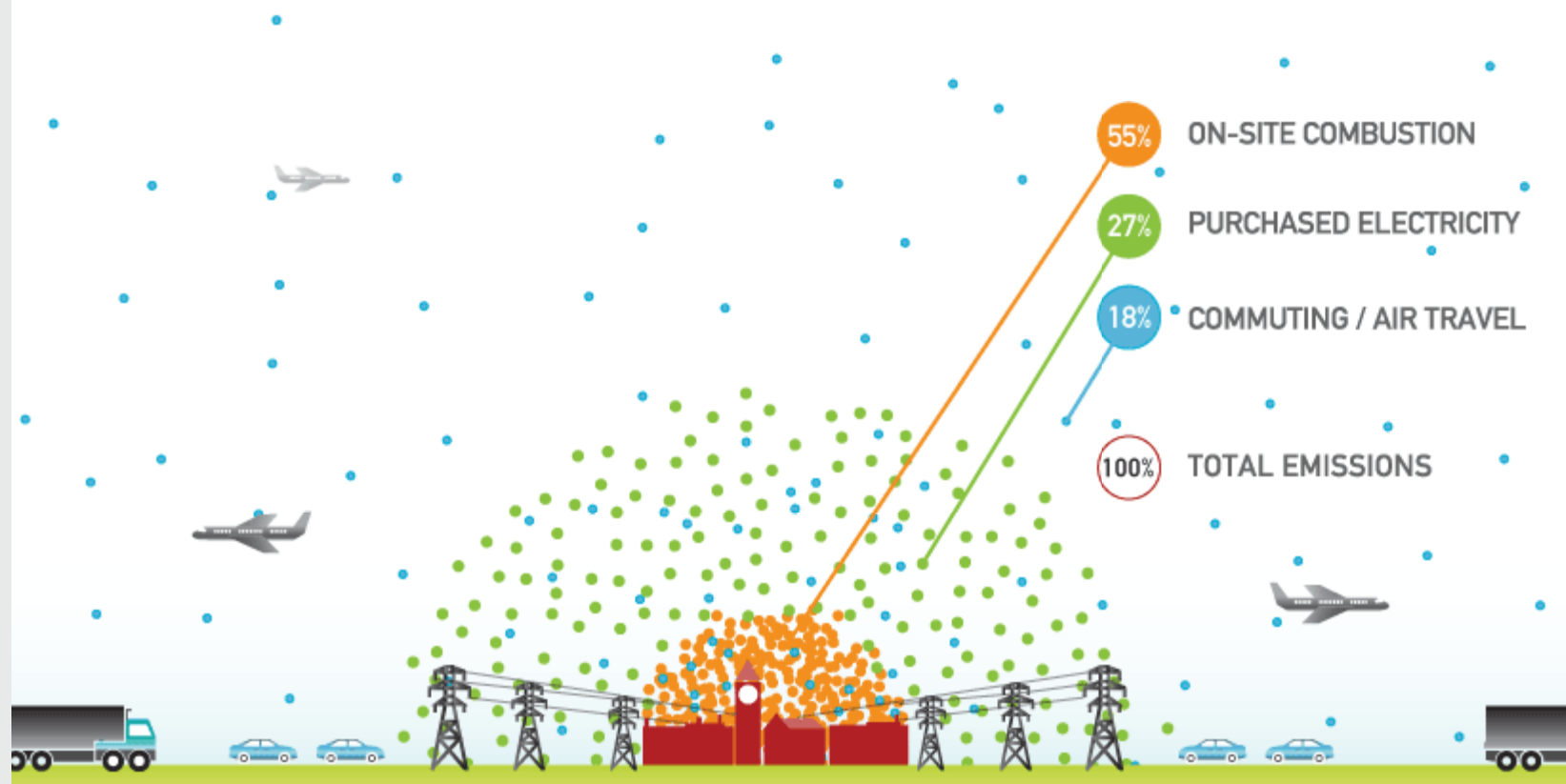
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CORNELL'S CARBON FOOTPRINT

The fiscal year 2008 carbon footprint for the Ithaca Campus is estimated at 319,000 metric tons CO₂-equivalent (CO₂-e), which includes carbon dioxide, nitrous oxide, and methane (the greenhouse gases associated with fossil fuel consumption). On-site combustion is the largest component at 176,000 metric tons CO₂-e and represents approximately 55% of our total footprint. Cornell University also uses a significant amount of electricity. This electricity use is responsible for 87,000 metric tons CO₂-e. At 9% and 8%, the respective footprints associated with commuting and air travel are comparable in magnitude. Scroll over the colored emission circles above for a detailed breakdown.

Want more details on Cornell's carbon inventory? The full 2008 inventory as reported to the [American College and University Presidents Climate Commitment](#) is posted on their website.

UNDERSTANDING EMISSIONS

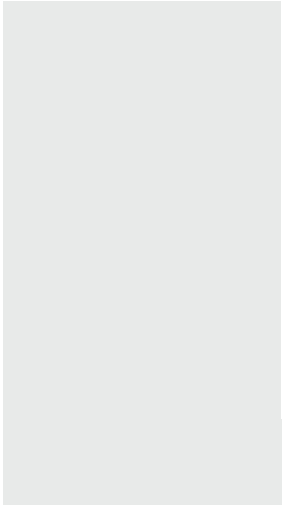
For consistency in reporting, emissions are reported by the following three categories:

ADDITIONAL INFORMATION

Completed in 2000, Cornell's Lake Source Cooling Plant reduced the campus energy use for cooling by 80% — saving 20 million kWh/year of electricity or enough for 2,500 homes.

When complete in the fall of 2009, Cornell's Combined Heat and Power Plant (CCHPP) will reduce campus CO₂ emissions by over 20%.

One-third of Cornell's faculty and staff commute by means other than single-occupancy vehicles.



Scope 1: Direct and fugitive emissions including electrical generation, heating, cooling, and fleet vehicles

Scope 2: Indirect emissions occurring as a result of purchased electricity consumption

Scope 3: Indirect emissions occurring as a consequence of an entity's activities.

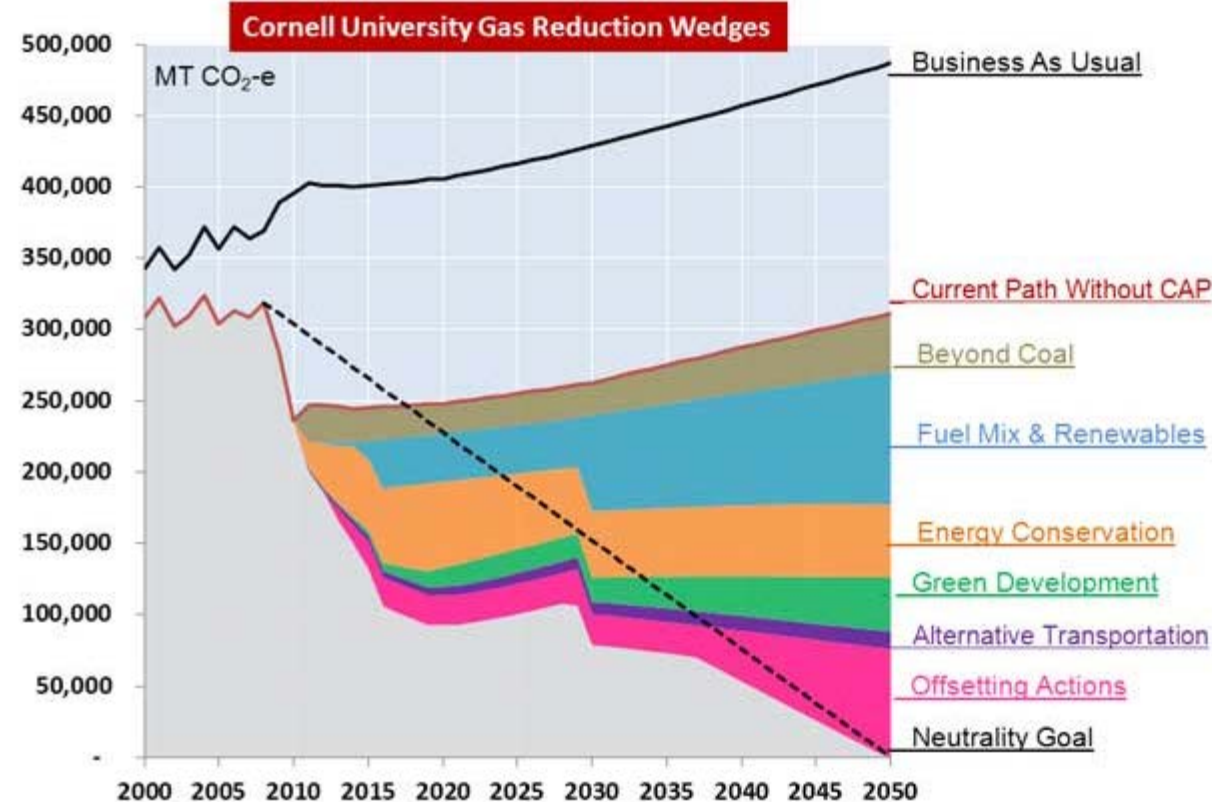
For more information refer to the [World Resource Institute GHG Protocol](#).



Achieving Net Zero Emissions



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STABILIZATION WEDGES AS A PLANNING PARADIGM

The diagram above illustrates two initial forecasts for Cornell's annual greenhouse gas emissions. The "Business as Usual" line indicates the likely emissions profile had Cornell not invested in significant upgrades to campus infrastructure and energy conservation. The "Current Path without CAP" line indicates the emissions profile that includes all initiatives for conservation and efficiency that occurred prior to the Climate Action Plan (CAP). The five colored areas below the "Current Path without CAP" line represent the five categories, or Wedges, of focus for the CAP: Green Development, Energy Conservation, Fuel Mix & Renewables, Transportation, and Offsetting Actions.

The CAP was developed using the wedge concept originally advanced by Princeton researchers Robert Socolow and Stephen Pacala in the article "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies" in the journal *Science*, in 2004. The original concept called for identifying off-the-shelf technologies that, if implemented widely, could abate 25 billion tons of CO₂ emissions over 50

ADDITIONAL INFORMATION

[American College and University Presidents Climate Commitment](#)

[The Stabilization Triangle: Tackling the Greenhouse Gas Problem with Today's Technologies](#)

[Intergovernmental Panel on Climate Change](#)

[Pew Center on Global Climate Change](#)

years. In the CAP, the scale of an individual wedge was not restricted, but rather the wedge represents a specific focus area in which abatement ideas could be identified and considered—allowing internal and external experts to focus their efforts during the planning process.

LEADING THE WAY TO NEUTRALITY

If global emissions levels are to be successfully cut to 85% of 2000 levels by 2050—as suggested is necessary by the Intergovernmental Panel on Climate Change—strong leadership will be required. The role of colleges and universities, and specifically Cornell, has historically been to provide just such guidance. In the case of global climate change, leadership must extend to the classroom, in the research setting, and in our everyday operations. Simply put, it must—it will—be pervasive.

As indicated by the wedge diagram above, the actions to reduce our operational emissions have a logical hierarchy. In its green development plans, Cornell seeks to avoid future emissions to the extent possible. Growth will happen. Smart growth—efficient, compact, and purposeful—must happen. Where current energy use is concerned, the expansion of our conservation efforts to reduce the intensity and overall quantity of consumption will eliminate emissions and associated energy costs the university currently bears. Our transportation demand management initiatives will likely yield avoided emissions through such activities as alternative work strategies or eliminated business travel and reduced emissions from an improved fleet fuel economy and shorter and/or more efficient commuting.



Achieving Net Zero Emissions



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- [Green Development](#)
- [Energy Conservation](#)
- [Alternative Transportation](#)
- [Fuel Mix and Renewables](#)
- [Offsetting Actions](#)



Actions to eliminate greenhouse gas emissions, broaden academic research, enhance educational opportunities and outreach efforts.



GREEN DEVELOPMENT

- [building energy standards](#)
- [space planning and management](#)
- [improved land use](#)



ENERGY CONSERVATION

- [building energy conservation](#)
- [conservation outreach](#)
- [steam line upgrade](#)
- [smart grid](#)



ALTERNATIVE TRANSPORTATION

- [commuter travel](#)
- [business travel](#)
- [campus fleet](#)



FUEL MIX AND RENEWABLES

- [hybrid e.g.s. system](#)
- [wind power](#)
- [c.u.r.b.i.](#)
- [upgraded hydro capacity](#)
- [wood co-firing](#)
- [turbine generator replacement](#)



OFFSETTING ACTIONS

- [defined offsets](#)
- [undefined offsets](#)
- [community offsets](#)

19 ACTIONS TO NET ZERO EMISSIONS BY 2050

The overall plan could produce millions of dollars in net savings over 40 years. Green Development recommendations reduce the size of future construction programs, creating superior buildings while reducing energy use of the projects we build. Energy Conservation recommendations reduce current and future campus energy needs while supporting growth in

HOW WE DID IT

Over 700 individual ideas were offered by the hundreds of Cornell faculty, staff, students, and local community who participated in the Climate Action Plan process. The 19

academic and research programs. Transportation recommendations reduce fuel expenditures and improve the aesthetic environment of the campus. Fuel Mix and Renewables recommendations focus on regional and global research priorities, jobs creation, and available local resources. Offsetting Actions include a Community Energy initiative suggested by local community leaders, as well as agriculture and forest management related offsets on Cornell's own lands.

CAP actions are spread throughout various university operating units and many build on existing Cornell programs.

Actions incorporate many of these suggestions.

These actions were formulated by a broad-based group of facilities and academic staff, student representatives, and administrative leaders who focused on specific action areas, or wedges. To find out more about this process, click on the [process](#) link on the left-hand margin of this page.



GREEN DEVELOPMENT

"With seed funds from the Center for a Sustainable Future and the Climate Action Plan, teams of faculty are now collaborating on smart-grid technology, energy generation and distribution in the built environment, and behavior change. I am grateful that the plan provides a comprehensive framework for our research to be demonstrated on campus it enhances our land-grant mission to educate the public and dramatically reduces our carbon footprint."

Ying Hua, assistant professor of design and environmental analysis, teaches an award-winning course on collaborative sustainable building practices and sees a crucial link between Cornell's researchers and the Climate Action Plan.



ENERGY CONSERVATION

"At Cornell, our integrated approach to renewable energy utilization, conducted in parallel with implementing efficiency improvements, sets a high standard for our sister institutions. The value that the university brings to the Climate Action Plan through research and teaching opportunities, demonstration of unique technologies, and outreach far exceeds the simple value of using specific renewable resources for campus needs. Cornell's measurable actions are providing a means for America to enter a new era of innovation and sustainable energy development."

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



TRANSPORTATION

"Transportation systems and travel habits constitute a significant challenge to our ability to reduce the carbon footprint caused by human activities. Travel behavior is based on more than rational economic criteria; it also involves emotions, attitudes, status concerns, and perceptions about travel cost and times. Cornell has made major progress by addressing these issues through its incentive programs that are the envy of other communities and institutions. In order to further reduce the carbon footprint, as envisioned by Cornell's long-term plan, these programs need to be expanded significantly."

Arnim Meyburg, professor emeritus in the School of Civil and Environmental Engineering, is a world-recognized expert in transportation engineering and planning.



FUEL MIX AND RENEWABLES

"The Cornell University Renewable Bioenergy Initiative is powerful by itself. The potential for research, education, outreach, and job creation are immense, generating broad interest among our funding partners and communities across New York State. The Climate Action Plan, which supports this effort and shows its value within a broader context of sustainable agricultural systems and communities, is critical to our plans to continue to reinforce the land-grant mission of Cornell."

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





OFFSETTING ACTIONS

"Through my course Planning the Carbon Neutrality Campaign and collaborative research with Richard Stedman in the Department of Natural Resources, I have been able to expose students to real-world communication challenges and advance our theoretical understanding of climate and energy-related perceptions. Now by surveying more than 1,500 local residents and 3,000 Cornell students, we are analyzing campus and community attitudes toward specific proposed Climate Action Plan initiatives, including conservation measures and alternative sources of energy."

Katherine A. McComas, associate professor of communication, specializes in science, environmental, and risk communication.





Green Development



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Actions to avoid capital construction and energy use, shorten commuting distances, and increase space efficiency.



[learn more](#)



[learn more](#)



[learn more](#)

* Average Greenhouse Gas Reduction in Metric Tons (CO₂-e)

AVOIDING THE IMPACT OF DEVELOPMENT

While the most sustainable structure is the one that is never built, physical growth is necessary to support the university's mission. The CAP extends the planning elements of the Campus Master Plan with actions that will increase space efficiency while reducing capital construction, single occupant vehicle impact, and energy use. The array of recommended Green Development actions are not focused on specific technologies or approaches for carbon abatement, but rather on establishing effective university policies.

Carbon abatement opportunities in future capital development relate to energy-efficient building design and optimal use of space in campus land as well as built spaces, creating superior natural environments and buildings that will serve as physical demonstrations of sustainability to future generations.

Green Development prevents unmanaged growth in greenhouse gas emissions and is the most cost-effective path towards future climate neutrality. With diligent implementation, a green development program should ultimately pay for itself many times over while, in Cornell's case, reducing annual campus carbon emission potentially by tens of thousands of metric tons of CO₂-e by 2050 (compared to a business as usual

ADDITIONAL INFORMATION


**AVOID
REDUCE
REPLACE
OFFSET**

These actions all serve to avoid Cornell's energy consumption.

Green Development prevents unmanaged growth in Greenhouse Gas emissions and is the most cost-effective path towards future climate neutrality. A well-implemented green development program will pay for itself many times over.

estimate).

GREEN DEVELOPMENT SUMMARY

	APPROX ANNUAL GHG REDUCTION		ACTION STARTS	NEXT STEPS	FINANCIAL
	Metric Tons (CO ₂ Equivalent)	Percent of 2050 Footprint			
building energy standards	29,000	9%	near-term	incorporate into CU design standards	saves money
space planning and management	9,000	3%	near-term	update & implement space guidelines	saves money
improved land use	included in transportation	N.A.	near-term	implement through campus master plan	costs money
TOTAL	38,000	12%			

ACCOMPLISHMENTS TO DATE

Cornell total building square footage expands by 15% since 1990 with 0% carbon footprint increase from Central Utilities.

1999 North Campus Residential Initiative - Cornell's first project to include sustainable design goals.

Alice Cook House, New York State's first LEED-certified residence hall, open in 2004.

Green Building Oversight Committee formed in 2005 integrates "green building" standards into campus construction programs.

New standard adopted in 2008 mandate that construction over \$5 million be LEED Silver and 30% more efficient than similar buildings.

Weill Hall opens in 2008 as Cornell's first LEED Gold facility, a cutting-edge research building 40% more energy efficient than similar buildings.

Cornell Plantations manages 4,000 acres of diverse natural areas both on and off campus, including forests that sequester carbon.

INTERNAL LINKS

[Cornell Green Buildings](#)

[Master Planning and Land Use](#)

[Cornell Commitment to Nature](#)

EXTERNAL LINKS

[American Society of Heating, Refrigerating and Air-Conditioning Engineers](#)

[What is LEED?](#)

GREEN DEVELOPMENT TEAM MEMBERS

John Kiefer, Planning Design and Construction – Admin and Operations (Cornell Team Lead)

Mike Walters, Affiliated Engineers, Inc / AEI (Consultant Team Lead)

Steve Beyers, Section Leader, Energy and Environmental Engineering Section

Mary-Lynn Cummings, Space Planning

Gilbert Delgado, University Architect

David Hoffer, Student

W.S. "Lanny" Joyce, Director of Energy Management, Energy & Sustainability

Liz Kolacki, Planning Design and Construction – Design Section

Randy Lacey, Planning Design and Construction – Design Section

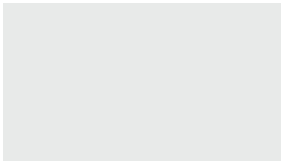
Bob Stundtner, Planning Design and Construction – Design Section

Mina Amundsen, University Planner

Charlotte Mosher, Johnson School of Management

DOWNLOADS

[Report of the Naturalization Action Team](#) (pdf)



Gregory Falco, LEED AP



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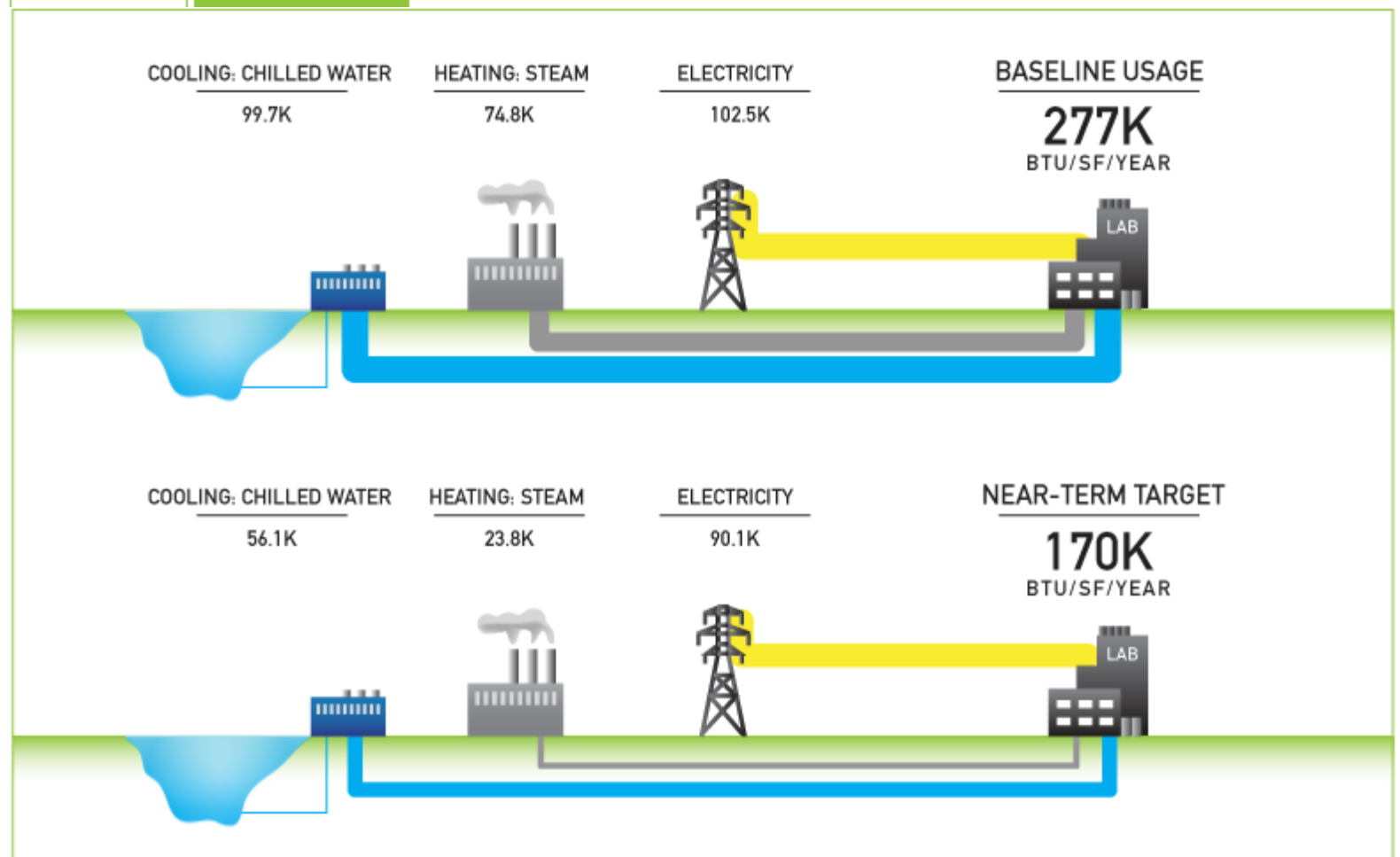


BUILDING ENERGY STANDARDS: BUILDING ENERGY USE INTENSITY



LAB ENERGY

OFFICE ENERGY



AVOIDING THE IMPACT OF DEVELOPMENT

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 limit energy consumption while respecting initial capital resources. This requires new building design to ultimately limit energy usage to 50% of the industry standard baseline (ASHRAE 90.1). These are aggressive goals that will

ADDITIONAL INFORMATION

Energy Use Intensity, or EUI, is used to describe building energy efficiency. Standard EUI units are in terms of BTUs per square foot per year.

OFFICE ENERGY

COOLING: CHILLED WATER

17.7K

HEATING: STEAM

36.1K

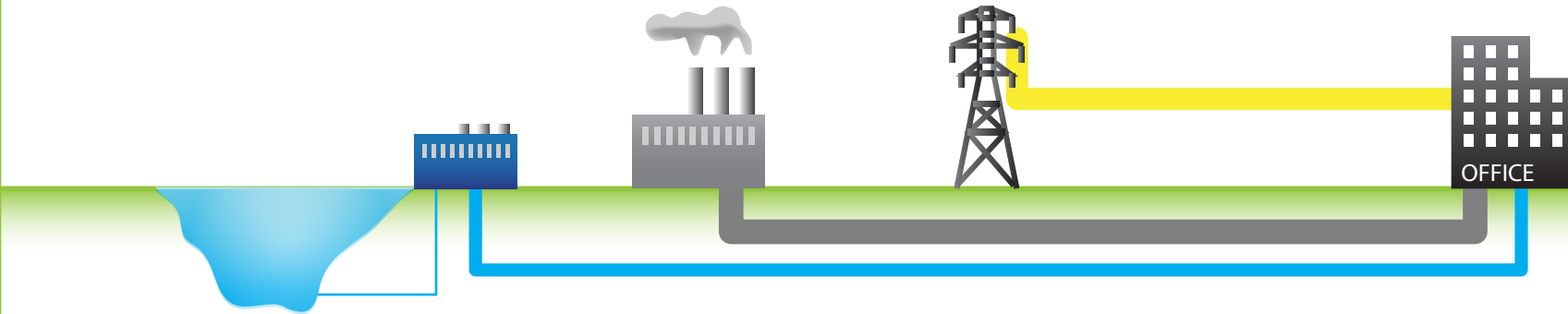
ELECTRICITY

30.2K

BASELINE USAGE

84K

BTU/SF/YEAR



COOLING: CHILLED WATER

14.8K

HEATING: STEAM

19.1K

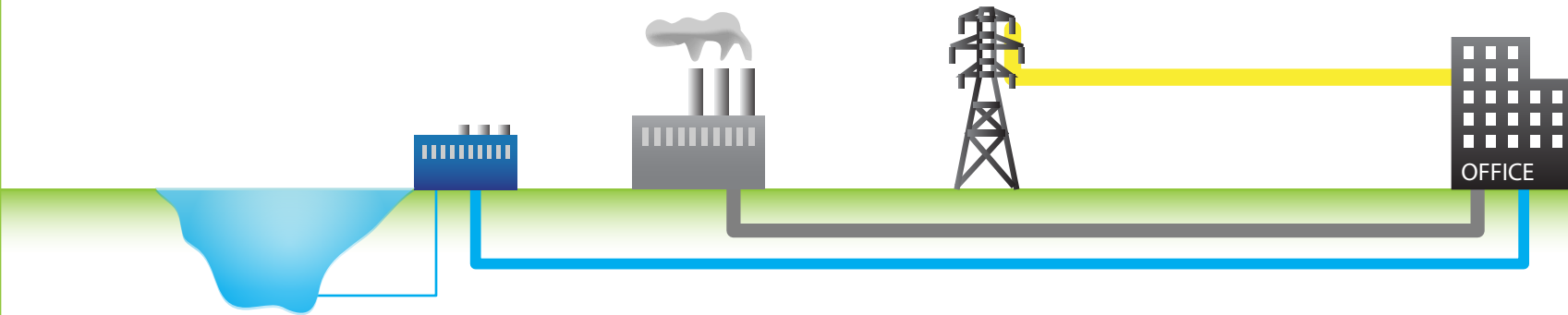
ELECTRICITY

23.8K

NEAR-TERM TARGET

50K

BTU/SF/YEAR



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 the success of Cornell's LEED/30 standard that previously required new construction projects to be certified under the United States Green Building Council'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 ASHRAE 90.1 (2007). 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.

On average laboratories use 5-10 times more energy than dormitories on a per square foot basis.

For more information on energy efficiency in New York State see New York State Energy Research and Development Authority's (NYSERDA) website [here](#).

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standard 90.1 is the reference for building energy efficiency. For more information on this standard see ASHRAE's website [here](#).



Green Development



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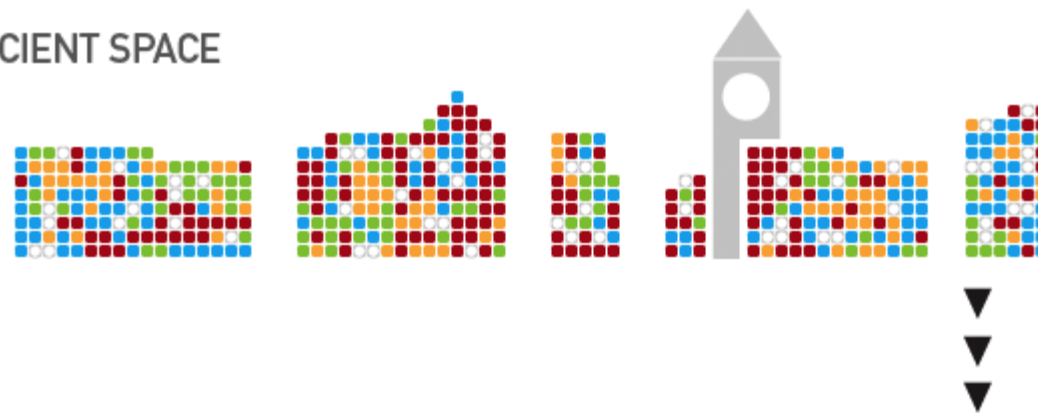
[Offsetting Actions](#)



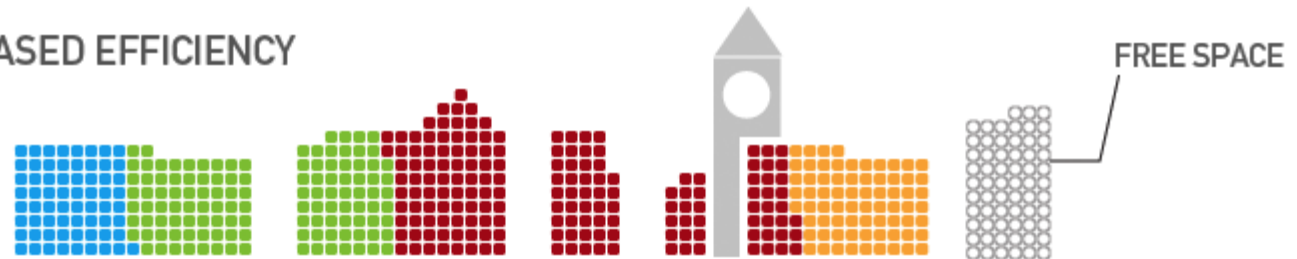
SPACE PLANNING AND MANAGEMENT: TREATING SPACE AS A RESOURCE



INEFFICIENT SPACE



INCREASED EFFICIENCY



AVOIDING THE IMPACT OF DEVELOPMENT

More effective use of existing space holds the potential to reduce the material, energy, and land resources consumed by new buildings and slow overall campus growth in the building-square-foot terms. Space planning and management enhancements increase utilization rates and building efficiency. These goals are accomplished through a detailed evaluation of program space needs of new construction or renovation projects using consistent standards. Implementation will begin through selective utilization studies of existing space and development of updated space guidelines and space management principles. The CAP anticipates alternative works strategies will be phased in over time, supporting the effort to reduce campus square footage growth.

ADDITIONAL INFORMATION

Space is a very visible, fairly permanent, consistent and somewhat finite resource. Space creation is the University's largest single capital investment. Created space obligates the University to significant, on-going operations and maintenance expenses. The CAP supports new policies and procedures that encourage the University community to manage space in a systematic, purposeful way.



Green Development



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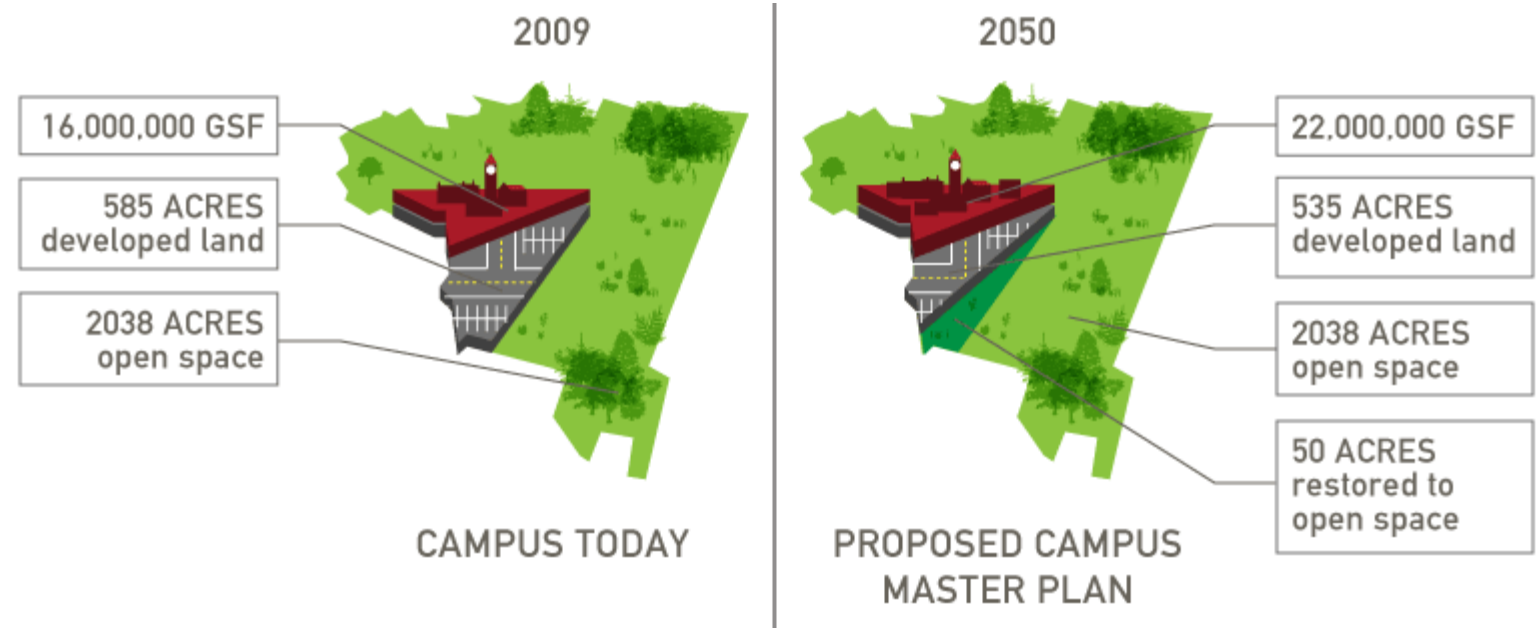
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IMPROVED LAND USE: INTEGRATE DEVELOPMENT AND GREEN INFRASTRUCTURE



AVOIDING THE IMPACT OF DEVELOPMENT

The Campus Master Plan established a framework for future physical development of the campus with a compact footprint and a mix of land uses that leads to reduced infrastructure and Vehicle Miles Traveled (VMT) on campus. This framework can be enhanced and implemented through better integration of landscape with infrastructure and naturalization efforts that will 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 CO₂e reductions, better environmental quality, and long term savings in infrastructure and operational spending for a healthier community.

ADDITIONAL INFORMATION

[Master Plan](#)

[Mosaic Poster](#)



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 **Actions focusing on both technology and behavior within Cornell's 15 million square feet of existing space.**



BUILDING ENERGY CONSERVATION PROGRAMS TO CONSERVE ENERGY: LIGHTING RETROFIT PROGRAM, FUME HOOD REDUCTION, HVAC CONSERVATION, WEATHERIZATION, & VENTILATION
49,000* [learn more](#)

CONSERVATION OUTREACH
SAVING ENERGY THROUGH EDUCATION
2,000* [learn more](#)

STEAM LINE UPGRADE
REDUCING THERMAL LOSS
2,000* [learn more](#)

SMART GRID EFFICIENT SUPPLY AND DEMAND SYSTEM RESEARCH
[learn more](#)

* Average Greenhouse Gas Reduction in Metric Tons (CO₂-e)

ENERGY CONSERVATION: OPPORTUNITIES TO SAVE MONEY AND ENERGY

After Green Development, Energy Conservation is the most cost-effective path to reducing greenhouse gas emissions. Energy conservation actions capitalize on the enormous opportunity represented by the roughly 15 million gross square feet of existing Cornell space in Ithaca. Energy conservation actions focus on both technology and behavior. Technology upgrades, enhancements, and modifications are focused on campus buildings and are largely an extension of the proven energy systems maintenance and retrofit efforts that have held Cornell's energy

FACTS

**AVOID
REDUCE
REPLACE
OFFSET**

These actions all serve to reduce Cornell's energy consumption.

consumption at 1990 levels throughout the 15% growth in space and significant space upgrades from 1990-2008.

By expanding the success of past efforts and including conservation outreach and residential and dining facilities initiatives, conservation efforts can reduce GHG emissions associated with existing facilities by almost 50,000 tons CO₂e annually while providing commensurate savings for the university. Together with green development efforts, these initiatives cannot only reduce current campus energy needs but future needs as well, without compromising the growth of academic and research programs.

ENERGY CONSERVATION SUMMARY

	APPROX ANNUAL GHG REDUCTION		ACTION STARTS	NEXT STEPS	FINANCIAL
	Metric Tons (CO ₂ Equivalent)	Percent of 2050 Footprint			
building energy conservation	49,000	15%	near-term	Continue/Extend Planned Efforts	saves money
conservation outreach	2,000	<1%	near-term	Continue Planned Efforts	saves money
steam line upgrade	2,000	<1%	near-term	Pursue Research Grant	saves money
smart grid	TBD	TBD	near-term	Create Outreach Action Plan	supported by grants
TOTAL	53,000	16%			

ACCOMPLISHMENTS

Conservation efforts since the 1980s have reduced campus energy use over 35% through variable flow air and water systems, and a 4,000 ton variable speed chiller that uses 40% less electricity than the constant-speed standard.

Savings since 2002 from the Energy Conservation Initiative exceed \$6 million annually, with a 20% reduction goal for campus by 2012.

Building energy use data and resulting carbon footprints are available on the [website](#).

4.4 million gallon thermal storage tank introduced in 1991 allows off-peaking cooling, increasing efficiency by 10%.

Backpressure steam turbine electric generators produce nearly 12% of campus electricity at 70% efficiency (a typical power plant is 35-45% efficient.)

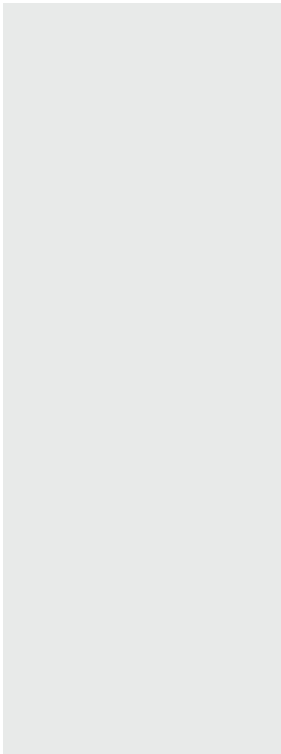
Kyoto Task Team chartered; Cornell on track to reduce GHG emissions below 1990 levels by 2010.

Each year Cornell Cooperative Extension helps New York State residents make their homes energy efficient and greener through the Save Energy, Save Dollars and Green Building workshops.

INTERNAL LINKS

[Track your buildings energy use](#)
[Energy Conservation Initiative](#)
[Energy Saving Tips](#)
[Cornell Energy Fast Facts](#)
[Cornell's District Heating system](#)

Academics and Outreach
[Greenhouse Efficiency Research](#)
[Energy Efficiency Research](#)
[Consumer Education for Energy Efficiency](#)



TEAM MEMBERS	EXTERNAL LINKS
W.S. "Lanny" Joyce, Director of Energy Management, Energy & Sustainability	Energy Conservation Policies in Higher Education
Stan Wrzeski, Affiliated Engineers (Consultant Lead)	Energy and sustainability outreach programs
Steve Beyers, Section Leader, Energy and Environmental Engineering Section	Power Systems Engineering Research Center
Rick Bishop, Foreperson: BAS Preventive Maintenance & ECI	NY Heat Smart Program
Lynette Chappell-Williams, Director, WDELO	DOE Smart Grid
Mary-Lynn Cummings, Director of Space Planning	GE Smart Grid Website
Allen Hebert, Energy Engineer & Manager of Energy Conservation Initiative projects	
Ying Hua, Assistant Professor, Department of Design & Environmental Analysis	
Andrew Hunter, Professor, Chemical and Biomolecular Engineering	
D. Randall Lacey, University Engineer, PDC	
Audrey Lowes, Utilities and Energy management	
Karen Muckstadt, Director of Facilities Management	
Shane Rothermel, '10 Bio & Environmental Engineering	
Christine Stallmann, EHS Director	



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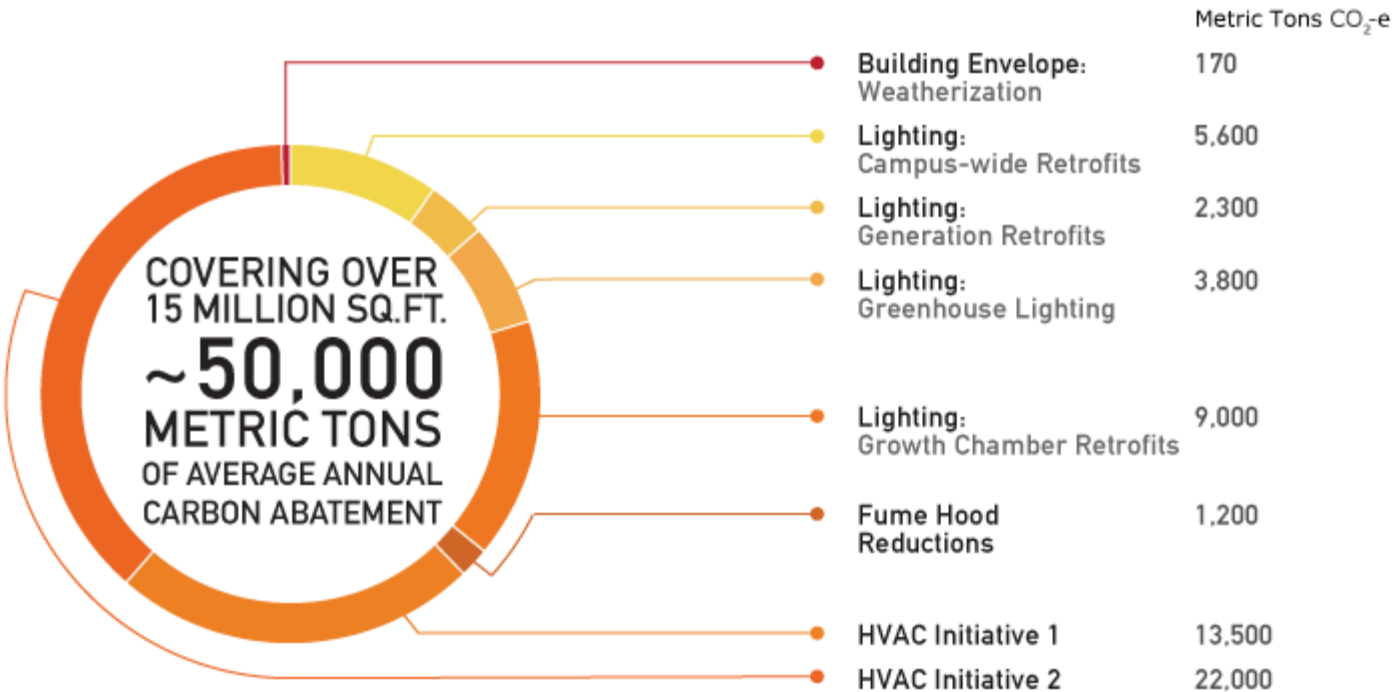
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BUILDING ENERGY CONSERVATION: PROGRAMS TO CONSERVE BUILDING ENERGY



REDUCING CURRENT ENERGY USE ON CAMPUS

Building Energy Conservation encompasses a range of programs that, if approved, will address lighting upgrades and retrofits, HVAC systems energy conservation, research-focused improvements, and other conservation programs.

LIGHTING

Campus-wide Retrofit Program: Over the next 10 years, ongoing lighting retrofits will be continued so that a remaining two-thirds of campus (approximately 10 million GSF) is converted to high efficiency fluorescent fixtures with occupancy-based controls. This effort alone is estimated to achieve an average annual abatement of ~5,600 tons and reduce annual electrical usage for campus lighting by 25%.

Second Generation Retrofits: After the current round of campus-wide retrofit program tasks is completed a second effort is envisioned during

ADDITIONAL INFORMATION

From 1985 through the present, nearly 20,000 horsepower of building variable speed drives were installed on fans and pumps in heating, ventilating, and air conditioning (HVAC) systems saving approximately 30,000,000 kWh annually.

The campus buildings that require 100% outside air for ventilation supply and exhaust over 3 million cubic feet of air every minute.

1,000 tons of CO₂-e could be

years 16-40. 2nd generation retrofits are likely to be heavily solid-state Light Emitting Diode fixtures that will provide an additional 2,300 tons of average annual abatement and reduce annual electrical demand for campus lighting by an additional 50% to 0.5 W/sf.

Greenhouse Lighting: The existing high-intensity, outdoor-type lighting in existing greenhouses will be replaced with lower-intensity, high-efficiency dimmable lighting fixtures, along with a greenhouse-specific lighting control system. Greenhouse lighting fixture and control upgrades will create lighting that is more efficient, more uniform, and dims in response to increased daylight. This will achieve an average annual abatement of ~3,800 tons.

Growth Chamber Lighting and Controls Retrofits: Growth chambers use refrigeration, heating, and lighting to simulate environmental conditions for plant growth research. Collectively, campus growth chambers use 10% of Cornell's electric energy. This program would retrofit lighting and controls in up to 500 growth and refrigerated chambers (100 per year) over the next 5 years. This program would produce an average annual abatement of 9,000 tons.

FUME HOOD REDUCTIONS

Fume hoods account for 10% of Cornell's total cost of energy, or \$7.5 million annually. Working with respective departments, their researchers, and Cornell Environmental Health and Safety, unused fume hoods will be deactivated and rooms re-balanced to reduce overall air flow requirements (and the corresponding heating, cooling, and dehumidification demands) in many existing laboratory spaces. By deactivating 125 fume hoods (about 10%) an average annual abatement of 1,200 tons will be achieved with commensurate operational cost-saving.

HVAC ENERGY CONSERVATION INITIATIVE

HVAC Energy Conservation Initiative 1: The current Energy Conservation Initiative (ECI) by the Cornell Energy and Sustainability Department Energy Management Section will be continued and expanded to cover all Ithaca Campus facilities, including significantly increasing conservation-focused maintenance and doubling capital investment in conservation projects. Conservation-focused maintenance will be expanded in contract colleges to include occupied space controls facilities. A new conservation-focused PM (Preventive Maintenance) program will be added for Campus Life (residential and dining) and the professional schools (Hotel, Law, Business). The expanded initiative will require additional staffing and create 13,500 tons of average annual abatement.

HVAC Energy Conservation Initiative 2: ECI 2 provides for the retrofit of heat recovery devices and replacement of pneumatic space controls with direct digital controls providing for increased management of energy demand, along with other longer payback measures. ECI 2 will include off-central-campus facilities that were not included in the initial five years of ECI 1. This continued initiative will last from years 6-15 and create 22,000 average annual tons of abatement.

reduced annually if every lab variable volume fume hood sash was closed when not in use.

60 tons of CO₂-e could be reduced annually if 1000 under-desk convection heaters were changed to radiant heaters.

BUILDING ENVELOPE - WEATHERIZATION

Windows and doors will be caulked and weather-stripped to reduce outside air infiltration. Windows required for ventilation will remain operable. The first year's pilot effort will focus on the 10 worst buildings from the older areas of campus, identifying the most effective package of measures and means to implement them. That package will then be used to improve 30 buildings the following year. Weatherization will create 170 tons of average annual abatement with high visibility and occupant comfort improvement.

LABORATORY VENTILATION EFFECTIVENESS

There is professional consensus that a higher quality air flow, properly controlled, creates a safer work space with lower quantities of air. Lab air flows will be modified, and the resulting energy cost savings will be used for space administration, monitoring and testing to verify that lab environments will indeed be safer. Environmental Health and Safety staff necessary to effect this initiative will be paid for with a portion of the savings that will be realized before the end of the pilot period. This program will be applied to 200 lab spaces each year for five years and on aggregate reduce ventilation rates from 8/4 (occupied/unoccupied) air changes per hour to 6/3.

BUILDING COMMISSIONING

Interval data will be analyzed with software created to provide staff involved with energy management a powerful interface with building operation and control information. Analysis tools will be used to direct conservation-focused maintenance efforts. Data and analysis tools will be widely available to PDC Control and Refrigeration Shop staff, building management, energy engineers, and design engineers.



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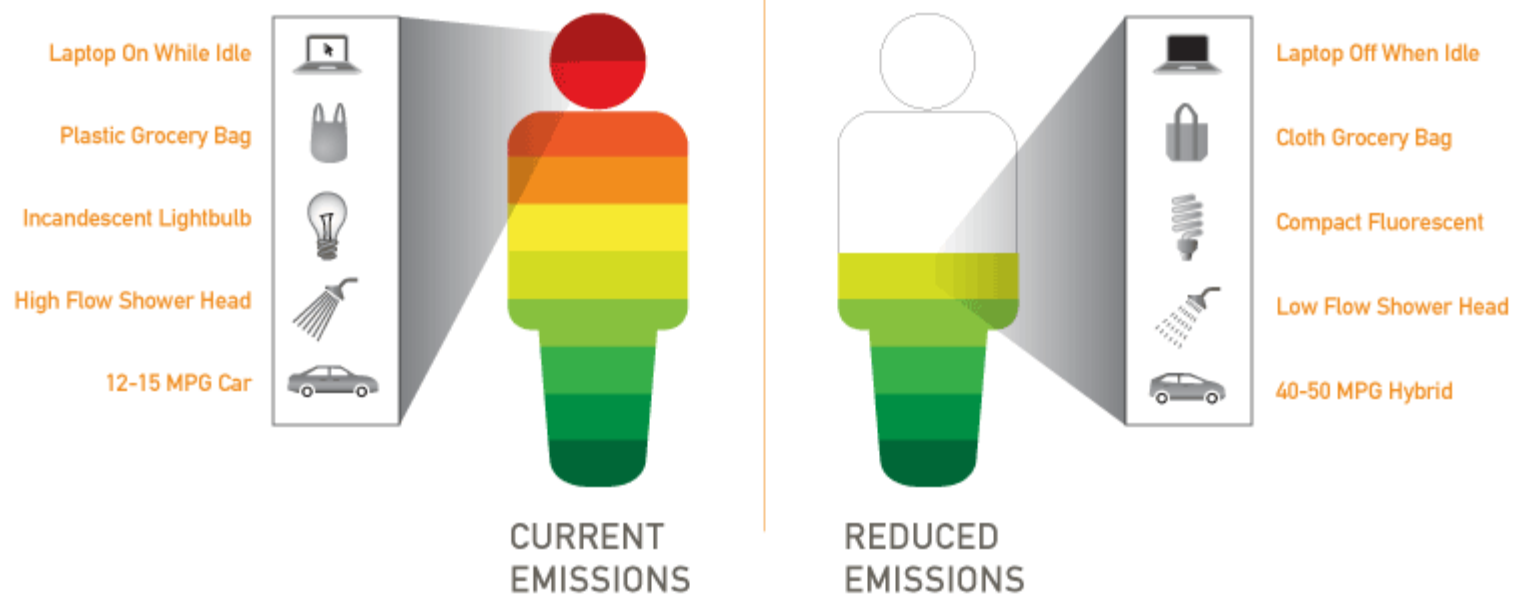
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CONSERVATION OUTREACH: TEACHING THE CAMPUS TO SAVE ENERGY



USING EDUCATION TO SAVE ENERGY

Savings may be possible at low cost 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. Indeed, while difficult to predict, the potential for cost-effective energy savings through this action is enormous. To achieve this, conservation outreach is a necessity. Over the next 1-2 years, a pilot program is proposed 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.

Each Eco-Rep would be supervised by a Building Manager/Coordinator for

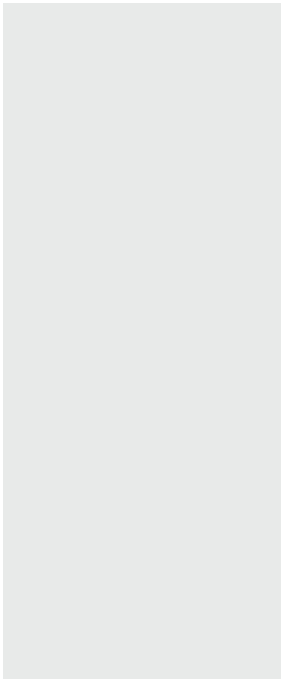
FACTS

CO₂e reduced if every student on campus used power saver features on computer:
1300 tons per year (representing just over 1% of Cornell's annual electricity usage)

CO₂e reduced if 1000 new office printers were energy star certified:
60 tons per year

CO₂e reduced if every staff member turned off 2- 4' fluorescent lamps for 2hrs /day:
120 tons per year

>



academic buildings or Residence Life staffer for campus housing. Technical support would be provided by Cornell Energy and Sustainability Department Energy Management Section , while programmatic support would be provided by Cornell's Sustainability Coordinator in the Cornell Energy and Sustainability Department.

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.

CO₂e reduction if 1000 students used "smart" plug strip with printers and laptops plugged in:
170 tons per year



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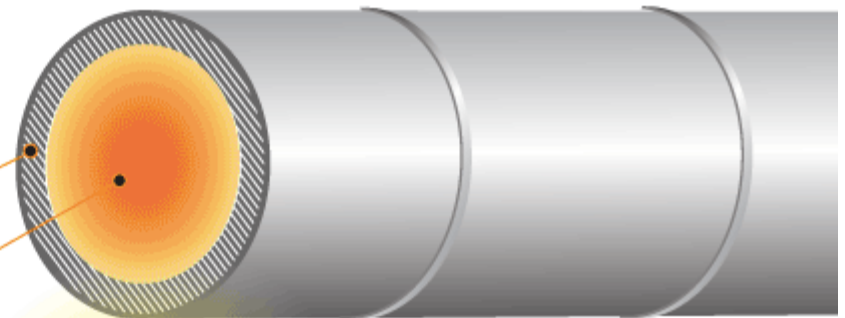
STEAM LINE UPGRADE: REDUCING THERMAL LOSS



UPGRADED PIPE Negligible Losses

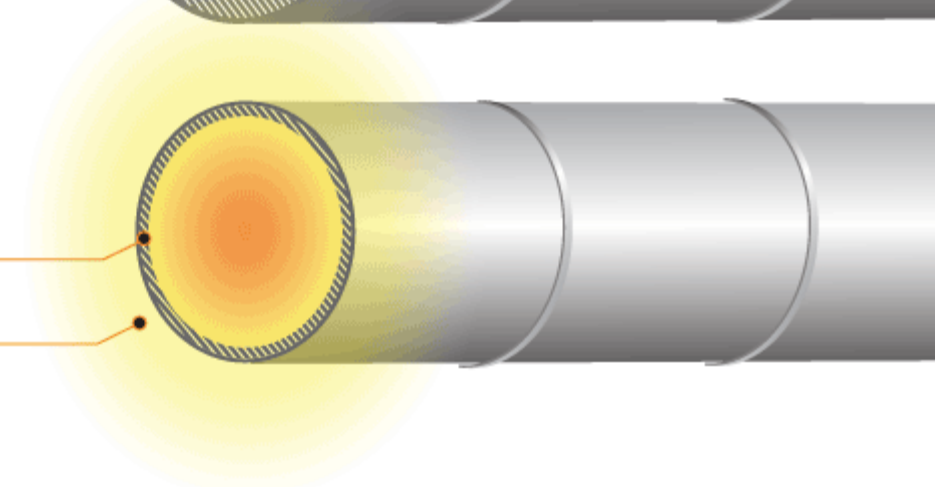
R-16 Insulation
Saves 13,600 MMBTU/yr

High Thermal Distribution Efficiency



OLDER PIPE 8-12% Losses

R-2 Insulation
Heat Loss
340 BTU/hr/Linear Foot



LOWER COAL CONSUMPTION FOR STEAM PRODUCTION

Estimates show that losses range from 8 to 12 percent throughout the entire campus steam distribution system. Newer installations at Cornell are very energy efficient and well insulated, so losses are fairly low. However, there is some older piping in place that has fairly high heat loss and is in Cornell capital planning for future repair/upgrade. This is particularly true of a piece of the system to the east of the central plant extending out to Guterman Lab and the Veterinary College.

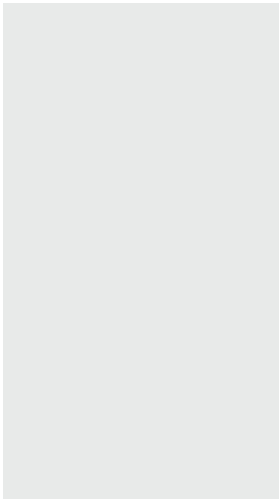
The Guterman line has a current insulation value of approximately R-2. If this 12-inch line were upgraded to pipe having insulation with an R-16 rating, the heat loss would be reduced by about 340 Btu per hour per linear foot. The line is estimated to be roughly 4,000 feet long, which equates to about 13,600 mmBtu per year in heat savings.

ADDITIONAL INFORMATION

There are over 13 miles of steam piping on campus, and another 12 miles of condensate return.

In the 1980's steam could be seen rising from several quads on campus, evidence of a deteriorated steam system.

Today, thanks to decades of steady improvement and upkeep, steam losses are only a fraction of past losses.



This savings will result in lower energy input for steam production. Cornell had planned to replace the Guterman line in about 10 years for reliability reasons. If this project is moved closer in time, due to an emphasis on energy savings, the higher present value of the future expense can be offset by the expected energy savings.

The Guterman line is one of the few remaining areas needing an upgrade.



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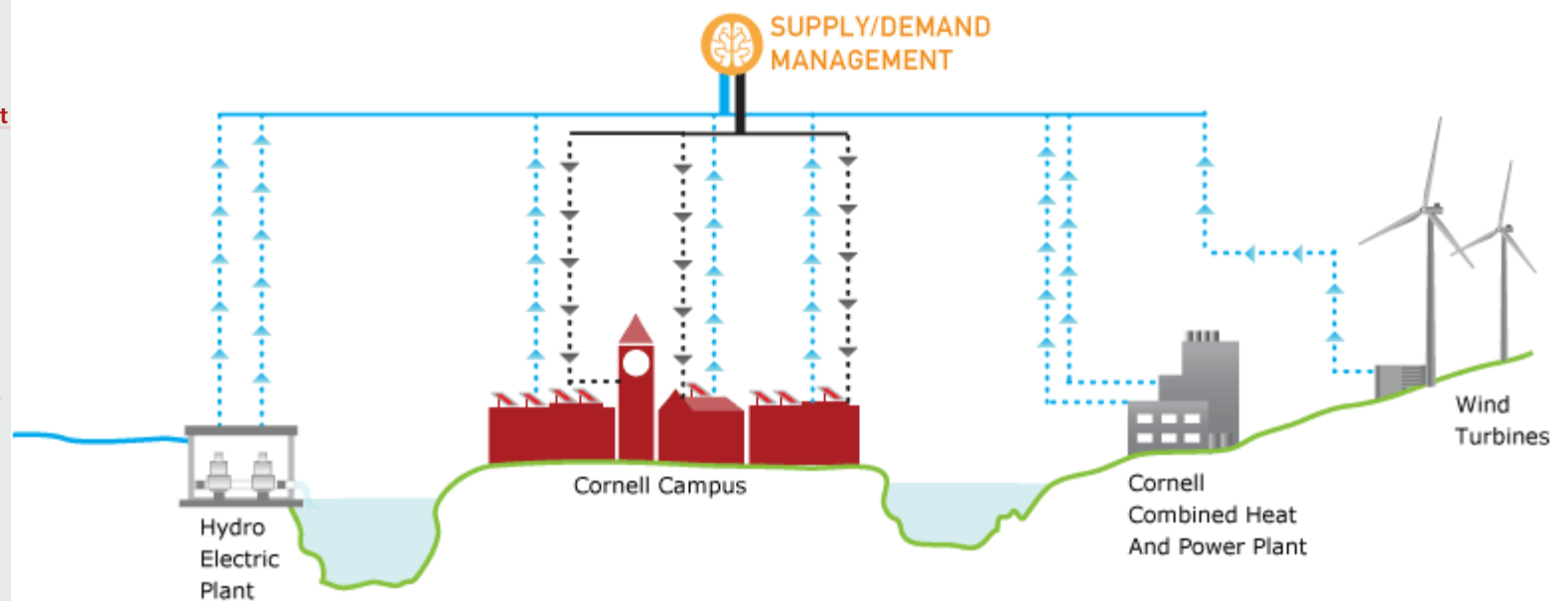
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SMART GRID: FULLY INTEGRATED ENERGY SYSTEMS



PILOT PROJECT FOR SMART GRID TECHNOLOGY

Cornell already has well-integrated building management systems to adjust temperature, lighting, and other indoor environment settings, according to time of day, occupancy, season, and room use and is investing in state-of-the art electrical transformers and switchgear across campus, allowing our energy managers to track energy usage in real time. Smart Grid features can build on these resources by adding an additional level of sensors and controls into the electrical distribution systems at the building or equipment level.

Information provided by a Smart Grid system, integrated with existing data, will allow Cornell to be better stewards of our limited energy resources. By monitoring all of our energy and distribution sources as well as campus energy demand and modulating operation of chilled water pumps, gas turbines, or even (future) geothermal pumps to match systems needs in real time, such variable-output renewable energy sources as wind, solar, and hydropower can be more effectively utilized.

ADDITIONAL INFORMATION

[New York State Smart Grid Consortium](#)

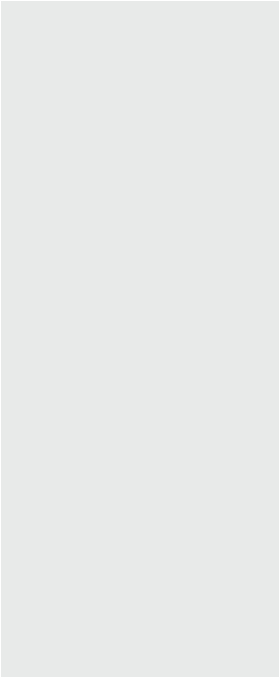
[US DOE Office of Electricity Delivery and Energy Reliability](#)

[The Smart Grid: An Introduction \(.pdf\)](#)

[US DOE, Smart Grid System Report](#)

[Smart Grid City, Boulder, CO](#)

[NEMA Facts on Smart Grid](#)



Full integration of grid- and building-energy system information and controls would provide both practical and multidisciplinary academic benefits; by better understanding how our actions effect energy demand, the Cornell community would have greater control over building energy use.

Looking beyond university boundaries, Cornell's internal smart grid would have the potential to communicate with broader smart grid efforts across New York State and the country. The New York State Smart Grid Consortium is currently working with university, industry, and government partners to achieve its strategic smart grid vision and become the model for the nation. The US Department of Energy recently dedicated \$1.25 million towards the creation of a Smart Grid Clearinghouse website, and \$57 million for seven smart grid demonstration projects throughout the country.



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 **New approaches can reduce current transportation-related GHG emissions by ~25%.**



* Average Greenhouse Gas Reduction in Metric Tons (CO₂-e)

TRANSPORTATION PROGRAMS


Existing transportation systems and paradigms are slow and difficult to change. While GHG emissions reductions are greater in other wedge areas, the actions in the Transportation Wedge have significant public visibility as well as broad (regional, national, and global) applicability. The actions included in this wedge represent a reduction in current transportation-related GHG emissions of about 25%. Transportation-related CAP actions are strongly intertwined with University policy and existing and future land-use patterns.

By building on the success of Cornell's comprehensive transportation demand management program and expanding efforts to promote and enable lower-carbon travel and alternative work strategies, transportation initiatives have the potential to reduce annual greenhouse gas emissions 12,000 tons by 2050, netting almost \$12 million (NPV) in reduced parking construction and fuel costs, and improving the campus environment.

ADDITIONAL INFORMATION

AVOID
REDUCE
REPLACE
OFFSET

These actions serve to reduce GHG emissions related to transportation.

ALTERNATIVE TRANSPORTATION SUMMARY					
	APPROX ANNUAL GHG REDUCTION		ACTION STARTS	NEXT STEPS	FINANCIAL
	Metric Tons (CO ₂ Equivalent)	Percent of 2050 Footprint			
business travel	8,000	3%	near-term	create travel action plan	saves money
commuter travel	2,000	<1%	near-term	implement through TIMS	saves money
campus fleet	2,000	<1%	near-term	develop campus fleet standards	saves money
TOTAL	12,000	4%			

ACCOMPLISHMENTS	INTERNAL LINKS
<p>OmniRide introduced in 1990, providing free transit anywhere in Tompkins County for faculty and staff who give up a parking permit.</p> <p>RideShare created in 1992 as a carpool incentive to reward employees for sharing their commute.</p> <p>Cornell purchased two new mail trucks in 1995 and converted them to natural gas as the primary fuel, installing natural gas fueling stations for overnight refueling.</p> <p>Four GEM (Global Electric Motorcars) vehicles purchased in 2003 for staff to use in the field; these two-person, electric-only, zero-emission vehicles run all day on a charge and recharge overnight.</p> <p>Beginning in 2005, all new-to-Cornell students received their first-year OmniRide pass at no charge, with passes heavily discounted for future years.</p> <p>In 2008, Cornell helped launch community-based Carshare and Vanpool programs.</p>	<p>Transportation Options at Cornell</p> <p>Demand Management Program</p> <p>Alternative Fuel Vehicles</p> <p>Commuting Alternatives</p> <p>Carpooling at Cornell</p> <p>Cornell Fleet Service</p> <p>Cornell Travel Services</p>

TEAM MEMBERS	EXTERNAL LINKS
<p>David Lieb, Transportation Services (Team Lead)</p> <p>Nathaniel Grier, Martin/Alexiou/Bryson (Consultant Lead)</p> <p>Spring Buck, Transportation Services</p> <p>Lois Chaplin, Cornell Local Roads Program</p> <p>Joe Lalley, Facilities Services</p> <p>Bill Stebbins, Transportation Services</p>	<p>Ithaca Carshare</p> <p>Bike Ithaca</p> <p>Flexible Work Schedule Resources</p>



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BUSINESS TRAVEL: ENCOURAGING LESS CARBON-INTENSIVE ALTERNATIVES



AIR TRAVEL

1700 LBS CO₂-e



CARPOOLING

650 LBS CO₂-e



TELECONFERENCING

0 LBS CO₂-e



ITHACA – CHICAGO
EXAMPLE BUSINESS TRIP

PROVIDING BUSINESS TRAVEL OPTIONS

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.

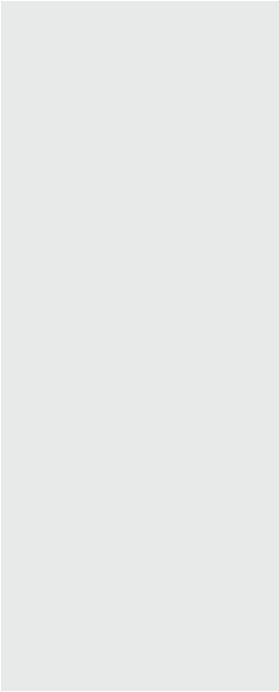
Reductions in business travel emissions are difficult. Business travel is not centrally controlled or regulated by the university—generally the main limitation being individual budgetary restrictions. Business travel also complements Cornell's educational mission, whether by researchers attending conferences or by staff supporting the ongoing operations of the university.

The recommended approach to reducing this sector's carbon footprint is the development of a business travel model decision system. This program would assist travelers in understanding the impacts of their travel and seeking a less carbon-intensive alternative where feasible. Education and awareness will be central to achieving reductions in business travel-related emissions. This will include raising awareness about not only the impacts of such travel, but also the array of less carbon-intensive options available (e.g., ground vs. air travel, direct vs.

ADDITIONAL INFORMATION

On a per-mile basis, the greenhouse gases from flying are 1.5 times as much as driving.

If four people carpool to a conference 250 miles away instead of flying, they could save roughly 1.2 tons of CO₂-e (and roughly \$1,000).



indirect flights).

Another key component of this plan would be increased investment in and reliance on teleconferencing. Travelers would be encouraged to consider teleconferencing in place of an actual trip. To this end, teleconferencing capability standards will be established for individual computers as well as for centralized meeting facilities. Building and renovation standards should recommend the installation or upgrade of effective teleconferencing facilities, as appropriate.



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COMMUTER TRAVEL: DECREASING SINGLE OCCUPANCY VEHICLES



50% REDUCTION

NO CO₂-e EMISSIONS



WALKING & BIKING

10 TIMES LESS CO₂-e



VANPOOL

6 TIMES LESS CO₂-e



BUS

PROVIDING COMMUTING OPTIONS

This CAP action builds on current Transportation Impact Mitigation Strategies (TIMS) programs, incorporating both incentives and program flexibility, including alternative work strategies such as flex-time and flex-place, coupled with disincentive pricing strategies.

Cornell has a long-running program in transportation demand management (TDM) which seeks to provide commuters with options other than the single-occupant vehicle (SOV). Just under half of all employee commuters regularly travel to campus by a means other than SOV; the rates are much higher for students, with roughly four-fifths of graduate students and nearly all undergraduate students using an alternative mode.

The action sets long-term goals above and beyond the TIMS as well as intermediate targets to track interim success. At a minimum, the plan strives to reduce the rate of employee SOV usage by 25 percent within 15 years and hopes the decrease might be as high as 50 percent. The action targets all modes, but will emphasize vanpool, transit, and biking, areas that, it is felt, mesh well with the current commuting needs. This will be accomplished with initiation of a vanpool program this fall, in

ADDITIONAL INFORMATION

The average vanpool rider emits 3.5 times less CO₂-e than the typical Tompkins Consolidated Area Transit rider who already is already 25 percent more efficient than an average SOV commuter.

If you can fill all the seats, the reduction is even greater. Riders in a full vanpool van emit 1.6 times less CO₂-e each than do riders in a full bus and nearly 10 times less CO₂-e.

If you work from home 1 day a week, you will reduce your transportation carbon footprint by 20 percent.

The typical Tompkins County

cooperation with the local transit agency and local governments. Cornell is one of three partners in the transit agency and will continue to support improved and expanded service, including express park and ride, a service particularly well-suited to the many suburban and rural employees of the university. A key program change will be to introduce additional flexibility in benefits to cater to those with more variable travel demands who may not be able to commit to a single mode. Additionally, improvements in flexible work arrangements are expected to reduce the average daily commute trips to the university.

Additional operating and capital costs of the action for the first 15 years are projected to be between forty and seventy percent less than projected capital expenditures for new parking over the same period. Over that same time frame, it is expected that the program will reduce the demand for parking on campus that roughly \$25 million in capital expenditures for new parking will be avoided.

household makes nearly 6 vehicle trips per day. If you can eliminate just 1—by sharing a ride, walking, or chaining trips, for example—that amounts to over 350 trips per year, 3,000 miles of travel and over 1-1/2 tons of CO₂-e.

[Transportation Demand Management Program \(TDM\)](#)

[Transportation Impact Mitigation Strategies \(TIMS\)](#)

[Cornell's Local Bus Service \(TCAT\)](#)

[Cornell's Transportation Webpage](#)



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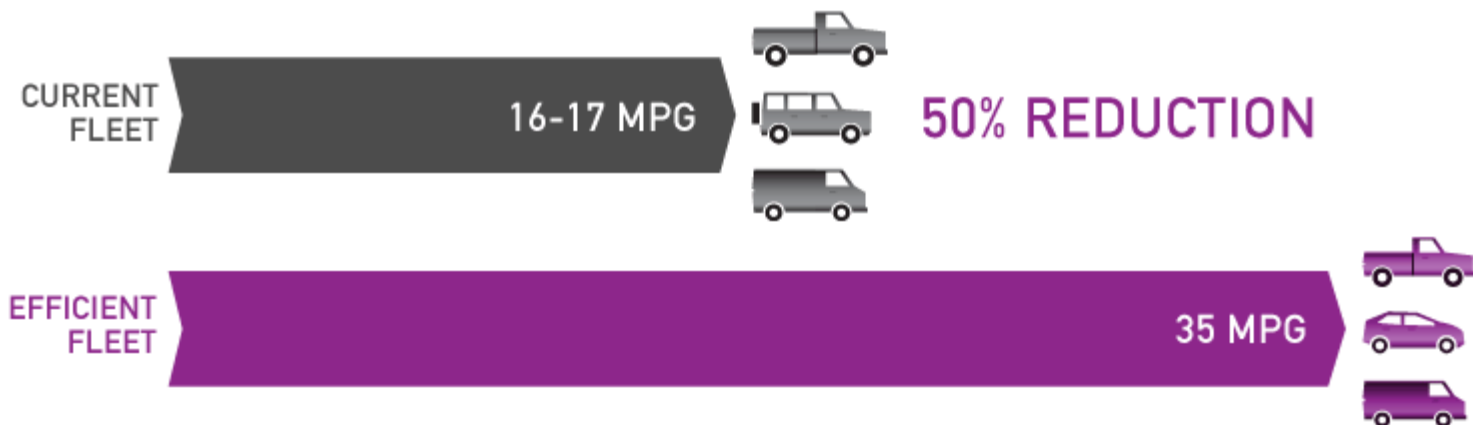
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CAMPUS FLEET: REDUCING FUEL CONSUMPTION



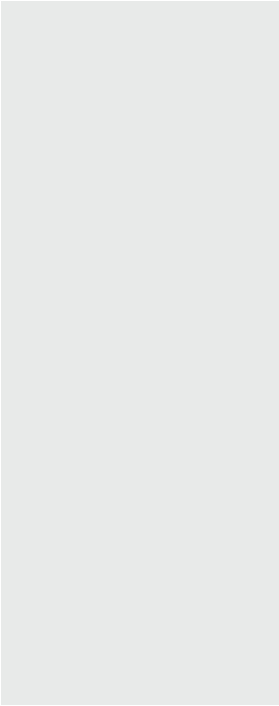
FLEET SERVICES VEHICLE IMPROVEMENTS

Establishing a higher fleet fuel efficiency standard will reduce fuel consumption by university-owned vehicles. The CAP action also includes a program to improve the mix of available fleet vehicles, allowing users to rent smaller or hybrid vehicles as appropriate. As technology develops and becomes standardized, alternative fuel vehicles may also be introduced.

Given that business travel and service use is critical to the operations of the university, the primary potential for reduction of greenhouse gas emissions lies in the improvement of the fleet average fuel economy. Currently, average fuel economy for the contract college fleet is just below 20mpg. Because of different reporting requirements, the fuel economy of the remainder of the Cornell-owned vehicles is less well known, but is estimated to be in the upper teens, perhaps 16-17mpg. Improvement of the contract college fleet average fuel economy to 35 mpg would result in nearly a 50% reduction in fuel consumption, and thus greenhouse gas (GHG) emissions, for these vehicles. However, 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 focus on higher efficiency vehicles, often

ADDITIONAL INFORMATION

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.



meaning 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 but also often do not satisfy the daily needs of the users. Conversion to a bio-fuel is possible though currently there is not a sufficiently large and continuous supply available locally to provide substantial impact. This approach, however, will likely be the focus of efforts for further fleet fuel-reductions beginning in 10 to 15 years as relevant technologies have further matured.



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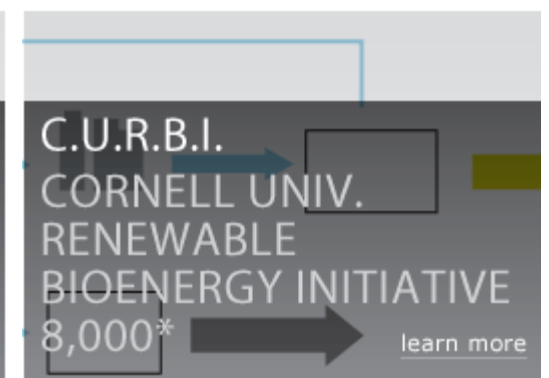
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Offsetting Actions

 **Promote research and job creation by taking actions that substantially replace current fossil fuel needs with renewable energy.**



* Average Greenhouse Gas Reduction in Metric Tons (CO₂-e)

THE MULTI-SOURCE RENEWABLE ENERGY RESEARCH INSTITUTION

Cornell began operation of its new combined heat and power (CHP) system in late 2009, reducing total campus GHG emissions by about 20% through improved efficiency and the substitution of natural gas for coal. Additional fuel mix and renewable energy actions will account for the majority of the necessary carbon reduction in the CAP—almost 200,000 tons of carbon abatement in 2050.

Renewable energy initiatives focused on regional and global research priorities, jobs creation and available local resources are combined to substantially replace the current fossil fuel needs of Cornell with renewable energy. Options that replace fossil fuels tend to require more


FACTS

AVOID
REDUCE
REPLACE
OFFSET

These actions are all intended to replace current fossil fuels.

capital investment that pays back over time. Some of the more innovative options require research monies to make them financially viable and to encourage further development, extending their usefulness to the broader community, potentially creating local and regional jobs, and ideally transforming the marketplace.

Contingent on Cornell's success in receiving funding targeted for these efforts, their culmination can reduce Cornell's energy and carbon compliance costs and eliminate 170,000 tons CO₂-e on an average annual basis, while advancing Cornell as the premier multi-source renewable energy research institution in the nation.

FUEL MIX AND RENEWABLES ENERGY SUMMARY					
	APPROX ANNUAL GHG REDUCTION		ACTION STARTS	NEXT STEPS	FINANCIAL
	Metric Tons (CO ₂ Equivalent)	Percent of 2050 Footprint			
hybrid e.g.s. with biogas	113,000	35%	near-term	pursue research grant	supported by grants
wind power	13,000	3%	near-term	create project plan	saves money
c.u.r.b.i.	8,000	2%	near-term	complete study and pursue grant	supported by grants
upgraded hydro capacity	1,000	<1%	near-term	budget and create project request	saves money
wood co-firing	1,000	<1%	near-term	work with CALS to identify source	costs money
turbine generator replacement	1,000	<1%	near-term	budget and create project request	saves money
TOTAL	137,000	42%			

ACCOMPLISHMENTS	INTERNAL LINKS
Fall Creek hydroelectric generation plant opened in 1904, producing more than 1.5 times Cornell's total electric use; today it produces 2% of Cornell's electricity.	Hydroelectric Power
Central Heating Plant (CHP) built in 1922 to provide central steam heat.	Solar Power
Original co-generation plant installed in 1986-87.	Cornell Lake Source Cooling
Cayuga Lake source cooling system became operational in 2000, conserving 80% of electricity for cooling.	Combined Heat and Power Project
Solar panels installed on Day Hall, the Cornell Store, and the Hoffmann Challenge Course since 2006, producing more than enough energy to power McGraw tower.	CURBI
Combined Heat-and-Power plant (natural gas) became operational in late 2009, reducing GHG emissions 20% from 1990 levels, and cutting coal consumption approximately 50%.	
Farm Services developing a biodiesel reactor to turn dining hall waste oil to biodiesel for use on campus.	

Shoals Marine Lab's wind turbine and solar panels power buildings and lab instruments that monitor chemistry-climate connections for New England.

TEAM MEMBERS	EXTERNAL LINKS
James R. Adams, Director of Utilities, Energy & Sustainability (Team Lead)	DOE Geothermal Technologies Program
Jerry Schuett, Consultant, Affiliated Engineers, Inc. (Consultant Lead)	
Stacey Edwards, Utilities Engineer	
W.S. "Lanny" Joyce, Director of Energy Management, Energy & Sustainability	USGS National Geothermal Resource Assessment
Tim Fahey, Professor - Department of Natural Resources	
Drew Lewis, CU Agricultural Experiment Station, Manager of Technology Services/Agricultural Operations	Map of wind resources in Tompkins County, NY
Pat McNally, Environmental Health & Safety	
Edward R. Wilson, Sustainable Energy Team Manager, Energy & Sustainability	NREL Biomass Cofiring overview
David Weinstein, Senior Research Associate, Natural Resources	
John Carter, Consultant, Affiliated Engineers, Inc.	
Rob McKenna, Consultant, Energy Strategies, Inc.	



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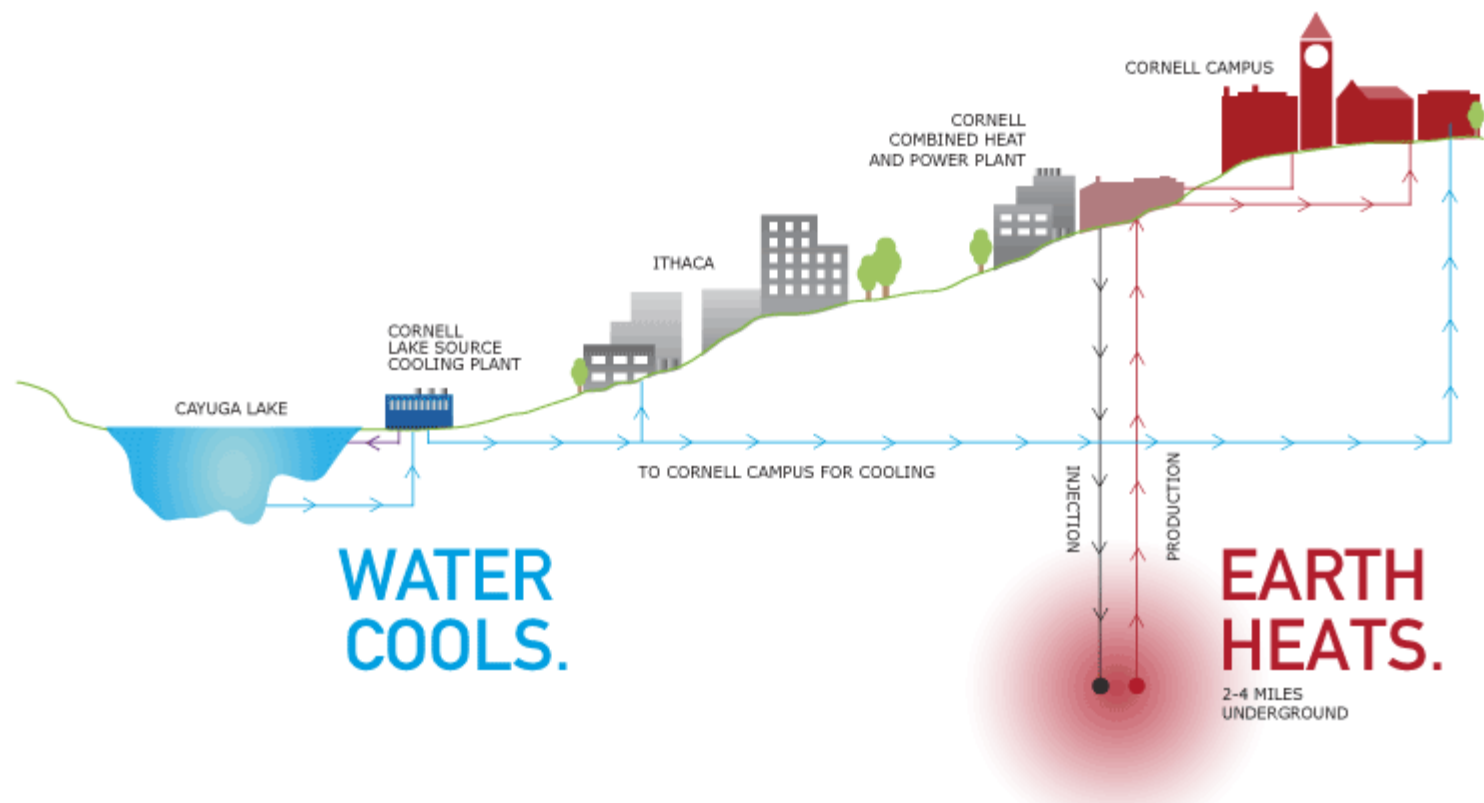
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HYBRID EGS SYSTEM: UTILIZING EARTH'S NATURAL ENERGY



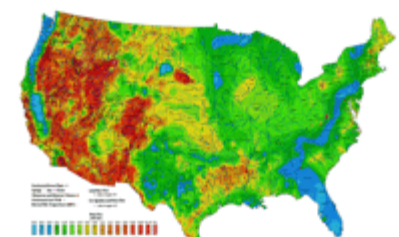
HYBRID ENGINEERED GEOTHERMAL SYSTEMS (EGS) WITH PEAK BIOGAS

This comprehensive "hybrid" action envisions a marriage of two innovative demonstration-scale research projects on the Cornell campus, Engineered Geothermal Systems (EGS) and Bio-Mass Gasification. Together with the existing Lake Source Cooling system, this action could allow Cornell to substantially heat and cool the campus using natural, renewable resources and stored heat energy from the earth, as illustrated by the diagram above.

EGS, commonly referred to as, "Deep Hot Rock" is an emerging technology that proposes to utilize the heat energy available deep beneath the earth's surface (about 2 - 4 miles) to generate district heating and electricity via generation and distribution equipment located at the surface. The initial EGS action, which is of national interest, will rely on federal funding and will provide multidisciplinary research opportunities while providing partial campus heat. State-of-the-art organic

ADDITIONAL INFORMATION

How deep? How hot? Cornell and Ithaca sit atop a more shallow geothermal resource compared to other areas of New York and the northeast U.S.



Subject to grant funding, Cornell will

Rankine cycle heat engines, another technology of national interest, are also included for generation of electrical power during periods in which campus heating needs are lower.

Cornell's Croll Professor of Sustainable Energy Systems in the College of Engineering, Jeff Tester, is a national expert in EGS. As an extension of his research and in coordination with the CAP, Professor Tester collaborated with other faculty, Cornell Facilities and the Environmental Compliance and Sustainability Office to submit a research grant proposal to the US Department of Energy for funding this demonstration project.

Ultimately, the EGS installation could be expanded, converting the entire campus steam system to hot water heat distribution, with EGS providing a majority of campus heating needs. Rather than over-build the EGS to meet peak heating season loads, the CAP evaluation includes a hybrid system that would link the EGS system to a biomass-to-biogas system design based on the results of the Cornell University Renewable Biofuels Institute (CURBI), an initiative described as a separate action in this plan. During very cold weather when EGS alone is not enough, the biogas would be used to provide the additional hot water needs of campus. Converting biomass to biogas opens up the possibility of co-generation or direct combustion, as appropriate to the energy needs of campus.

Completely realized this energy supply innovation would provide for nearly 113,000 tons (CO₂ equivalent) of average annual carbon abatement—35% of the total 2050 footprint.

study an on-campus application that will target hot rock located between 12,000 and 18,000 feet below the earth's surface.

According to Jeff Tester, Cornell's Croll Professor of Sustainable Energy Systems in the College of Engineering and expert in EGS, a two-well binary system (illustrated above) could produce up to 20 MW of thermal energy—about 600,000 MMBtu per year. This equates to about half of Cornell's current annual thermal demand.



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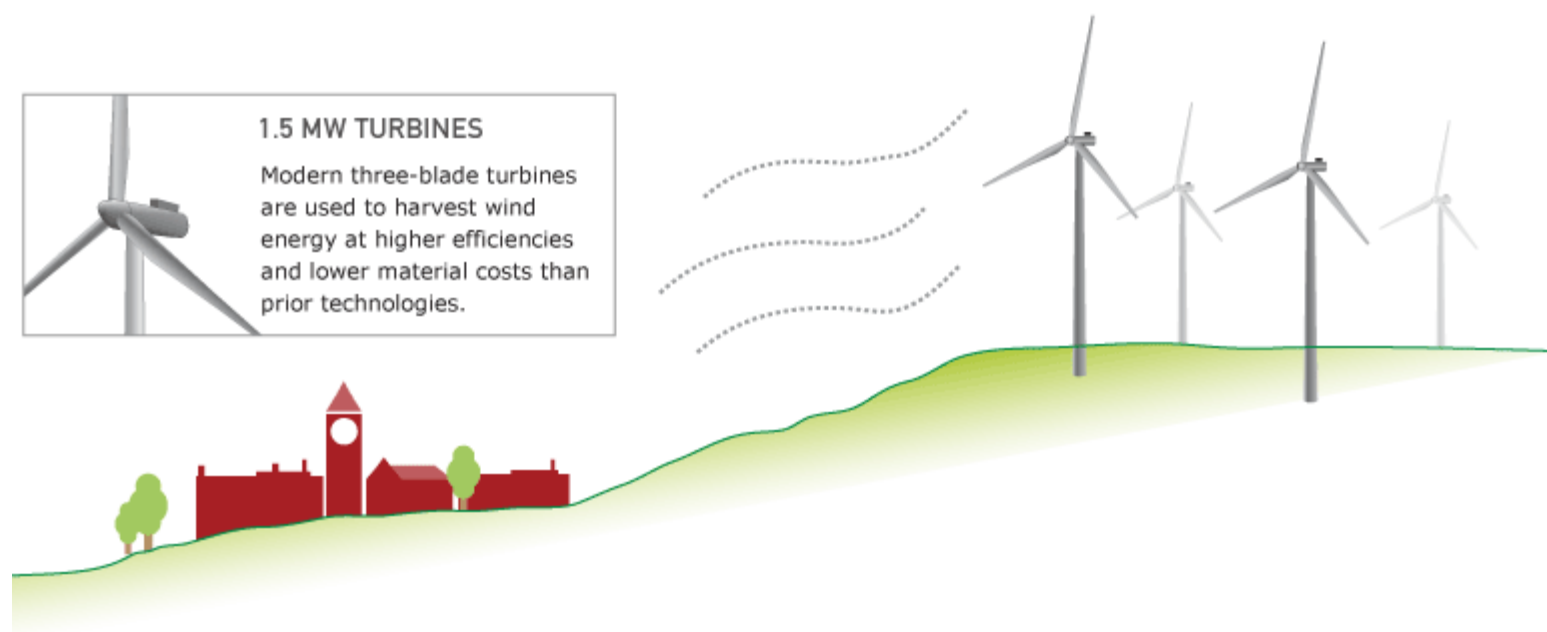
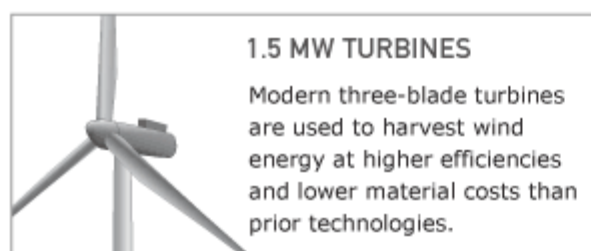
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WIND POWER: HARNESSING WIND ENERGY



CONNECTING UTILITY-SCALE WIND

The CAP-proposed wind power project includes eight 1.5 MW wind turbines with a combined rated capacity of 12 MW, connected directly into the Cornell electric system. Assuming a capacity factor of 29 percent, annual output from the turbines would total about 30,500 MWh.

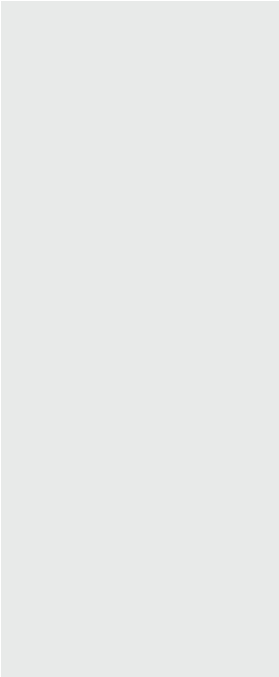
A challenge for Cornell will be to match generation capacity to campus needs. The majority of that production will occur during October through April when Ithaca experiences the most wind, the same time period that the Cornell Combined Heat and Power Project can provide the most electricity. Cornell's need for a broad portfolio of "stored" and "naturally fluctuating" energy resources reflects the challenge of broader society, which also seeks to improve its stewardship of energy resources. While Cornell anticipates supplying some of the renewable energy from the wind turbines to the electric grid as it balances campus electrical supply and demand, it also seeks to 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.

ADDITIONAL INFORMATION

The U.S. Department of Energy is developing 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.

While turbine design continues to evolve, Cornell researchers in the Sibley School of Mechanical and Aerospace Engineering have joined the search for even more reliable and efficient turbine designs.



Cornell continues to seek out and track a broad range of renewable energy options. Currently, wind power is one of the most cost-effective options available. Though a specific project site has not been finalized, preliminary estimates are that the cost of a wind project would be about 4 times less expensive (on a per-KW basis) than a solar photovoltaic system, based on existing technology and the availability of solar energy in our climate. However, researchers continue to seek out newer, more cost-effective applications for both wind and solar technologies. As time moves forward, Cornell will continue to review the cost efficiencies of various renewable technologies to implement the best energy options.



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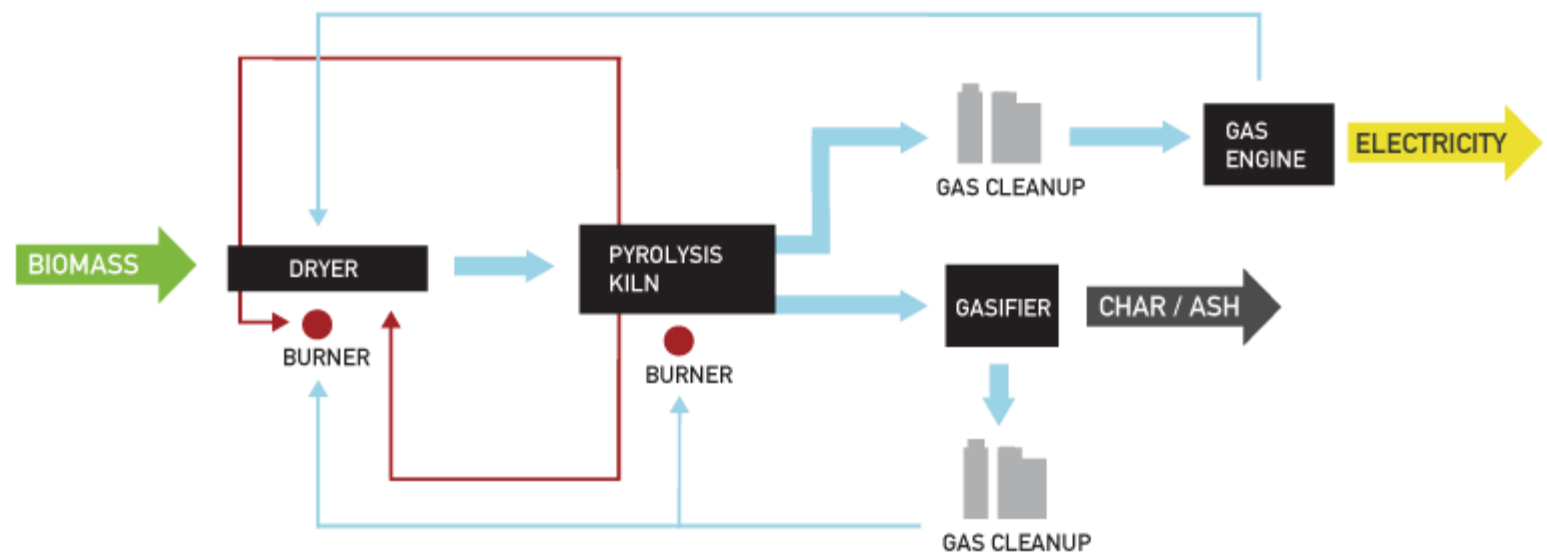
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C.U.R.B.I.: BIOMASS = ENERGY



CORNELL UNIVERSITY RENEWABLE BIOENERGY INITIATIVE (CURBI)

The Cornell University Renewable Bioenergy Initiative (CURBI) is in the initial stages of a feasibility study that will determine how best to use 57 campus waste streams and other university-owned biomass resources to generate renewable energy for the university. The feasibility study, supported by a matching grant from the New York State Energy Research and Development Authority (NYSERDA), is considering several options, including direct combustion, anaerobic digestion, and pyrolysis/gasification as potentially "stackable" technologies-so that waste products from one system can be used by another. For example, switchgrass could be used as a feedstock for a cellulosic ethanol process. The waste bagasse from that process could then be used in an anaerobic digester to produce a useable fuel. And finally, the waste from the digester could feed a pyrolysis/gasification process to produce a combination of syngas and biochar.

Although the exact combination and utilization of energy conversion technologies is yet to be determined by the CURBI feasibility study, a conservative estimate of 50 percent efficiency translates to about 150,000 MMBTU of fossil fuels offset by available biomass resources. Assuming

ADDITIONAL INFORMATION

CURBI includes the development of an on-campus, renewable biofuels research center that provides hands-on training for students while offsetting campus fossil fuel purchases.

What do all those terms mean? You can find out more details by visiting the [CURBI Site](#).

DEFINITION TABLE:

PYROLYSIS

A process that produces gas by heating organic matter in the absence of oxygen. The resultant biogas or synthetic gas is high in carbon monoxide, hydrogen, and other gases.

that energy offsets the use of natural gas for steam production, CURBI has a carbon reduction potential of about 8,700 metric tons of CO₂-e per year. Additional carbon reduction may be achieved by production of biochar, which both sequesters carbon and promotes the growth of new biomass when applied to soil.

BAGASSE

Material, often fibrous, left after a product -in the form of juice-has been extracted from a plant.

BIOCHAR

A valuable soil amendment with a multitude of beneficial properties that also sequesters carbon for generations, making it the only currently known "carbon negative" biomass conversion technology.

SYNGAS

synthetic gas, a misnomer for the "natural" renewable hydrocarbon gas mixture produced from biomass that can be used as a fuel for a combustion turbine to create heat and electricity, or in a simpler boiler to produce heat.

ANAEROBIC DIGESTION

A biological fermentation process that occurs in sealed units at temperatures elevated slightly above ambient conditions, producing a combustible mixture of methane and carbon dioxide containing small amounts of other gases.



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UPGRADED HYDRO CAPACITY: IMPROVING EFFICIENCY AND OUTPUT

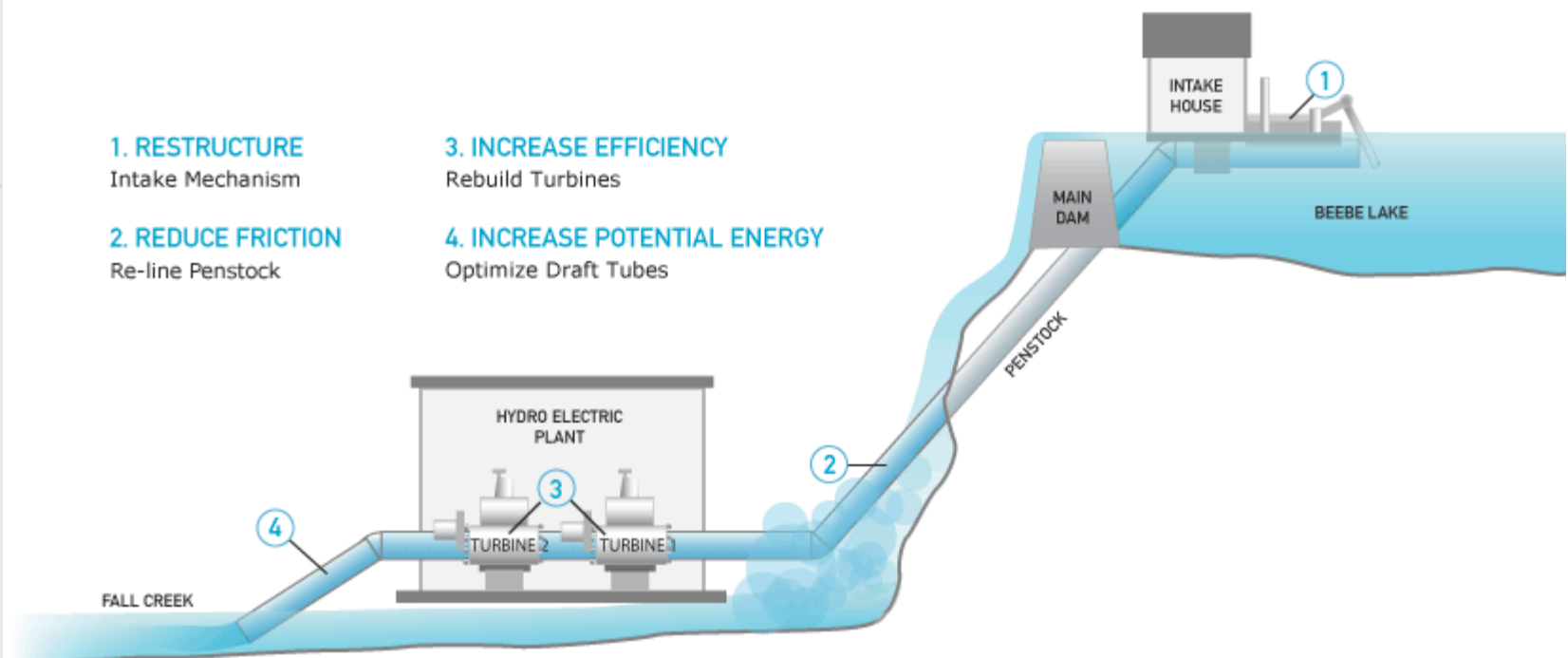


1. RESTRUCTURE
Intake Mechanism

2. REDUCE FRICTION
Re-line Penstock

3. INCREASE EFFICIENCY
Rebuild Turbines

4. INCREASE POTENTIAL ENERGY
Optimize Draft Tubes



UPGRADES TO HYDRO ELECTRIC POWER PLANT

1. Restructure the Intake:

Although it has been updated since the hydroelectric plant was originally constructed, 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 bellmouth entrance and replacing the entrance gate within the existing intake structure could eliminate just over half of this pressure loss, adding 300 Mwh per year and reduce GHG emissions by about 120 metric tons CO₂ per year.

2. Re-line the Penstock:

Relining the existing penstock with high density polyethylene (HDPE) would reduce pressure loss due to friction at an estimated cost of \$1 million. The increased pressure would provide a 4.2 percent increase in output or 250 MWh per year and reduce Cornell GHG emissions by about 100 metric tons CO₂ per year.

ADDITIONAL INFORMATION

In 1981 Cornell restored, and continues to operate, the hydroelectric plant built in the early 1900's. The facility generates an average 5,000 MWh (5 million kWh), enough for 600 homes.

Cornell's co-founder, Ezra Cornell, once operated a second hydropower station which diverted some flow around Ithaca Falls, located lower along Fall Creek. The remnants of the former penstock still existing at this site, which is now owned by the City of Ithaca.

3. Rebuild the Turbines:

The turbines currently operate at about 65 percent efficiency—considerably lower than their rated efficiency of 80 percent. This 15 percent increase in efficiency equates to about 900 MWh per year in additional output or about 370 metric tons of CO₂ each year in GHG emission reductions and is the result of guide vane and turbine runner wear on both turbines. Replacing these components of the turbines would return them to their rated efficiency.

4. Optimize Draft Tubes:

By connecting tubes to the turbine exits and extending them below the tailwater surface, the total water pressure could be increased by 5 percent. This added pressure would increase output from the plant by as much as 350 MWh per year and reduce Cornell GHG emissions by about 140 metric tons CO₂ per year.



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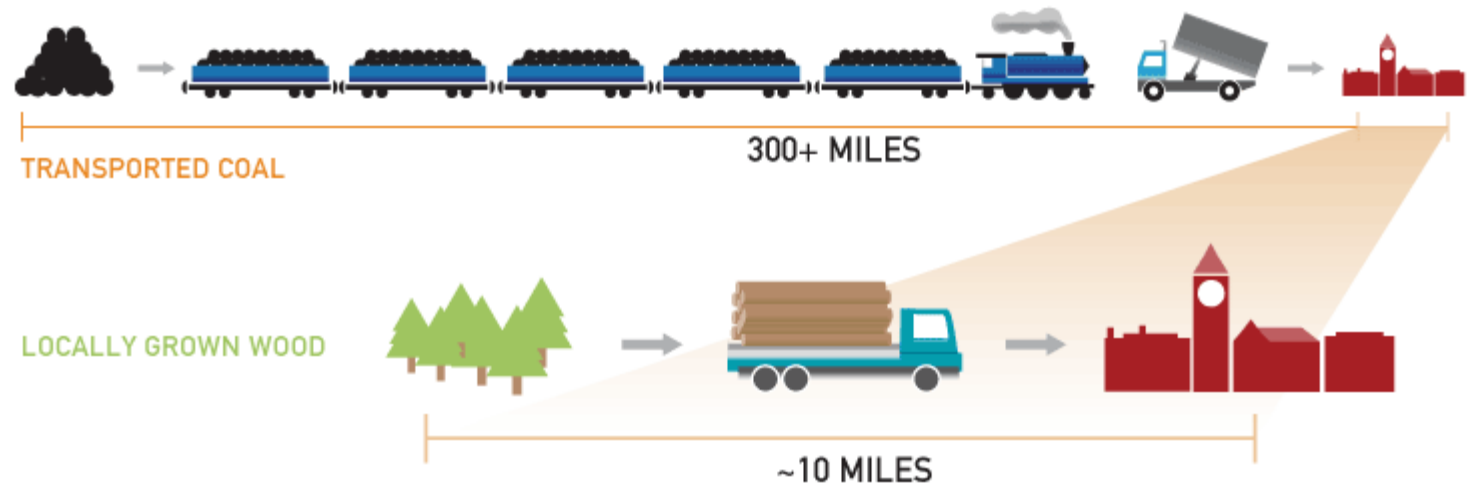
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WOOD CO-FIRING: NET ZERO BIOMASS



NET ZERO BIOMASS

10 percent of the coal burned in two main Cornell solid fuel boilers could be replaced with wood (on a weight basis) with limited modifications to upgrade or add solid fuel handling and storage.

Co-firing 10 percent wood on a weight basis equates to about 4.5 percent on a Btu basis assuming 5,400 Btu/lb wood at 40 percent moisture. Moisture contained in the wood requires additional energy to heat and boil and effectively lowers the heating value of the wood by about 1,100 Btu/lb to about 4,300 Btu/lb. Faculty from Cornell's College of Agriculture and Life Sciences have estimated the future cost of wood based on the cradle-to-grave costs of sustainable forest management, harvesting, and transportation. While the first costs of such a resource would likely exceed that of coal, the overall costs are lower when impacts to people and planet are considered.

In addition to the capital required for fuel storage and handling upgrades, an additional 0.5 full-time employee (FTE) will be required to manage the additional complexity of the systems. This option is viable until mid-2011 (when Cornell has committed to eliminate coal use). In the future, Cornell seeks to completely replace coal with other renewable sources, including biomass gasification to turn biomass into a gas that can be combusted in

FACTS

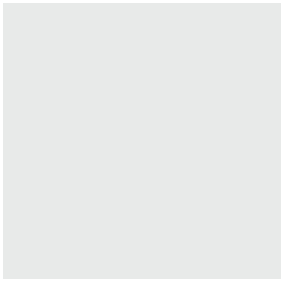
5,400 BTU
wet pound



12,000 BTU
dry pound



Sustainable Forest Management will add to the cost of the wood resource, but these practices are critical to this option being viable in the long run.



a boiler or co-generation turbine.



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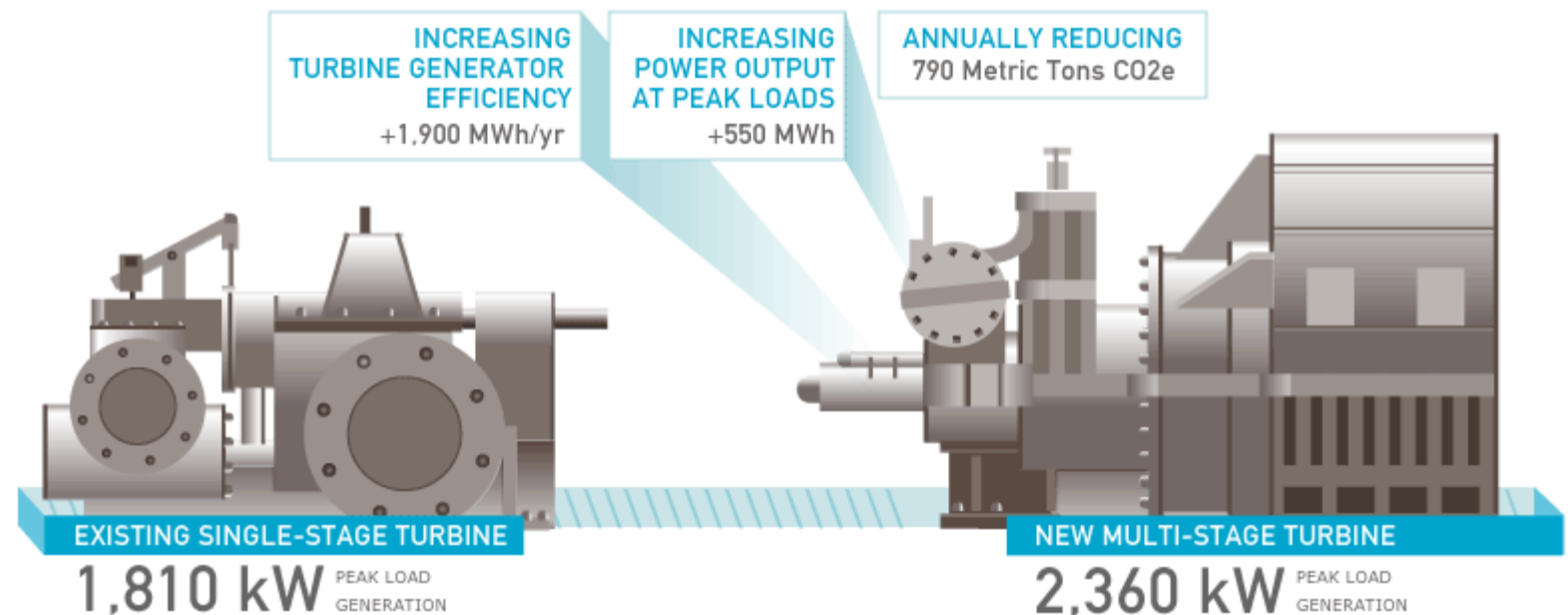
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TURBINE GENERATOR REPLACEMENT: INCREASING COGENERATION CAPACITY



GREATER EFFICIENCY THROUGH UPGRADES

The power output of Cornell's Central Heating Plant Cogeneration facility could be increased by approximately 550 kW at peak load conditions with a more efficient backpressure steam turbine generator (TG-1). Whereas the existing steam turbine generator is rated at 1,810 kW, a newer multi-stage turbine can achieve 2,360 kW. The new turbine's higher full and part load efficiency would increase annual generation by approximately 1,900 MWh per year based on the generator operating 3,500 hours.

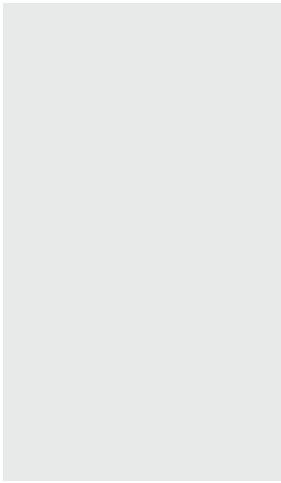
The ability to pass additional steam through the new generation will result in "cooler" steam being exported to campus for heating during the winter months. This steam is still adequate for campus needs, but a slightly greater supply will be needed to meet our steam demand. Cornell's cost savings calculations have accounted for the additional fuel needed to deliver the total energy to heat the buildings, while making more electricity during the "cogeneration" process.

Assuming that increased capacity would offset electricity purchased from NYSEG, the reduction in Cornell's GHG footprint would be about 650 metric tons of CO₂ per year.

FACTS

Cornell has two steam turbines. Together, they generated about 10% of the electricity used on campus in 2008. One of these turbines is already being rebuilt (and therefore not included as a future action in the Climate Action Plan). Together, the two turbine improvements would increase the power output to about 13% of campus needs, with the same input energy requirements.

Cornell's Combined Heat and Power Project (CCHPP) adds combustion turbines to Cornell's energy mix. These combustion turbines will generate electricity from the combustion of natural gas, with the exhaust heat used to provide steam.



Together with our existing hydropower plant and the two steam turbines, Cornell will be able to produce almost 85% of its own electricity in 2010 and beyond.



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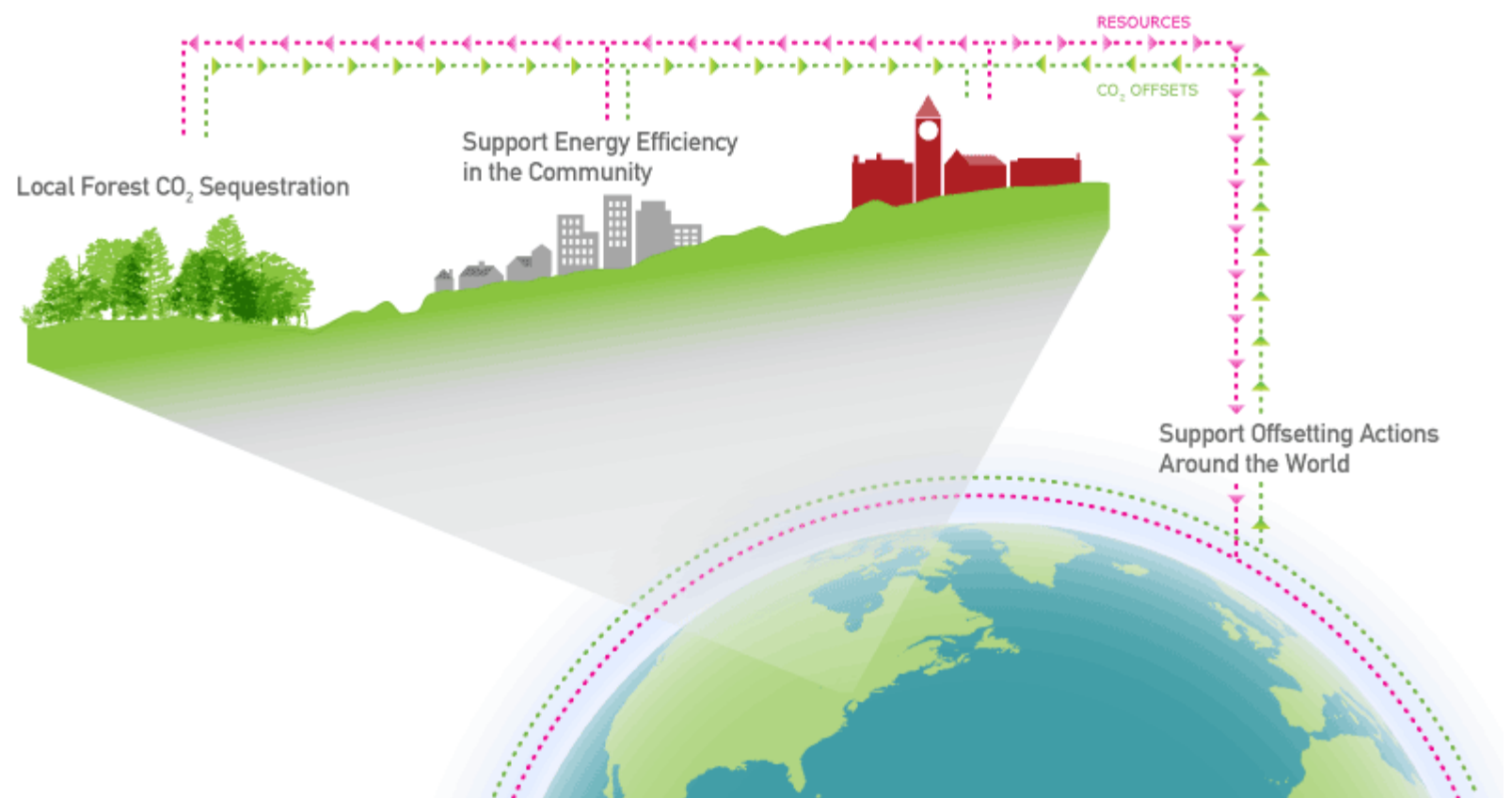
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CO₂ Achieving climate neutrality may require actions that extend beyond the campus.



A PORTFOLIO OF OFFSETTING ACTIONS

While a measure of last resort, offsetting actions may have a role to play in Cornell's pursuit of climate neutrality. Should actions described in the other wedge areas provide even the projected total reduction in carbon emissions by 2050, further efforts may be required to reach the ultimate goal of zero. Based on the array of potential actions in the Climate Action Plan (CAP), major offsetting actions would likely not be required for at least 20 years. Over this time, Cornell anticipates advancements in renewable energy, energy storage, and other emerging technologies to provide opportunities heretofore unimagined. Additionally, periodic

ADDITIONAL INFORMATION


**AVOID
REDUCE
REPLACE
OFFSET**

While offsets are generally the lowest priority, Offsetting Actions have the potential to extend our research and service outward.

refinements will be made to the CAP that will provide further actions for implementation in the years to come.

Offsets may have two important potential roles to play in the CAP: 1) as an enhancement of Cornell's land-grant mission that complements direct emissions reductions, and 2) as a cost-effective measure that can contribute to compliance with emerging mandatory federal greenhouse gas (GHG) regulations. In either case Cornell anticipates helping to develop offsetting practices by creating local and regional offset programs featuring sustainable technologies that are related to our mission of education, teaching, and research. Unless directly tied to this mission our intent is not simply to participate in the purchase of market-based offsets.

The [CAP recommends](#) (quality offsets white paper) that any Cornell investments in high-quality (verifiable) offsets, be directly linked to Cornell's core mission and a contributor of co-benefits to the community and the environment.

OFFSETTING ACTIONS SUMMARY					
	APPROX ANNUAL GHG REDUCTION		ACTION STARTS	NEXT STEPS	FINANCIAL
	Metric Tons (CO ₂ Equivalent)	Percent of 2050 Footprint			
defined mission-linked offsets	23,000	7%	near-term	generate project plan	costs money
undefined mission-linked offsets	61,000	19%	long-term	define in future	costs money
community offsets	3,000	1%	mid-term	develop protocol with community	costs money
TOTAL	87,000	27%			

DEFINED MISSION LINKED OFFSETS	ADDITIONAL INFORMATION
<p>Afforestation</p> <p>Afforestation is the process of converting idle pasture or cropland to forest land by planting and actively managing the land to grow mature trees. The goal of afforestation projects is to enhance carbon sequestration by allocating lands away from cropland and pasture that may have lower carbon storage capacity to forest cover that has higher carbon storage potential. Research in the carbon storage capacity of different types of land uses is ongoing. However, afforestation is an accepted carbon offset strategy in carbon trading institutions such as the Chicago Climate Exchange (CCX) Clean Development Mechanism under the Kyoto Protocol, and the Regional Greenhouse Gas Initiative (RGGI).</p> <p>There are over 14,000 acres of land owned and managed by Cornell's College of Agriculture and Life Sciences in the Ithaca area. 2,500 to 5,000 acres of this land could be targeted for afforestation for purposes of carbon capture and sequestration. The areas proposed for afforestation are forest areas not managed by Cornell Plantations and include Cornell properties located on Mt. Pleasant, near the Tompkins County Airport, and</p>	<p>Sequestration potential from afforestation on Cornell lands was estimated using the US Forest Service's Carbon Online Estimator or COLE.</p> <p>Sequestration potential from forest management on Cornell lands was estimated using the US Forest Service NED2 model.</p> <p>For more information on biochar and pyrolysis see the Cornell University Renewable Bioenergy Initiative (CURBI) Site.</p>
INTERNAL LINKS	

near and Harford Animal Science Teaching and Research Center. Several of these areas include, or are adjacent to, existing forestlands.

The CAP proposes that 100 acres will be afforested each year for 10 years, resulting in a total of 1,000 acres of newly forested lands. After subtracting the amount of natural sequestration expected from conversion of idle fields to forest, the total offset potential of the project is 3,800 metric tons of CO₂ per year.

Forest Management

Intensive forest management may be possible on all 6,636 acres of Cornell University owned forestlands. The areas proposed for intensive forest management are forest areas not managed by Cornell Plantations and include Cornell properties located at Arnot forest, on Mt. Pleasant, near the Tompkins County Airport, and near and Harford Animal Science Teaching and Research Center.

The carbon sequestration rate of the existing conditions in the 6,636 acres of Cornell forest lands is estimated to be 7,770 metric tons of CO₂ per year, while the average sequestration rate of the same acreage intensively managed over the next 50 years (2009 - 2058) could sequester 30% more for a net potential additional sequestration of 2,330 metric tons CO₂ per year. Cornell University Department of Natural Resources estimates this net sequestration potential is after the annual harvesting of 2,500 tons of biomass each year for use at the Cornell central heating plant.

Biochar

Biochar is charcoal produced from the slow pyrolysis of organic biomass such as wastes from agriculture, forestry, and residential yard wastes. Pyrolysis is a thermo-chemical reaction where biomass is heated in the absence of oxygen. The pyrolysis process that creates biochar also creates gaseous byproducts, commonly referred to as syngas (or synthetic gas), which can be used as a fuel source for the generation of heat or electricity.

The production of biochar has been proposed as an effective method for long-term capture and sequestration of carbon in the earth. The entire process is considered a carbon "sink," as it returns carbon captured during the photosynthesis of biomass growth to the soil for long-term sequestration in the form of biochar. The process of creating biochar is an alternative to extracting all of the useable energy from the feedstock through complete combustion.

A feasibility study is underway to assess a 1 to 2-ton/hour continuous capacity slow pyrolysis plant as part of the Cornell University Renewable Bioenergy Initiative (CURBI). A pilot-scale or full-scale pyrolysis process could be located on lands owned and managed by Cornell near the Ithaca campus.

A large-scale pyrolysis unit could potentially use approximately 8,000 - 15,000 tons of dry biomass feedstock per year. This unit could potentially produce 2,400 to 4,500 tons of biochar per year, which would contain 4,700 - 8,900 tons of CO₂, depending upon the feedstock biomass used

[Managing local forests to sequester carbon](#)

[Research on Biochar](#)

[Research on Carbon capture and storage](#)

[Research on Carbon Sequestration in Agriculture](#)

[Faculty experts in carbon offsets](#)

[Farm education on carbon offsets](#)

EXTERNAL LINKS

[Colorado Carbon Fund](#)

and the amount of syngas produced.

The following existing waste sources may be available for use as pyrolysis feedstock:

- Yard waste biomass,
- Pre-ground pallet waste,
- Wastes currently being composted (e.g., food waste),
- Other organic wastes from the College of Veterinary Medicine, College of Agriculture and Life Sciences, polo barns and greenhouses.

UNDEFINED MISSION LINKED OFFSETS

The Cornell plan provides for the potential use of undefined mission-linked offsets as required to, at a minimum, stay in step with the straight-line reduction goals called for by the Intergovernmental Panel on Climate Change (an 85% reduction of 2000 levels by 2050). Based on Cornell's analysis, major investments in offsets are not likely necessary for 20 years or more. Over this time period further definition to this offset category will be established to the extent that they are required.

COMMUNITY OFFSETS

The term offsets itself suggest that Cornell's campus community is not a closed entity, but an integral member of the broader community. A local carbon offset initiative suggested by local environmental leaders is included, whereby faculty, students, and Cornell Cooperative Extension and Facilities staff would assist community members in expanding renewable energy and conservation efforts. With appropriate auditing and structure, the initiative could generate third-party verifiable carbon offsets for sale to individuals or institutions or could be earned and "retired" to acknowledge the environmental benefit. Cornell would explore this as a model community-based "local offsets" program, potentially with joint funding through appropriate community or governmental entities.

TEAM MEMBERS

James R. Adams, Director of Utilities, Energy & Sustainability (Team Lead)
Jeff Burks, Energy Strategies, Inc.(Consultant Lead)
Steve Beyers, Section Leader, Energy and Environmental Engineering
Section
Robert R. "Bert" Bland, Senior Director, Energy & Sustainability
Michael Hoffman, Professor, Entomology
W.S. "Lanny" Joyce, Director of Energy Management, Energy &
Sustainability
Sid Leibovich, Samuel B. Eckert Professor, Mechanical & Aerospace
Engineering
David Weinstein, Senior Research Associate, Natural Resources
Gary Stewart, Assistant Director, VP Gov. & Community Relations
Katherine McEachern, '09 Design & Environment Analysis, President of
Kyoto Now!



Culture Change



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- [PROCESS](#)
- [INVENTORY](#)
- [FORECAST](#)
- [ACTIONS](#)
- [CULTURE](#)



CORNELL AS LIVING LABORATORY FOR THE WORLD

Cornell University's mission, role, and very identity have always been linked to leadership in education and research, developing technologies that will impact the world and providing students with a clarity of knowledge that they will carry into their adult lives as tomorrow's leaders.

The Climate Action Plan (CAP) is a natural extension of that identity of leadership, focused specifically on education and research to generate solutions to the challenges of global climate change in the areas of fuel and renewable energy, transportation, energy conservation and efficiency, and the built environment.

The CAP has been organized around the goal of eliminating campus greenhouse gas emissions by 2050, an increasing global imperative and an immediate practical exercise in institutional management, setting a concrete target, a comprehensive scope, and a strategic schedule to guide research and education. Through the implementation of the Climate Action Plan Cornell becomes a living laboratory for the world. Through the 'Living Laboratory' approach students, staff, faculty, and extension agents are asked to "become the change" and "walk the talk." In particular this will depend on new collaborations across campus between operational

ADDITIONAL INFORMATION

Cornell must be prepared for life on a "small" planet, including: allocating diminishing resources while maintaining social stability; promoting innovation that will lead to productive careers and job growth; and promoting behavior that supports sustainability at individual, as well as societal, levels.

[Student Sustainability Guide \(PDF\)](#)

[Track your building's energy](#)

[Get Involved in Campus Sustainability](#)

[Cornell efforts across the state](#)

[Center for a Sustainable Future](#)

staff, faculty, and students. Lessons learned here, practices refined, and innovations developed will help Cornell become climate neutral, and will set an example for universities, municipalities, and governments, throughout the US and around the globe.

Culture change often equates with daily habits. This philosophy has long since been adopted by the Cornell community through such efforts as the comprehensive transportation demand management program fostering higher efficiency in transportation and use of less carbon-intensive modes of travel, and building energy initiatives and conservation efforts to reduce campus energy consumption. While Cornell, as an institution, has historically demonstrated ever-increasing environmental stewardship through broad university programs, the individual Cornellian is equally responsible for enabling the myriad of incremental changes required by the future imperative of global warming. The duration of a daily shower, the mode of a morning's commute to campus, the selection of local food—these habits are rich with potential for positive impact.

The new generation of culture change will be in the realm of perception. Continued campus growth is likely necessary to support the university's mission. Comprehensive space planning—improving building space efficiency—will have the effect of reducing the size of future construction programs, optimizing energy-use intensity. Decisions will be based on a reprioritization of criteria, placing greater importance on the cost of carbon, future energy costs, and other environmental factors. Over time, Cornell's efforts will help decision-makers at all levels from the home to board rooms to city hall understand the climate and energy impacts of their choices.

The future of culture change engages practical imagination. The impacts of applied research are often seamless, more known than perceived—the significance of sustainable technology doesn't lie in how it looks but in what it does. Cornell already offers more than 150 courses that incorporate aspects of climate change and sustainability and six climate- and sustainability-related degree granting programs. The Cornell Cooperative Extension system offers homeowners and landowners capacity-building programs to increase energy efficiency and produce renewable energy across New York State. Over a dozen student clubs are making headway in changing policies and developing innovative solutions such as the solar decathlon house and 100 mpg car. In the coming years, university-wide understanding of Cornell's achievements as the premier climate and energy, land-grant institution in the nation, and awareness of the practical knowledge developed here, can create in every graduate, faculty member, administrator, staff member, and researcher—indeed, in every New York resident—a sustainable leader of tomorrow.

Cornell University is a learning community that seeks to serve society by educating the leaders of tomorrow and extending the frontiers of knowledge. Leadership in climate neutrality is a strategic direction to advance the university's core mission of teaching, research, and outreach. In support of this mission, the Climate Action Plan has been developed with broad representation from campus constituencies—toward the goals of advancing research, educating innovators and change-makers, and helping catalyze a low-carbon economy across the state and globe. For

more information on research and teaching in sustainability see the Center for a Sustainable Future at www.sustainablefuture.cornell.edu.

Specific recommendations for creating a living laboratory.

Teaching

Integration of climate neutrality into the educational experiences of students supports Cornell's mission. The plan enhances the ongoing work of over 15 student clubs and our faculty who teach over 150 courses focused on sustainability and climate change, recommending:

- continued incorporation of climate change and sustainability themes into the curriculum
- support for faculty development in sustainability education
- increased opportunities for experiential learning through interdisciplinary teams addressing climate challenges
- utilization of the campus as a living research laboratory for academic-operations collaboration

Research

Cornell research is at the leading edge of science, engineering and design, new technologies, social processes, and policies related to climate change issues. The Center for a Sustainable Future advances multidisciplinary research in energy, environment, and economic development that involve more than 30 on-campus centers, 300 faculty, and 60 state extension agents in initiatives at local, national, and international levels. Supporting these research efforts, the Climate Action Plan recommends:

- support for interdisciplinary faculty teams to strengthen related research proposals
- seed funding of cross-campus collaborations in sustainability science
- workshops, conferences, and events to connect Cornell researchers and identify new research opportunities

Outreach

As New York State's land-grant university, Cornell helps turn knowledge into practical actions and contributes to the state's economic prosperity. Cornell is committed to climate- and sustainability related education through programs and partnerships that promote knowledge with a public purpose:

- state-funded experiment stations
- county extension offices of Cornell Cooperative Extension
- applied research centers, and more

For profiles of outreach efforts across New York visit www.cornell.edu/outreach/programs.

2009 Cornell Climate Action Plan
MAKING CLIMATE NEUTRALITY A REALITY

Downloads



Cornell Climate Action Plan – Consultant Team

Following a two-month process of proposals, interviews, and discussions on scope and approach, Cornell hired a team of consultants led by Affiliated Engineers, Inc (AEI). The team also included Energy Strategies for financial assessment, risk exposure and decision process support and Martin/Alexiou/Bryson for transportation consulting. This team of consultants was supported by and worked directly with a broad-based Cornell team led by Cornell's Environmental Compliance and Sustainability (ECOS) staff.

Affiliated Engineers, Inc.

AEI is a multi-discipline technical consulting firm providing innovative solutions for complex and large scale projects worldwide, supporting the excellence of a diverse clientele. The firm's markets of specialization include: Energy and Sustainability, Science and Technology, Healthcare, Utility Infrastructure, Industrial Test Facilities, Higher Education, Federal Government, Cultural and Public Facilities, Process and Clean Manufacture, and Commercial Buildings. AEI can be found on the web at www.aeieng.com.

Energy Strategies

For twenty-five years, Energy Strategies has provided support to clients with respect to investment in energy infrastructure and technology, energy project development, the purchase and sale of energy commodities, and energy regulation and policy. In recent years, approaches to energy and sustainability in general, and climate change in particular, have converged. Energy Strategies has continued to evolve its understanding of the full range of current and emerging energy opportunities as well as the suite of analytical practices and advanced tools that can be used to provide insight and confidence to our clients. Clients include many of the leading energy practitioners within a wide range of economic sectors including higher education, healthcare, manufacturing, technology, government, energy, utility, and commercial real estate. Energy Strategies is located in Salt Lake City and on the web at www.energystrat.com.

Martin/Alexiou/Bryson, PLLC

M/A/B specializes in transportation planning and traffic engineering services for public and private organizations. The firm is known for its innovative solutions designed to meet the needs of a broad range of clients and communities in an era of new challenges and shifting priorities. The principals of the firm are committed to their belief that transportation is about people, not just moving vehicles. Being a small firm allows the principals of Martin/Alexiou/Bryson to work directly with clients in meeting their individual needs. We are committed to developing cost-effective, practical transportation solutions that enhance a community's quality of life. Our planning approach also reflects our belief that successful planning must involve meaningful participation by the public. M/A/B can be found on the web at www.mabtrans.com.

Cornell Basis Notes

May

2009

These “Basis Notes” provide a structure for fostering and capturing the robust dialogue necessary to assure a well-documented, transparent, and rigorous “Base Case” that will be used as the foundation for comparison during the development of the Cornell Climate Action Plan. The “Base Case” that results from this dialogue will be documented in a final “basis” document.

Base Case

Prepared by Energy Strategies, LLC
215 South State Street, Suite 215
Salt Lake City, UT 84111
(801) 355-4365

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1 Charter and opportunity statement

1.1 The Base Case Working Group has been formed to:

Coordinate the development of a Base Case that be used as a foundation for comparison in the formulation of the Cornell Climate Action Plan (CAP). The Base Case will qualify and quantify a set of potential future Environmental, Social, Economic and Institutional scenarios that Cornell University may anticipate if it were to conduct “business as usual” (BAU). The future scenarios will incorporate decisions that have already been made as well as pending decisions, e.g. the CIT building and the Energy Recovery Linac , and will form the foundation for comparison when new alternative are considered for inclusion in the Climate Action Plan (CAP).

2 Definitions

2.1 Base Case

The Base Case provides a point of reference that enables us to compare the impact of each future decision/alternative, i.e. as an incremental decision. The Base Case incorporates all decisions already taken, e.g. Master Plan, whether fully implemented at this point or not. The Base Case should anticipate any general and/or institution specific regulatory requirement to mitigate GHGs.

2.2 Other reference cases

There may be other “Reference Cases” that the University chooses to highlight its GHG related progress. For example:

- Business as usual operations before major actions already taken
- Carbon footprint given the actions already implemented

3 Sources of information

- 2008 Master Plan
- 2008-2009 Financial Plan, Capital and Operating
- Utility 5-year plan

4 Base Case Building Blocks

4.1 Demand drivers and factors

4.1.1 Campus population (current and expected)

4.1.1.1 Students

Fall	Ithaca Campus Enrollment		
	Ithaca Undergraduate	Ithaca Graduate/ Professional	Total Ithaca Campus
1988	12,943	5,482	18,425
1989	13,026	5,555	18,581
1990	12,801	5,588	18,389
1991	12,915	5,712	18,627
1992	12,861	5,660	18,521
1993	13,097	5,684	18,781
1994	13,262	5,628	18,890
1995	13,372	5,542	18,914
1996	13,512	5,337	18,849
1997	13,294	5,134	18,428
1998	13,442	5,207	18,649
1999	13,669	5,352	19,021
2000	13,590	5,405	18,995
2001	13,801	5,619	19,420
2002	13,725	5,850	19,575
2003	13,655	5,965	19,620
2004	13,625	5,893	19,518
2005	13,515	5,932	19,447
2006	13,562	6,077	19,639
2007	13,510	6,290	19,800
2008	13,846	6,427	20,273

Source: CU Office of Institutional Research and Planning, http://www.dpb.cornell.edu/F_Enrollment.htm
(see Appendix F for more detail)

Forecast Assumptions:

The Campus Master Plan (CMP) includes the following statement:

“Cornell’s overall population is not expected to grow significantly. The number of undergraduates is expected to hold steady at approximately 13,000....The number of

graduate students is expected to increase in step with the number of new faculty, from a current total of approximately 6,000 to about 7,000.^{iv}

For the purposes of the CAP base case it will be assumed that the undergraduate population will “hold steady” at the 2008 enrollment of 13,846 through 2050 and that the graduate/professional enrollment will increase straight-line from 6,427 in 2008 to 7000 by 2040, per the CMP, and continue at the same straight-line growth rate through 2050.

4.1.1.2 Workforce, Ithaca Campus (2007-2008)

- Faculty – 1,637
- Other Academic Staff – 1,193
- Support Staff – 7,540
- Total – 10,370

Source: 2008-2009 Financial Plan, Operating and Capital, p. 73 (see Appendix A for history and detail)

Forecast Assumptions:

The Campus Master Plan includes the following statement regarding a 30 year time horizon:

“Cornell’s overall population is not expected to grow significantly....The number of faculty members should increase slowly, from a current total of approximately 1,600 to between 1,700 and 1,800.... The staff population will also likely grow from a total of approximately 8,400 to about 9,100, mostly to support the new space that is likely to be built.”^{iv}

For the purposes of the CAP base case it will be assumed that the faculty population will “increase slowly” straight-line from 1,637 in 2008 to 1750 (midpoint of CMP estimate) by 2040 and continue increasing at that same rate through 2050. It is assumed that other academic staff, not mentioned in the CMP, will increase at the same rate as Faculty through 2050. It is assumed that Support Staff will increase straight-line from 7540 in 2008 to 8750 (midpoint of CMP estimate) by 2040 and continue at the same straight-line growth rate through 2050.

The Transportation-focused Generic Environmental Impact Statement (t-GEIS)ⁱⁱⁱ modeled four ten-year population growth scenarios as follows: Scenario 1 – 0 persons; Scenario 2 – 300 persons; Scenario 3 – 1,500 persons; and Scenario 4 – 3,000 persons. Using the CMP assumptions outlined above, the ten-year population growth is just over 600 people. This is within the range of the t-GEIS scenarios.

4.1.2 Buildings (Campus Area)

Distribution of Space – Cornell University *					
Category	Cornell University		Master Plan Subset		Master Plan as a % of Cornell Total
	Count	% of Total	Count	% of Total	
Number of Buildings	1,074		613		57%
Gross Square Feet	17,743,941	100%	14,255,895	100%	80%
Net Square Feet	15,017,069	85%	12,068,607	85%	80%
Net Assignable Square Feet	11,305,714	64%	8,606,543	60%	76%
Net Assignable Research Square Feet	2,526,429	14%	1,889,097	13%	75%
* Represented is space owned or occupied by Cornell as of the fall of 2007, including the facilities of the Weill Cornell Medical College in New York City, the School of Industrial and Labor Relations in New York City and Albany, the regional offices of Alumni Affairs and Development in several cities, and various off-campus research and extension locations associated with the College of Agriculture and Life Sciences, including the Geneva Experiment Station. Excluded are facilities of the Weill Cornell Medical College in Doha, Qatar, the Arecibo facility in Puerto Rico, and other program space located in both Washington, D.C. and New York City.					

Source: 2008-2009 Financial Plan, Operating and Capital, p. 45

According to the March 2009 capital plan, the campus area growth through 2014 will be as follows:

	Additions	Deletions	Renovations
2008	271,000	-44,000	59,900
2009	231,000	0	66,521
2010	38,000	-49,000	73,068
2011	428,000	0	78,704
2012	58,000	0	191,495
2013	164,000	0	196,138
2014	0	0	181,424

For detail regarding campus area growth through 2014 see Appendix C.

Note on growth from the CMP:

“Over its history, the total floor area at Cornell has increased by an average of one million square feet per decade, although for the past 50 years, the average has been closer to two million square feet. Looking ahead, changing demographics and a focus on sustainable development suggest Cornell will grow more conservatively than in recent decades....The campus master plan assumes the university will add 3-4 million gross square feet (GSF) of development to the campus in the next 30 years, but provides a framework and identifies development areas that could accommodate more than that.”

Source: Source: 2008 Campus Master Plan, pp. 22-23

Forecast Assumptions:

For the purposes of the CAP base case analysis it will be assumed that the growth through 2014 will be according to the March 2009 capital plan (see Appendix C for detail) then straight-line from 2014 to current (2008) plus 4 million GSF by 2040. The CMP also indicated that the expected growth to 2060 is current plus 6 million GSF. The growth from 2040 to 2060 will be an additional 2 million GSF (6 million minus 4 million), distributed equally per year.

The resulting growth modeled in the base case is below:

	GSF	Net Growth per Capital Plan/CMP	Average Growth per Year
2008	14,256		
2014	15,357	1,101	184
2040	18,256	2,899	112
2060	20,256	2,000	100

4.1.2.1 Square footage renovated by year

Assume that 2% is renovated per year, but 1% is associated with increase in energy use because the other 1% already has a full HVAC system.

4.1.2.2 Energy use intensity

4.1.2.2.1 Energy use intensity – New Buildings

The projected energy use for new buildings in the base case has been forecasted per the Energy Use Intensity numbers in the table below:

Building Type	Base Case (KBTU/GSF)			
	EUI	Electric	Steam	Chilled Water
Laboratory	280	81	134	65
Office/Classroom/Admin	84	24	42	18
Residential	76	23	38	15
Supporting/Other	7	7	0	0

Source: Total EUI numbers from AEI Model. Breakdown by Utility from the Net Load Growth provide by CU staff to consultant team.

The weighted average EUI by year for new GSF added in the Capital Planning period are:

	Additions	Deletions	Weighted Average - EUI - Additions		
			ELE [kWh/GSF]	STM [klb/GSF]	CHW [thr/GSF]
2008	271,000	-44,000	23.87	0.121	5.38
2009	231,000	0	6.78	0.035	1.30
2010	38,000	-49,000	21.86	0.150	5.73
2011	428,000	0	19.73	0.101	4.42
2012	58,000	0	7.01	0.038	1.47
2013	164,000	0	5.07	0.023	0.89
2014	0	0	0.00	0.000	0.00
2015+	Weighted average for 2008 through 2014		12.65	0.064	2.71

For detail regarding campus area growth through 2014 see Appendix C.

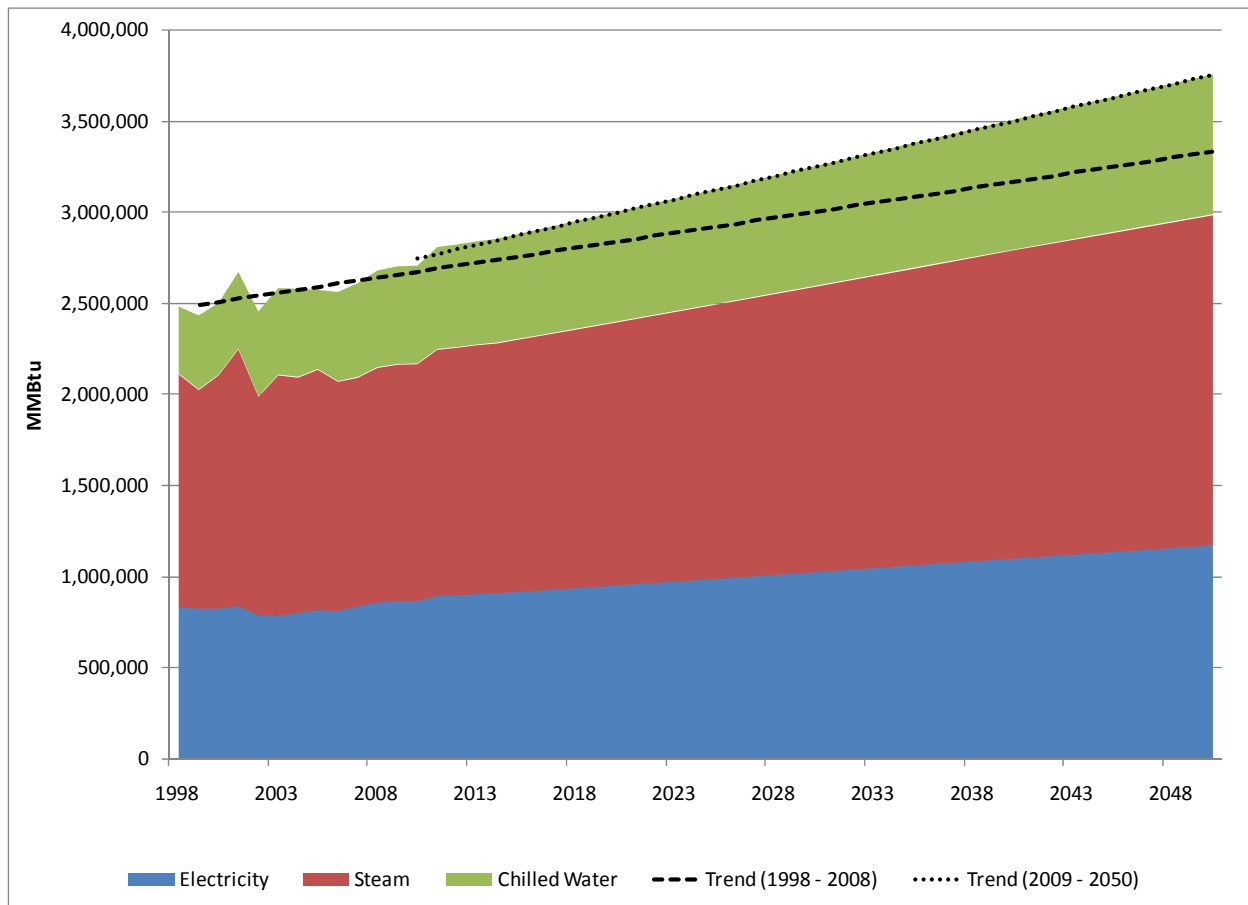
4.1.2.2.2 Energy use intensity – Renovations

Appendix C highlights the square footage that will be renovated by 2014. This same spreadsheet also includes the expected **incremental** EUI associated with those renovations which is reflected in the table below. After 2014, the weighted average **incremental** EUI for the 2008 through 2014 will be applied to all business-as-usual renovations in the base case.

	Renovations	Weighted Average - EUI - Renovations		
		ELE [kWh/GSF]	STM [klb/GSF]	CHW [thr/GSF]
2008	59,900	9.64	0.049	2.15
2009	66,521	5.03	0.027	1.09
2010	73,068	3.94	0.021	0.83
2011	78,704	4.19	0.023	0.89
2012	191,495	3.79	0.021	0.80
2013	196,138	3.78	0.021	0.80
2014	181,424	6.01	0.032	1.31
2015+	Weighted average for 2008 through 2014	4.46	0.024	0.95

4.2 Utility demand (volumetric)

Based on the inputs above, the forecasted utility demand through 2050 is illustrated in the chart below. See Base Case Spreadsheet for more detail.



4.3 Sources of Marginal Supply

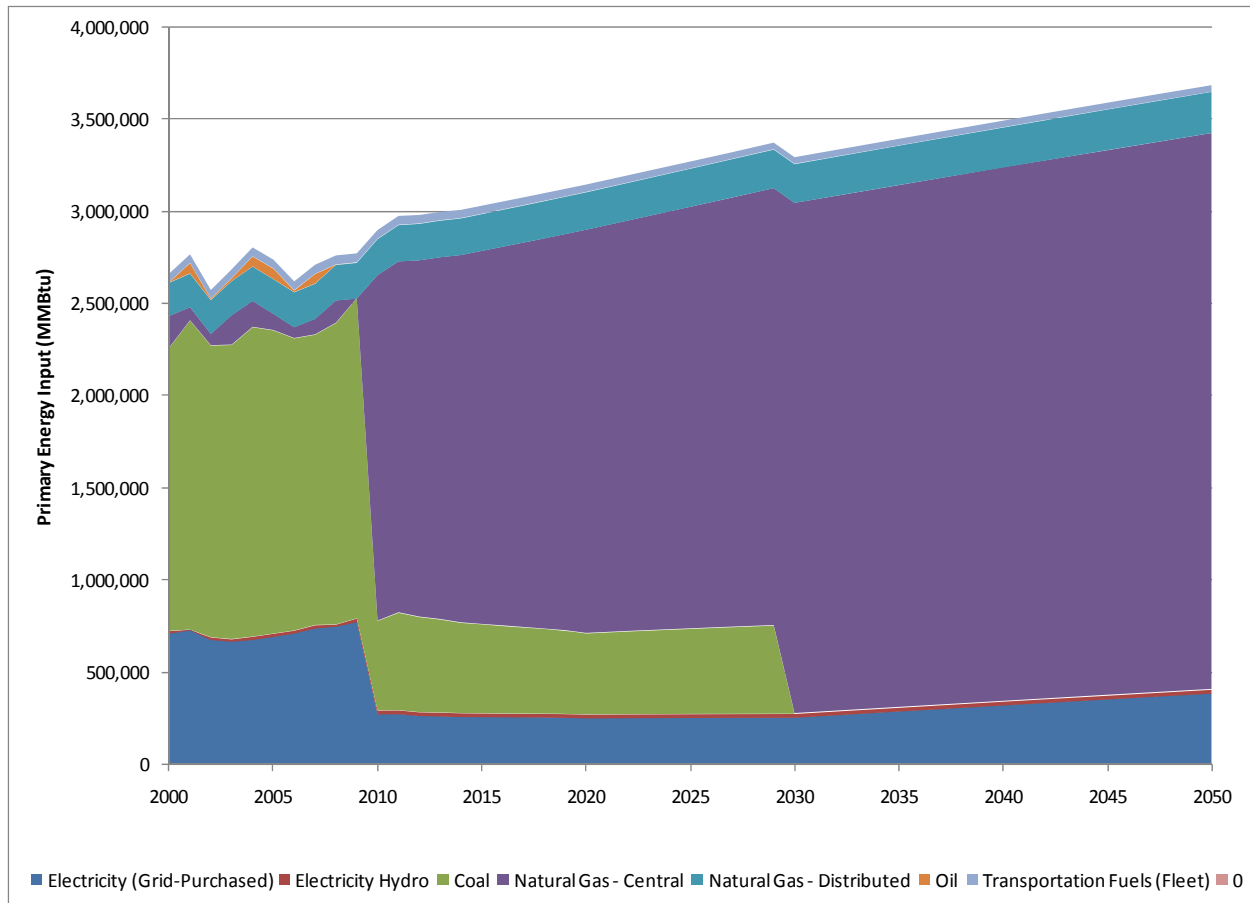
- Electricity - Purchased (e-Grid profile)
- Steam – Boiler (Coal)
- Chilled Water - Lake Source Cooling will be the primary source of marginal supply, but at some point supplemental chilling will need to be used in the peak chilling hours. David Frostclapp has performed an analysis to assess when this happens (see David Frostclapp Memo). David's methodology is used in the Base Case utility supply model. The following factors were used to calculate the electricity required to produce chilled water:

Electric Use Factors (kWh/thr)	
Lake Source Cooling	0.125
Electric Chillers	0.750

- Switch to Natural Gas in 2030 – the base case also assumes that the University discontinues the use of coal and 2030 and converts to all natural gas.

4.4 Primary energy consumption

According to the assumptions above, the primary sources of energy are illustrated in the graphic include below:

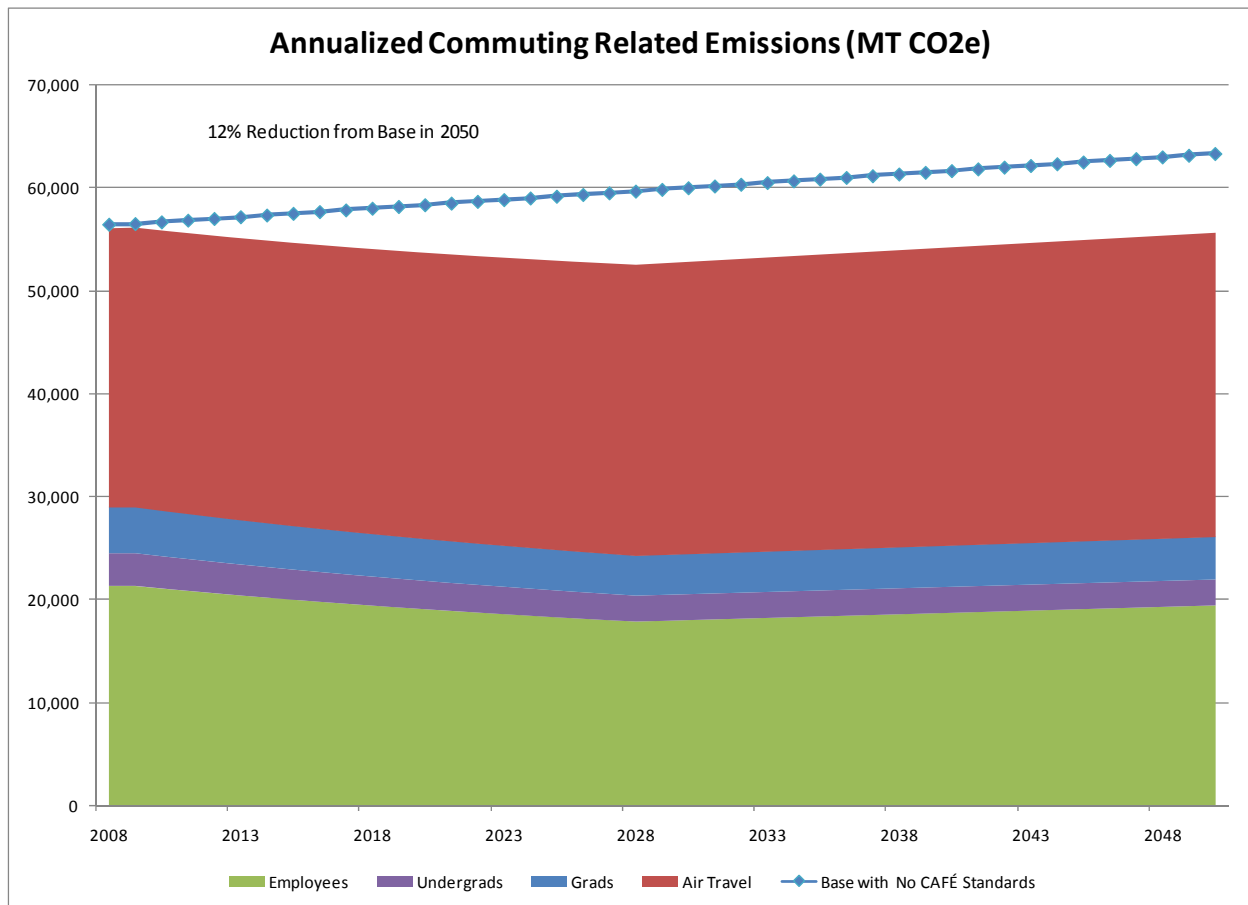


Distributed use of natural gas on campus and campus fleet usage of transportation fuels is forecasted to grow at 0.5% the campus GSF growth rate.

4.5 Transportation

4.5.1 Commuting

Commuting related emissions is expected to grow with population growth and has been calculated using the Commuter Transportation Emissions Estimate Calculator (Transportation Emissions Estimate Worksheet.xls provided by Nat Greer). The forecasted emissions are represented in the graphic below:



The above estimates **include** the CAFÉ standards, i.e. a 37% increase in average fuel efficiency for passenger cars and light duty trucks. See Appendix E for the forecasted values underlying the above graphic.

4.5.2 Air Travel

David Frostclapp used the following methodology to calculate the Air Travel related emissions for the 2008 inventory. This value was escalated with the forecasted growth in Faculty and other Academic Staff population.

FLIGHT TYPE	Mileage Round Trip
Domestic	14,788,614
International	16,182,496
Total	30,971,110
Conecting Trip Factor 15%	4,645,667
Landing /Take Off (LTO) Factor 10%	3,561,678
Multi-Passenger Factor 5%	1,958,923
Total Mileage	41,137,377
Mileage Related CO2 Emissions (metric tons)	9,873
Climate Forcing (upper atmosphere impacts)	16,784
Total CO2 (metric tons)	26,657
Rounded	27,000

4.5.3 Campus Fleet Emissions

Campus Fleet related Scope 1 emissions are included in the 2008 GHG inventory, p. 10, table 3-3. The base case assumes that these emissions will grow at .5% of overall square footage growth rate.

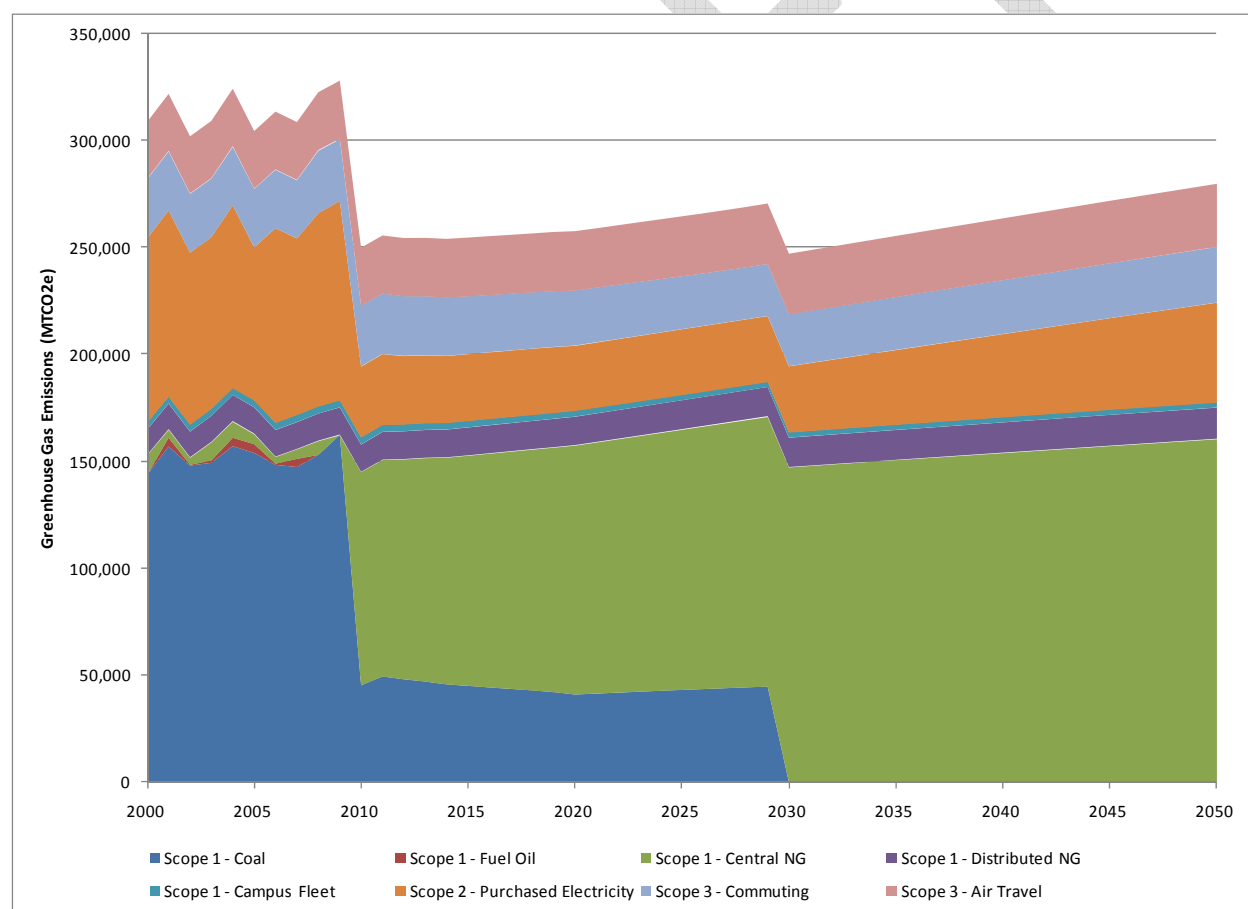
4.6 GHG factors

	CO2 (kg CO ₂ /MMBtu)	CH4 (g CH ₄ / MMBtu)	N2O (g N ₂ O/ MMBtu)
Coal	93.46	1	0.7
Natural Gas	53.06	5	0.1
Fuel Oil	73.15	11	0.6
Propane	63.07	5	0.1
Gasoline - Mobile	70.88	NA	NA
Diesel - Mobile	73.15	NA	NA

	(lbs CO ₂ /MWh)	(lbs CH ₄ /MWh)	(lbs N ₂ O/MWh)
Purchased Electricity (eGRID 2006 NPCC Upstate NY)	819.68	0.024	0.016
	(lbs CO ₂ /MMBtu)	(lbs CH ₄ /MMBtu)	(lbs N ₂ O/MMBtu)
Purchased Electricity (eGRID 2006 NPCC Upstate NY)	240.09	0.0070	0.0047
	CO ₂	CH ₄	N ₂ O
Global Warming Potential	1	21	310

Source: Cornell University - Ithaca Greenhouse Gas (GHG) Emissions Inventory
FY 2008

Total GHG emissions in the base case, by source, are represented in the graphic below:



4.7 Capital commitment

4.7.1 Capital

Incremental capital commitment for alternatives will be quantified relative to the base case.

Base case – Assumes that the Coal Boilers will be replaced with two natural gas package boilers with a capital cost of \$40,000,000.

The items mentioned above, obviously, do not include all of the capital that will be committed campus wide over the forecast period. The costs that are not called out specifically will be considered as alternatives are considered to highlight potential avoided cost opportunities.

The Base Case does not include the potential incremental energy from the ERL and CIT Data Center.

4.7.2 Project expense

Quantify for incremental alternatives.

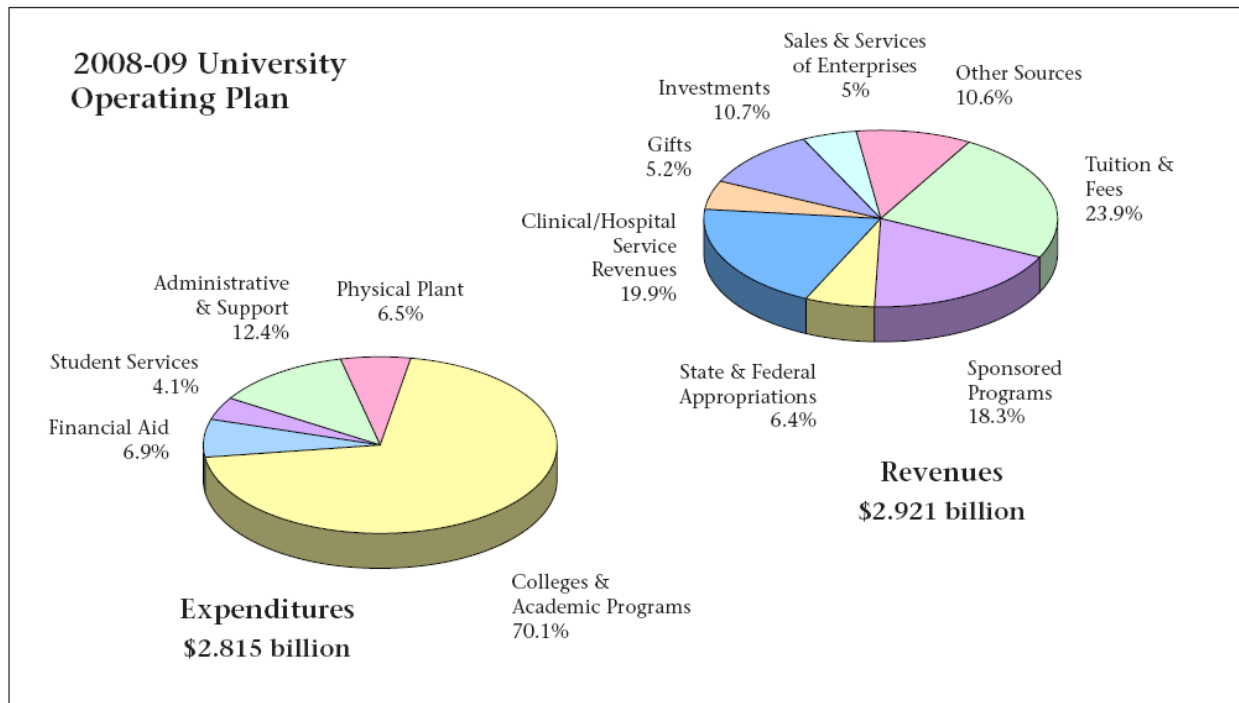
4.7.3 Land contributed

Quantify for incremental alternatives.

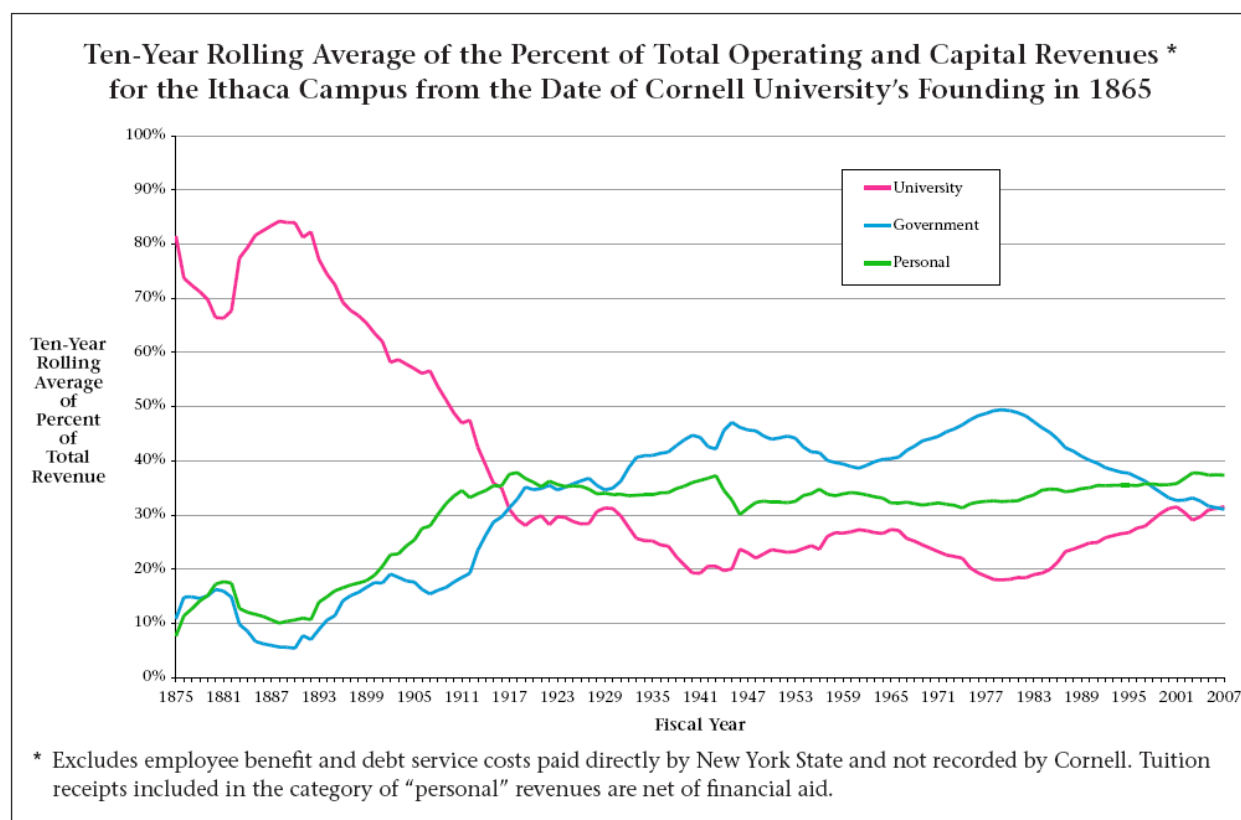
4.7.4 Capitalized contracts

Quantify for incremental alternatives

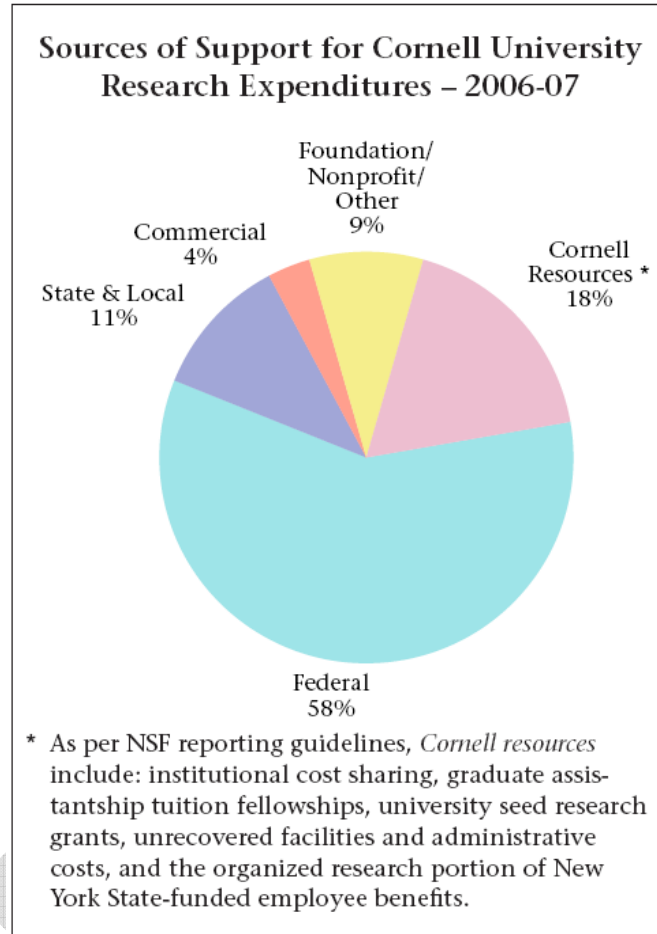
4.8 Revenue



Source: 2008-2009 Financial Plan, Operating and Capital, p. 5 (see Appendix B for Ithaca Campus detail)

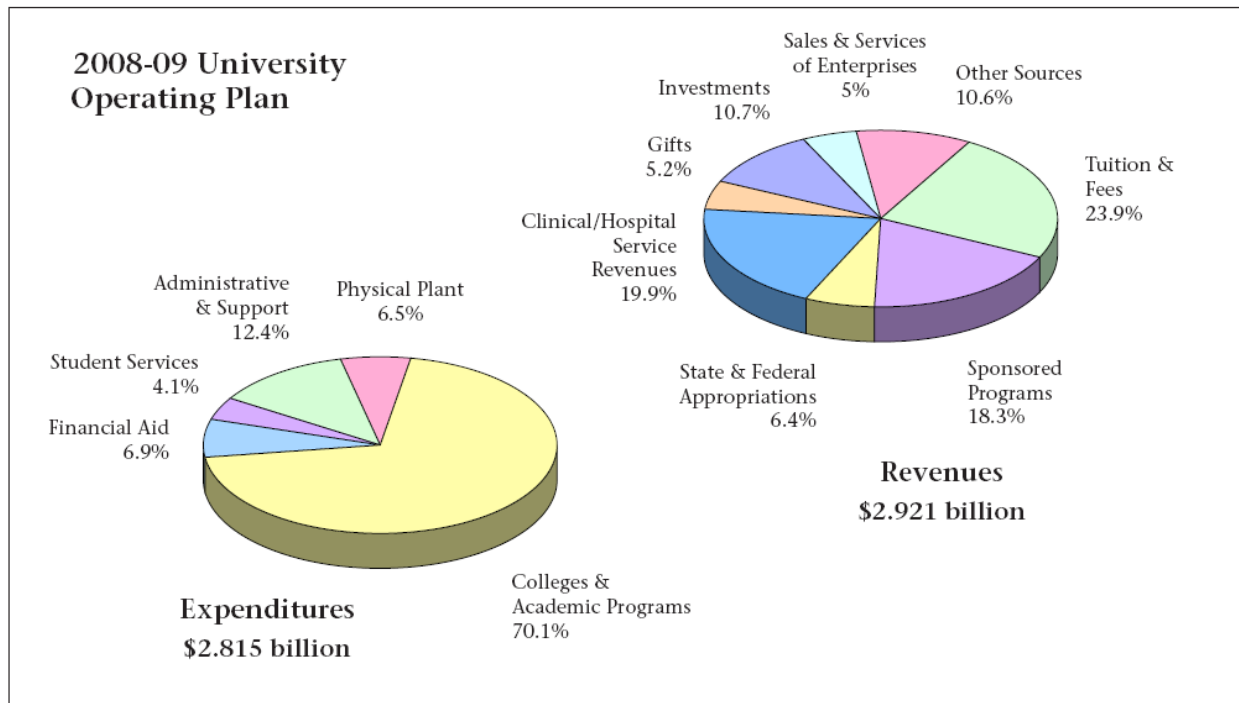


Source: 2008-2009 Financial Plan, Operating and Capital, p. 13 (see Appendix B for Ithaca Campus detail)



Source: 2008-2009 Financial Plan, Operating and Capital, p. 21 (see Appendix B for Ithaca Campus detail)

4.9 Expense



Source: 2008-2009 Financial Plan, Operating and Capital, p. 5 (see Appendix B for Ithaca Campus detail)

4.9.1 Base Case Utility Expense

Base case utility expenses have been forecasted for the following categories of expense:

1. **Primary Energy (Commodity) Expense:** This category of expense was calculated by multiplying the volume of commodity consumed (see section 4.4) by the forecasted commodity prices (see section 4.9.1.1.1 for Commodity price forecasts).
2. **Non-fuel Variable Expense:** Non-fuel variable expense was calculated for each utility type according to the values below:
 - a. Electricity: \$0.00 per kWh
 - b. Steam: \$3.00 per klb
 - c. Chilled Water: \$0.00 per thr
3. **Long-term Variable Expense:** This category of costs was calculated assuming that each incremental unit of demand would require some level of additional investment in equipment to meeting the growing load. The factors used were as follows:
 - a. Electricity: \$0.00 per kWh

- b. Steam: \$7.33 per klb. This assumes that over time additional boilers will need to be added to meet incremental demand. It was assumed that the typical new boiler would be a 100,000 lb capacity boiler with a capital cost of \$200 per lb of capacity and would operate on average 30% of the year for a total annual average production of 262,800 klbs. It was assumed that the cost of these boilers will be financed 100% with debt at the University's cost of capital and that the debt was amortized over 15 years and that the equipment has a 20-year capital life. The annual debt payment was then divided by the average klb production to arrive at the per klb rate reflected above.
- c. Chilled Water: \$0.1375 per ton hour. This assumes that over time additional mechanical chilling will need to be added to supplement the Lake Source Cooling to meet incremental demand. It was assumed that the typical new chiller would be a 4,000 ton capacity boiler with a capital cost of \$2,500 per ton of capacity and would operate on average 20% of the year for a total annual average production of 7,008,000 ton hours. It was assumed that the cost of these boilers will be financed 100% with debt at the University's cost of capital and that the debt was amortized over 15 years and that the equipment has a 20-year capital life. The annual debt payment was then divided by the average ton hour production to arrive at the ton hour rate reflected above.

Based on the above assumptions the present value of the base case utility expenses are represented below:

Total Primary Energy Cost	Variable Non-Fuel	Long-Term Variable	40 Year NPV
\$667,210,620	\$70,052,746	\$39,263,025	\$776,526,391

4.9.1.1 Commodity & GHG price forecasts

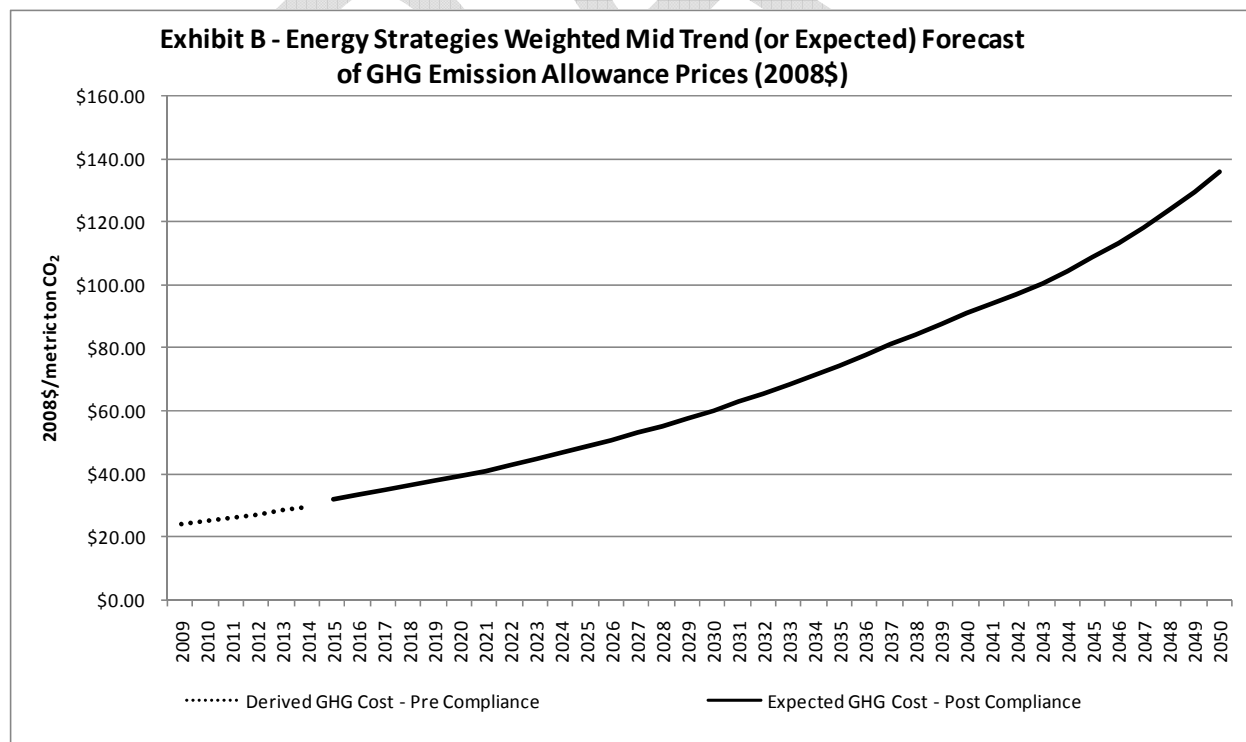
4.9.1.1.1 Commodity price forecasts

The commodity prices assumed for the base case are represented in the table below:

			Fiscal Years				Fiscal Years				Fiscal Years				Fiscal Years			
Energy Type	Type of Forecast Value	Unit (Source)	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045	2050			
Crude Oil	EIA 2009 AEO Ref Case April 09	2009\$/MMBtu (EIA)	\$ 7.27	\$ 9.19	\$ 11.11	\$ 12.68	\$ 14.04	\$ 15.35	\$ 18.82	\$ 19.41	\$ 20.39	Not Available						
Customer Baseline Equilibrium Cost (EV)																		
Natural Gas																		
Transportation Level	2009\$/MMBtu (ES)	\$ 7.7	\$ 8.4	\$ 8.6	\$ 8.6	\$ 8.8	\$ 9.1	\$ 10.7	\$ 12.4	\$ 14.8	\$ 15.1	\$ 15.2	\$ 14.9	\$ 13.6				
Distribution Level	2009\$/MMBtu (ES)	\$ 8.6	\$ 9.3	\$ 9.5	\$ 9.5	\$ 9.7	\$ 10.0	\$ 11.6	\$ 13.3	\$ 15.7	\$ 16.0	\$ 16.1	\$ 15.8	\$ 14.5				
Coal	2009\$/MMBtu (ES)	\$ 4.4	\$ 4.6	\$ 4.7	\$ 4.7	\$ 4.8	\$ 4.8	\$ 4.7	\$ 4.6	\$ 4.5	\$ 4.6	\$ 4.8	\$ 4.9	\$ 5.1				
Raw Biomass	2009\$/MMBtu (ES)	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.6	\$ 5.2	\$ 5.9	\$ 6.8	\$ 7.7	\$ 8.6	\$ 9.6	\$ 11.2				
Dist. Fuel Oil	2009\$/MMBtu (ES)	\$ 13.9	\$ 16.8	\$ 17.6	\$ 17.7	\$ 17.8	\$ 18.0	\$ 19.8	\$ 21.7	\$ 23.4	\$ 24.0	\$ 24.2	\$ 24.0	\$ 22.5				
Motor Gasoline	\$/gallon (ES)	\$ 2.7	\$ 3.0	\$ 3.2	\$ 3.3	\$ 3.3	\$ 3.4	\$ 3.7	\$ 4.0	\$ 4.3	\$ 4.5	\$ 4.6	\$ 4.7	\$ 4.6				
Biodiesel	\$/gallon (ES)	\$ 2.8	\$ 3.1	\$ 3.3	\$ 3.4	\$ 3.4	\$ 3.5	\$ 4.0	\$ 4.4	\$ 4.9	\$ 5.2	\$ 5.5	\$ 5.7	\$ 5.9				
Electricity - Grid	\$/MWh (ES)	\$ 89.0	\$ 90.9	\$ 92.8	\$ 94.9	\$ 97.0	\$ 98.8	\$ 105.6	\$ 113.0	\$ 121.6	\$ 123.3	\$ 128.5	\$ 134.0	\$ 139.5				
Electricity - Green	\$/MWh (ES)	\$ 114.0	\$ 115.9	\$ 117.8	\$ 119.9	\$ 122.0	\$ 122.0	\$ 126.3	\$ 139.1	\$ 154.0	\$ 163.0	\$ 174.8	\$ 186.2	\$ 200.9				
Customer Full Cost (EV)																		
Natural Gas	Transportation Level	2009\$/MMBtu (ES)	\$ 7.7	\$ 8.4	\$ 8.6	\$ 8.6	\$ 8.8	\$ 9.4	\$ 11.6	\$ 13.8	\$ 16.9	\$ 18.1	\$ 18.9	\$ 19.5	\$ 19.6			
Natural Gas	Distribution Level	2009\$/MMBtu (ES)	\$ 8.6	\$ 9.3	\$ 9.5	\$ 9.5	\$ 9.7	\$ 10.3	\$ 12.5	\$ 14.7	\$ 17.8	\$ 19.0	\$ 19.8	\$ 20.4	\$ 20.5			
Coal	2009\$/MMBtu (ES)	\$ 4.4	\$ 4.6	\$ 4.7	\$ 4.7	\$ 4.8	\$ 5.2	\$ 6.3	\$ 7.1	\$ 8.1	\$ 9.7	\$ 11.3	\$ 13.0	\$ 15.6				
Raw Biomass	2009\$/MMBtu (ES)	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.6	\$ 5.2	\$ 5.9	\$ 6.8	\$ 7.7	\$ 8.6	\$ 9.6	\$ 11.2				
Dist. Fuel Oil	2009\$/MMBtu (ES)	\$ 13.9	\$ 16.8	\$ 17.6	\$ 17.7	\$ 17.8	\$ 18.4	\$ 21.1	\$ 23.6	\$ 26.3	\$ 28.0	\$ 29.4	\$ 30.4	\$ 30.7				
Motor Gasoline	\$/gallon (ES)	\$ 2.7	\$ 3.0	\$ 3.2	\$ 3.3	\$ 3.3	\$ 3.4	\$ 3.8	\$ 4.2	\$ 4.7	\$ 5.0	\$ 5.2	\$ 5.4	\$ 5.6				
Biodiesel	\$/gallon (ES)	\$ 2.8	\$ 3.1	\$ 3.3	\$ 3.4	\$ 3.4	\$ 3.5	\$ 4.0	\$ 4.4	\$ 4.9	\$ 5.2	\$ 5.5	\$ 5.7	\$ 5.9				
Electricity - Grid	\$/MWh (ES)	\$ 89.0	\$ 90.9	\$ 92.8	\$ 94.9	\$ 97.0	\$ 100.7	\$ 112.3	\$ 123.7	\$ 137.4	\$ 145.2	\$ 156.6	\$ 168.8	\$ 184.5				
Electricity - Green	\$/MWh (ES)	\$ 114.0	\$ 115.9	\$ 117.8	\$ 119.9	\$ 122.0	\$ 122.0	\$ 126.3	\$ 139.1	\$ 154.0	\$ 163.0	\$ 174.8	\$ 186.2	\$ 200.9				
Carbon Price																		
GHG Allowances	2009\$/metric ton CO2e (ES)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 32.7	\$ 40.2	\$ 49.6	\$ 61.4	\$ 76.1	\$ 93.1	\$ 111.3	\$ 139.3				

For a more complete discussion of the methodology used to forecast the commodity prices, please see the Appendix

4.9.1.1.2 GHG price forecasts



Above taken from the GHG Financial Exposure memo prepared by Energy Strategies, LLC titled Financial Exposure to U.S. Climate Action Policy.

4.9.1.2 Debt

Outstanding External Debt by Category (dollars in millions)

<u>Category</u>	<u>4/30/71</u> <u>Principal</u>	<u>% of</u> <u>Total</u>	<u>2/29/08</u> <u>Principal</u>	<u>% of</u> <u>Total</u>
Residence/Dining	\$33.4	67%	\$290.7	38%
Physical Plant	3.5	7%	137.2	18%
Academic	7.0	14%	305.7	39%
Other/Miscellaneous	<u>6.2</u>	<u>12%</u>	<u>39.7</u>	<u>5%</u>
Total	50.1	100%	773.3	100%

Source: 2008-2009 Financial Plan, Operating and Capital, p. 27 (see Financial Plan pp. 58-59 for more detail).

The ability to access credit is not used to limit the expansion of the GSF in the base case.

4.10 Tax treatment

Base case assumes current tax treatment continues as is.

4.11 Terminal value and abandonment costs

Evaluate for incremental alternatives.

4.12 Miscellaneous

4.12.1 General inflation

"....inflation, as measured by a rolling average of the Consumer Price Index." (Source: 2008-'09 Financial Plan, Operating and Capital, p. 81.)

Base Case Inflation Assumption:

Use the CPI rolling average.

4.12.2 Escalation factors

The base case is reflected in constant dollars. Escalation factors other than general inflation will be noted as necessary.

4.12.3 Discount rate (Opportunity Cost of Capital/Hurdle Rate)

“The investment objective is to achieve a total return, net of investment expenses, of at least 5% in excess of inflation....” (Source: 2008-'09 Financial Plan, Operating and Capital, p. 81.)

Base Case Assumption:

Per the 2008-2009 Financial Plan, use 5 percent in excess of inflation.

4.12.4 Forecast period

Currently the forecast period is 2050, but will be extended as necessary until GHG neutrality is reached in the model.

5 APPENDICES

Appendix A – Workforce, Ithaca Campus

2007-08 Ithaca Campus Work Force Distribution	Full-Time and Part-Time Headcounts				Ratio of Support to Academic
	Academic Staff <u>Faculty</u>	<u>Other</u>	Support <u>Staff</u>	<u>Total</u>	
1. Agriculture & Life Sciences	376	351	1,122	1,849	1.54
2. Architecture, Art & Planning	55	12	44	111	0.66
3. Arts & Sciences	536	217	321	1,074	0.43
4. Engineering	236	62	199	497	0.67
5. Hotel Administration	42	16	264	322	4.55
6. Human Ecology	89	92	187	368	1.03
7. Industrial & Labor Relations	52	62	161	275	1.41
8. Johnson School	59	18	98	175	1.27
9. Law School	49	1	69	119	1.38
10. Veterinary Medicine	134	117	707	958	2.82
11. Subtotal Colleges	1,628	948	3,172	5,748	1.23
12. Research Centers		126	301	427	2.39
13. Other Academic Programs	9	100	656	765	6.02
14. Subtotal Other Centers	9	226	957	1,192	4.07
15. Total Academic Units	1,637	1,174	4,129	6,940	1.47
16. Student Services		17	1,108	1,125	
17. Administrative & Support		2	1,566	1,568	
18. Physical Plant			737	737	
19. Subtotal Support		19	3,411	3,430	
20. Total Work Force	1,637	1,193	7,540	10,370	2.66

Change in Support Staff					Change from 04-05	
	<u>04-05</u>	<u>05-06</u>	<u>06-07</u>	<u>07-08</u>	<u>Number</u>	<u>Percent</u>
1. Agriculture & Life Sciences	1,143	1,151	1,121	1,122	(21)	(1.8%)
2. Architecture Art, & Planning	32	33	43	44	12	37.5%
3. Arts & Sciences	339	339	329	321	(18)	(5.3%)
4. Engineering	221	218	203	199	(22)	(10.0%)
5. Hotel Administration	245	259	261	264	19	7.8%
6. Human Ecology	192	195	189	187	(5)	(2.6%)
7. Industrial & Labor Relations	171	169	160	161	(10)	(5.8%)
8. Johnson School	96	95	96	98	2	2.1%
9. Law School	65	65	70	69	4	6.2%
10. Veterinary Medicine	696	669	691	707	11	1.6%
11. Subtotal Colleges	3,200	3,193	3,163	3,172	(28)	(0.9%)
12. Research Centers	319	316	318	301	(18)	(5.6%)
13. Other Academic Programs	580	600	637	656	76	13.1%
14. Subtotal Other Centers	899	916	955	957	58	6.5%
15. Total Academic Units	4,099	4,109	4,118	4,129	30	0.7%
16. Student Services	975	1,045	1,081	1,108	133	13.6%
17. Administrative & Support	1,410	1,438	1,508	1,566	156	11.1%
18. Physical Plant	731	736	729	737	6	0.8%
19. Subtotal Support Units	3,116	3,219	3,318	3,411	295	9.5%
20. Total Support Staff	7,215	7,328	7,436	7,540	325	4.5%

Source: 2008-2009 Financial Plan, Operating and Capital, p. 73

Appendix B – Operating Plan Details (Ithaca Campus)

Ithaca Campus – Summary (dollars in thousands)				Change from Forecast to Plan		
	06-07 Actual	07-08 Plan	07-08 Forecast	08-09 Plan	Dollars	Percent
Resources						
1. Tuition & Fees	\$611,910	\$639,425	\$645,046	\$672,793	\$27,747	4.3%
2. Investment Distributions *	203,672	226,777	231,912	263,229	31,317	13.5%
3. Unrestricted Gifts	44,795	43,519	40,300	41,574	1,274	3.2%
4. Restricted Gifts	48,000	50,669	45,000	46,410	1,410	3.1%
5. Sponsored Programs (direct)	281,718	292,883	291,566	296,590	5,024	1.7%
6. Sponsored Programs (F&A)	74,738	76,533	75,674	77,825	2,151	2.8%
7. Institutional Allowances	57	39	39	50	11	28.2%
8. State Appropriations	156,403	173,938	169,010	169,723	713	0.4%
9. Federal Appropriations	16,766	16,781	17,100	17,840	740	4.3%
10. Enterprise Sales & Services	115,569	116,961	116,961	125,499	8,538	7.3%
11. Other Sources *	160,753	154,152	156,082	166,066	9,984	6.4%
12. Subtotal In-Year Revenues	1,714,381	1,791,677	1,788,690	1,877,599	88,909	5.0%
13. Transfers From Endowment	24,142	29,710	25,120	26,859	1,739	
14. Transfers From Plant	5,261	2,076	1,530	1,622	92	
15. Subtotal Transfers In	29,403	31,786	26,650	28,481	1,831	
16. Total Resources	1,743,784	1,823,463	1,815,340	1,906,080	90,740	5.0%
Uses of Resources						
17. Agriculture & Life Sciences	233,600	243,175	243,375	246,973	3,598	1.5%
18. Architecture, Art & Planning	21,154	23,936	24,077	24,383	306	1.3%
19. Arts & Sciences	169,581	179,150	179,830	182,190	2,360	1.3%
20. Engineering	121,376	130,515	132,515	136,685	4,170	3.1%
21. Hotel Administration	43,022	45,257	45,300	48,693	3,393	7.5%
22. Human Ecology	52,681	55,597	52,993	53,756	763	1.4%
23. Industrial & Labor Relations	40,466	44,698	43,685	44,373	688	1.6%
24. Johnson School	48,687	51,836	54,800	58,198	3,398	6.2%
25. Law School	25,323	25,918	26,218	27,339	1,121	4.3%
26. Veterinary Medicine	105,439	106,538	106,547	110,759	4,212	4.0%
27. Research Centers	98,892	90,224	92,500	96,933	4,433	4.8%
28. Other Academic Programs	128,365	137,659	140,500	149,446	8,946	6.4%
29. Centrally Recorded Financial Aid	154,273	163,418	157,599	179,979	22,380	14.2%
30. Student Services	100,995	106,255	106,078	116,721	10,643	10.0%
31. Administrative & Support	163,191	174,640	169,100	176,998	7,898	4.7%
32. Physical Plant	97,246	117,415	114,000	126,866	12,866	11.3%
33. Ithaca Campus All Other	8,718	6,505	7,275	7,558	283	3.9%
34. Cost Redistribution	(1,700)	(1,738)	(1,738)	(1,775)	(37)	2.1%
35. Subtotal Expenditures	1,611,309	1,700,998	1,694,654	1,786,075	91,421	5.4%
36. Transfers To Endowment	17,343	18,025	16,862	13,431	(3,431)	
37. Transfers To Plant	96,319	102,680	102,700	105,280	2,580	
38. Subtotal Transfers Out	113,662	120,705	119,562	118,711	(851)	
39. Total Uses of Resources	1,724,971	1,821,703	1,814,216	1,904,786	90,570	5.0%
40. Net From Operations	18,813	1,760	1,124	1,294	170	
41. <i>Additions to Operating Reserves</i>				22,026		
42. <i>Use of Operating Reserves</i>				20,732		
Note: * Amounts for 2006-07 and 2007-08 have been restated to conform with the 2008-09 plan presentation.						

Source: 2008-2009 Financial Plan, Operating and Capital, p. 33

Appendix B – Operating Plan Detail by College (Ithaca Campus)

Ithaca Campus – Detail (dollars in thousands)																			Total Ithaca Campus
	General Purpose Budget	Agriculture & Life Sciences	Arch. Art & Planning	Arts & Sciences	Engineering	Hotel School	Human Ecology	Industrial & Labor Relations	Johnson School	Law School	Veterinary Medicine	Research Centers	Other Academic Programs	Centrally Recorded Financial Aid	Student Services	Administrative & Support	Physical Plant	Ithaca All Other	
Resources																			
1. Tuition & Fees *	\$356,294	\$103,000	\$4,312	\$544	\$14,110	\$36,497	\$35,341	\$26,684	\$44,405	\$29,195	\$13,114		\$9,297						\$672,793
2. Investment Distributions	115,840	16,337	2,159	12,229	10,241	3,021	3,520	2,346	5,800	5,730	8,340	584	12,485	36,818	1,676	469	15,551	10,083	263,229
3. Unrestricted Gifts	8,129	6,600	281	2,843	4,000	715	499	691	2,394	1,972	2,500	139	1,701		10		9,100		41,574
4. Restricted Gifts		6,553	455	4,353	4,056	1,568	360	1,406	4,078	522	3,000	1,622	7,441	177	1,819			9,000	46,410
5. Sponsored Programs (direct)		76,750	176	21,715	45,671		14,215	5,672	418	129	34,180	78,568	7,920	10,542		634			296,590
6. Sponsored Programs (F&A)	45,954	16,791					3,540	1,125			10,400		(5)			20			77,825
7. Institutional Allowances		50																	50
8. State Appropriations	1,520	63,540				100	9,363	11,763	110	75	31,665		4,170				1,800	45,617	169,723
9. Federal Appropriations		10,050					3,634				600		3,536			20			17,840
10. Enterprise Sales & Services													1,042		92,414		32,043		125,499
11. Other Sources	40,193	16,968	1,207	1,534	1,650	18,071	1,898	9,028	1,109	284	23,710	3,905	20,937	6,400	9,005	4,625	5,542		166,066
12. Inter-Unit Transfers		5,883	1,640	2,813	8,609	(196)	(906)	22	(2,007)	(3,535)	(418)	6,087	15,827	1,739	5,543	38,640	(1,860)	(77,881)	
13. Subtotal In-Year Revenues	567,930	322,522	10,230	46,031	88,337	59,776	71,464	58,737	56,307	34,372	127,091	90,905	84,351	55,676	110,467	44,408	62,176	(13,181)	1,877,599
14. General Purpose Allocations (710,500)			12,665	135,651	54,566					386		6,598	68,692	122,030	31,578	135,233	111,851	31,250	
15. Transfers From Endowment		100			3,844			20	2,729		35				20		20,111		26,859
16. Transfers From Plant					1,206						226						190		1,622
17. Subtotal Transfers In		100			5,050			20	2,729		261				20		20,301		28,481
18. Total Resources	(142,570)	322,622	22,895	181,682	147,953	59,776	71,464	58,757	59,036	34,758	127,352	97,503	153,043	177,706	142,065	179,641	194,328	18,069	1,906,080
Uses of Resources																			
19. Salaries & Wages		154,095	11,878	109,877	79,690	25,752	29,922	26,493	27,957	14,563	66,647	44,765	68,659		49,399	99,993	66,103	1,125	876,918
20. Employee Benefits		12,089	3,394	29,635	18,407	7,859	2,011	1,570	8,422	4,399	5,038	11,969	18,637		15,384	36,440	21,728	3,232	200,214
21. Undergraduate Financial Aid		2,016	119	293	137	28	695	311				74	81	137,349	662				141,765
22. Graduate Financial Aid		17,601	2,449	18,999	7,890	283	3,785	2,381	7,484	2,475	6,477	868	4,551	42,630	85	100			118,058
23. General Expense		56,646	6,537	21,911	24,964	14,718	17,114	12,692	14,275	5,862	29,451	33,592	39,154		51,116	38,644	38,993	2,727	408,396
24. Capital Expense		4,526	6	1,475	5,597	53	229	926	60	40	3,146	5,665	18,364		75	1,821	42	474	42,499
25. Subtotal Expenditures		246,973	24,383	182,190	136,685	48,693	53,756	44,373	58,198	27,339	110,759	96,933	149,446	179,979	116,721	176,998	126,866	7,558	1,787,850
26. Accessory Instruction	(13,621)	3,566			(2,284)	1,469	712		(4,982)	(300)							15,440		
27. Administrative & Support	(97,911)	41,911		18	5,868	9,180	8,356		5,438	5,295	16,842		61		5,628	1,411	6,644	(10,516)	(1,775)
28. Financial Aid	(31,038)	18,488			3,552	6,675	4,541		9		46			(2,273)					
29. Subtotal Cost Redistribution	(142,570)	63,965		18	7,136	17,324	13,609		465	4,995	16,888		61	(2,273)	5,628	1,411	6,644	4,924	(1,775)
30. Net Expenditures	(142,570)	310,938	24,383	182,208	136,685	55,829	71,080	57,982	58,663	32,334	127,647	96,933	149,507	177,706	122,349	178,409	133,510	12,482	1,786,075
31. Transfers To Endowment		2,050		32	3,930	804		246		2,400			969						13,431
32. Transfers To Plant		4,723		3,900	7,000	2,475	2,111	153	400	12	3,350	722	1,618		20,184	1,303	57,329		105,280
33. Subtotal Transfers Out		6,773		3,932	10,930	3,279	2,111	399	400	2,412	3,350	722	2,587		20,184	1,303	57,329		118,711
34. Total Uses of Resources	(142,570)	317,711	24,383	186,140	147,615	59,108	73,191	58,381	59,063	34,746	130,997	97,655	152,094	177,706	142,533	179,712	190,839	15,482	1,904,786
35. Net From Operations		4,911	(1,488)	(4,458)	338	668	(1,727)	376	(27)	12	(3,645)	(152)	949		(468)	(71)	3,489	2,587	1,294
36. Additions to Operating Reserves †		6,692	3		1,798	784	28	1,378	150	287		27	2,573		46	271	3,489	4,500	22,026
37. Use of Operating Reserves †		1,781	1,491	4,458	1,460	116	1,755	1,002	177	275	3,645	179	1,624		514	342		1,913	20,732
Note: * Most of the tuition related to enrollments in the Colleges of Architecture, Art and Planning; Arts and Sciences; and Engineering is recorded in the general purpose budget and then allocated to these colleges. Exceptions to this pattern include the Rome, FALCON, and Master of Engineering Programs, where tuition is recorded directly by the colleges and is shown in line 1 for each of these three colleges.									Note: † Besides transfers in from and out to other funds (e.g., funds functioning as endowment and physical plant funds), the operating plan can involve additions to (line 36) and the use of (line 37) current fund operating reserves. These reserves for the Ithaca campus totaled \$333 million as of June 30, 2007.										

Source: 2008-2009 Financial Plan, Operating and Capital, pp. 40-41

Appendix C – Campus Area Growth (Detail)

	Name	Funding Year	Addition (A)	Deletion (B)	Renovation (C)	Net (A + B + C)	Type (High Level) - revised
1	MVR West Room 159, Student Study Lounge	2007	0		1000	1000	Study (library)
2	Riley Robb B74 Growth Chamber Infrastructure	2007	0		0	0	Laboratory (wet)
3	Savage - Kinzelberg Emergency Power System	2007	0		0	0	Infrastructure
4	Uris Library Plaza	2007	0		0	0	Infrastructure
5	Willard Straight Hall Digital Media Studio & HVAC	2007	0		6000	6000	Office / Classroom
6	Baker Institute for Animal Health Freezer Storage Facility	2008			2900	2900	Laboratory (wet)
7	Life Sciences Technology Building - Construction Phase	2008	265000			265000	Laboratory (wet)
8	Life Sciences Technology Building Additional Program for Division	2008	6000			6000	Laboratory (wet)
9	Bailey Plaza Project Construction Phase	2008	0		0	0	Supporting
10	Barn Renovations, Herbarium Collection	2008	0		7000	7000	Laboratory (wet)
11	Bradfield Hall 2nd Floor Lab Renovation	2008	0		1000	1000	Laboratory (wet)
12	Bradfield Hall Mechanical Upgrades AC 1 and 2	2008	0		0	0	Infrastructure
13	CALS Surge Facility Partial Refurbishment / Future HVAC	2008	0		2000	2000	Office / Classroom
14	Chemistry and Chemical Biology Third Floor Baker Laboratory	2008	0		7000	7000	Laboratory (wet)
15	Civil and Environmental Engineering Lab Renovation Project	2008	0		3000	3000	Laboratory (wet)
16	Demo of Misc Buildings in Prep / Animal Health Diag Ctr	2008	0	-44000	0	-44000	Laboratory (wet)
17	Food Science Ice Builder Replacement	2008	0		0	0	Infrastructure
18	Gannett Health Services Level Two Renovation	2008	0		1000	1000	Supporting
19	Hoy Road and Parking Improvements Project	2008	0		0	0	Supporting
20	Kroch Library Correct HVAC Functional Deficiencies	2008	0		0	0	Infrastructure
21	Lincoln Hall Control Valve Replacement	2008	0		0	0	Infrastructure
22	Morrison Hall	2008	0		2000	2000	Office / Classroom
23	Morrison Hall B-32 Ren for CALS Dean's Office Admin IT	2008	0		2000	2000	Office / Classroom
24	Morrison Hall Lab Renovations	2008	0		2000	2000	Laboratory (wet)
25	Mudd Hall Neurobiology & Behavior Raguso Lab Renovation	2008	0		2000	2000	Laboratory (wet)
26	Mudd Hall, Shaw Lab Renovation	2008	0		3000	3000	Laboratory (wet)
27	Olin Library Suite 106 Renovation - Phase Two	2008	0		4000	4000	Study (library)
28	Plant Science Roof Terrace	2008	0		4000	4000	Office / Classroom
29	Rice Hall Elevator Alterations	2008	0		0	0	Infrastructure
30	Sage Hall 234,242,244 Renovation	2008	0		1000	1000	Office / Classroom
31	Stair Access Addition at Plant Sciences Tunnel for CALS	2008	0		0	0	Office / Classroom
32	Uihlein Sugar House Addition	2008	0		0	0	Laboratory (dry)
33	Uris Hall Vertebrate Animal Facility - Phase I	2008	0		12000	12000	Laboratory (wet)
34	VMC Linear Accelerator Humidity Correction	2008	0		1000	1000	Laboratory (wet)
35	Wildlife Clinic	2008	0		3000	3000	Laboratory (dry)
36	Baker Institute Administration Offices	2009	0		0	0	Supporting
37	BTI Backflow Prevention	2009	0		0	0	Infrastructure
38	Child Care Center	2009	14000		0	14000	Office / Classroom
39	Equine Drug Testing Facility Demolition	2009		0	0	0	Laboratory (wet)
40	Equine Drug Testing Facility Upgrade	2009	0		0	0	Laboratory (wet)

Source: March 2009 capital plan

Appendix C – Campus Area Growth (Detail)

	Name	Funding Year	Addition (A)	Deletion (B)	Renovation (C)	Net (A + B + C)	Type (High Level) - revised
41	Ives Hall Faculty Building Rehabilitation	2009	6000		18521	24521	Office / Classroom
42	MVR 1933 and E Wing Phase II	2009	0		36000	36000	Office / Classroom
43	Rehabilitate Snyder Hill Pre-Treatment Building 1782	2009	0		0	0	Laboratory (wet)
44	Riley Robb Biofuels Lab & Bldg Systems Upgrade	2009	0		12000	12000	Laboratory (wet)
45	Sarkaria Lab - 5th Floor Comstock	2009	0		0	0	Laboratory (dry)
46	Sigma Phi Fraternity House Kitchen	2009	1000		0	1000	Residential
47	Uris Hall Vertebrate Animal Facility - Phase II	2009	0		0	0	Laboratory (wet)
48	WCRI House #4	2009	135000		0	135000	Residential
49	WCRI House #5	2009	75000		0	75000	Residential
50	Bruckner Hall Renovation	2010	0		0	0	Office / Classroom
51	Dairy Barn Relocation	2010	0		0	0	Laboratory (dry)
52	Newman Laboratory Systems	2010	0		0	0	Laboratory (wet)
53	SHA - Tower Renovation	2010	0		16000	16000	Office / Classroom
54	Stocking Hall Demolition	2010		-49000	0	-49000	Office / Classroom
55	Vet Waste Management System	2010	2000		0	2000	Infrastructure
56	MVR North Under-building Parking	2010	30000		0	30000	Supporting
NEW 1	CCF Misc Rehab	2010			29333	29333	Office / Classroom
NEW 2	VET Tower Rehab	2010			3750	3750	Laboratory (wet)
NEW 3	Rice Hall Rehab	2010			500	500	Office / Classroom
NEW 4	Warren Hall Renov	2010			5357	5357	Office / Classroom
NEW 5	Sigma Phi Frat	2010			0	0	Residential
57	Ives Hall Faculty Building Rehabilitation	2010	6000		18127	24127	Office / Classroom
58	Johnson Museum Addition and Renovations	2012	16000		8000	24000	Classroom
59	Animal Health Diagnostic Center	2011	126000		0	126000	Laboratory (wet)
60	Bradfield / Bruckner / Plant Science	2011	0		0	0	Laboratory (wet)
61	Clark Hall AEP Relocation / Renovation	2011	0		10000	10000	Office / Classroom
62	Milstein Hall	2012	42000	0	0	42000	Office / Classroom
63	MVR 1933 / East Rehab, Phase 3A	2011	0	0	35000	35000	Office / Classroom
64	MVR 1933 / East Rehab, Phase 3B (stair tower)	2011	5000	0	0	5000	Office / Classroom
65	MVR North Replacement Building	2011	93000		0	93000	Office / Classroom
66	Olin Hall Infrastructure Project	2011	0		0	0	Laboratory (wet)
67	Physical Sciences	2011	197000		0	197000	Laboratory (wet)
68	Plantations Welcome Center & Botanical Garden	2011	7000		0	7000	Office / Classroom
NEW 1	CCF Misc Rehab	2011	0	0	12667	12667	Office / Classroom
NEW 2	VET Tower Rehab	2011	0	0	6400	6400	Laboratory (wet)
NEW 3	Rice Hall Rehab	2011	0		500	500	Office / Classroom
NEW 4	Warren Hall Renov	2011	0	0	4286	4286	Office / Classroom
NEW 5	Sigma Phi Frat	2011			0	0	Residential
69	Ives Hall Faculty Building Rehabilitation	2011	0		9852	9852	Office / Classroom
70	Fernow Hall Renovation	2012	0	0	29500	29500	Office / Classroom

Source: March 2009 Capital Plan

Appendix C – Campus Area Growth (Detail)

	Name	Funding Year	Addition (A)	Deletion (B)	Renovation (C)	Net (A + B + C)	Type (High Level) - revised
71	Olin Library Stack Tower Renovation	2012	0	0	113000	113000	Study (library)
NEW 1	CCF Misc Rehab	2012	0	0	12667	12667	Office / Classroom
NEW 2	VET Tower Rehab	2012	0	0	6400	6400	Laboratory (wet)
NEW 3	Rice Hall Rehab	2012	0	0	500	500	Office / Classroom
NEW 4	Warren Hall Renov	2012	0	0	21429	21429	Office / Classroom
72	Phillips Hall Addition & Infrastructure	2013	0	0	0	0	Laboratory (dry)
73	CAP Garage (Central Avenue Parking Garage)	2013	64000	0	0	64000	Supporting
74	CIT Building	2013	0	0	0	0	Supporting
75	Computing and Information Sciences (Gates Hall)	2013	0	0	0	0	Laboratory (dry)
76	Stocking / Food Science Building	2013	100000	0	45000	145000	Office / Classroom
77	Warren Hall (includes adding chilled water to building)	2013	0	0	128000	128000	Office / Classroom
NEW 1	CCF Misc Rehab	2013	0	0	12667	12667	Office / Classroom
NEW 2	VET Tower Rehab	2013	0	0	6400	6400	Laboratory (wet)
NEW 3	Rice Hall Rehab	2013	0	0	500	500	Office / Classroom
NEW 4	Warren Hall Renov	2013	0		3571	3571	Office / Classroom
78	Goldwin Smith Addition Project Plan	2014		0	0	0	Classroom
79	USDA Plant Genomics	2014		0	0	0	Laboratory (wet)
80	Helen Newman	2014	0	0	0	0	Office / Classroom
81	University Health Services Center	2014	0	0	0	0	Laboratory (dry)
NEW 1	CCF Misc Rehab	2014		0	105667	105667	Office / Classroom
NEW 2	VET Tower Rehab	2014		0	53900	53900	Laboratory (wet)
NEW 3	Rice Hall Rehab	2014		0	16500	16500	Office / Classroom
NEW 4	Warren Hall Renov	2014			5357	5357	Office / Classroom

Appendix D - Ithaca Campus Enrollment Statistics

Ithaca Campus Enrollment Statistics from the CU Office of Institutional Research and Planning

Fall	Total Undergraduate Enrollment							Graduate School Enrollment			Professional School Enrollment				Ithaca Campus Enrollment		
	First-time Student	Freshman	Sophomore	Junior	Senior	Special	Total Undergraduate Registration	Endowed Division	Contract Division	Total Graduate Enrollment	Johnson School of Management (MBA)	Law School (JD)	Veterinary Medicine (DVM)	Total Professional Enrollment	Ithaca Undergraduate	Ithaca Graduate/Professional	Total Ithaca Campus
1988	2,927	3,047	3,254	3,281	3,348	13	12,943	2,641	1,500	4,141	500	529	312	1,341	12,943	5,482	18,425
1989	2,896	3,004	3,242	3,338	3,426	16	13,026	2,694	1,515	4,209	470	558	318	1,346	13,026	5,555	18,581
1990	2,870	2,959	3,133	3,199	3,491	19	12,801	2,671	1,567	4,238	478	551	321	1,350	12,801	5,588	18,389
1991	2,986	3,100	3,117	3,190	3,489	19	12,915	2,702	1,638	4,340	508	548	316	1,372	12,915	5,712	18,627
1992	2,922	3,022	3,288	3,151	3,375	25	12,861	2,689	1,573	4,262	534	539	325	1,398	12,861	5,660	18,521
1993	3,196	3,308	3,159	3,289	3,322	19	13,097	2,749	1,556	4,305	503	549	327	1,379	13,097	5,684	18,781
1994	3,043	3,125	3,455	3,240	3,416	26	13,262	2,677	1,580	4,257	507	543	321	1,371	13,262	5,628	18,890
1995	3,129	3,245	3,331	3,393	3,379	24	13,372	2,627	1,507	4,134	542	546	320	1,408	13,372	5,542	18,914
1996	3,115	3,205	3,386	3,312	3,586	23	13,512	2,522	1,461	3,983	506	532	316	1,354	13,512	5,337	18,849
1997	3,004	3,164	3,321	3,360	3,418	31	13,294	2,375	1,353	3,728	560	528	318	1,406	13,294	5,134	18,428
1998	3,076	3,237	3,300	3,438	3,436	31	13,442	2,421	1,376	3,797	574	524	312	1,410	13,442	5,207	18,649
1999	3,162	3,272	3,433	3,382	3,552	30	13,669	2,509	1,407	3,916	593	529	314	1,436	13,669	5,352	19,021
2000	3,054	3,207	3,404	3,407	3,534	38	13,590	2,496	1,422	3,918	619	547	321	1,487	13,590	5,405	18,995
2001	2,986	3,116	3,389	3,558	3,706	32	13,801	2,665	1,447	4,112	643	543	321	1,507	13,801	5,619	19,420
2002	3,003	3,086	3,303	3,485	3,804	47	13,725	2,821	1,467	4,288	664	568	330	1,562	13,725	5,850	19,575
2003	3,135	3,246	3,295	3,345	3,730	39	13,655	2,930	1,466	4,396	653	584	332	1,569	13,655	5,965	19,620
2004	3,054	3,115	3,525	3,372	3,565	48	13,625	2,859	1,454	4,313	655	589	336	1,580	13,625	5,893	19,518
2005	3,076	3,112	3,283	3,463	3,616	41	13,515	2,886	1,410	4,296	732	569	335	1,636	13,515	5,932	19,447
2006	3,188	3,242	3,337	3,310	3,634	39	13,562	2,874	1,480	4,354	827	564	332	1,723	13,562	6,077	19,639
2007	3,010	3,051	3,529	3,395	3,480	55	13,510	3,065	1,444	4,509	866	579	336	1,781	13,510	6,290	19,800
2008	3,139	3,209	3,439	3,508	3,616	74	13,846	3,096	1,469	4,565	932	583	347	1,862	13,846	6,427	20,273
Source: http://www.dpb.cornell.edu/documents/1000178.pdf								Source: http://www.dpb.cornell.edu/documents/1000197.pdf			Source: http://www.dpb.cornell.edu/documents/1000201.pdf				Source: http://www.dpb.cornell.edu/documents/1000171.pdf		

Appendix E – Scope 3 Transportation Emission Forecast

FYE	Annualized Commuting Related Emissions (MT CO2e)				Air Travel	Total
	Employees	Undergrads	Grads	Total		
2008	21,347	3,148	4,471	28,967	27,000	55,967
2009	21,347	3,148	4,471	28,967	27,058	56,025
2010	21,105	3,104	4,427	28,635	27,116	55,752
2011	20,871	3,060	4,385	28,316	27,175	55,491
2012	20,646	3,019	4,344	28,008	27,233	55,241
2013	20,428	2,978	4,305	27,712	27,291	55,003
2014	20,219	2,940	4,267	27,425	27,349	54,775
2015	20,017	2,902	4,230	27,149	27,408	54,556
2016	19,821	2,865	4,195	26,882	27,466	54,348
2017	19,632	2,830	4,161	26,624	27,524	54,148
2018	19,450	2,796	4,129	26,374	27,582	53,957
2019	19,273	2,763	4,097	26,133	27,641	53,773
2020	19,102	2,731	4,066	25,899	27,699	53,598
2021	18,936	2,699	4,037	25,673	27,757	53,430
2022	18,776	2,669	4,008	25,454	27,815	53,269
2023	18,621	2,640	3,981	25,241	27,874	53,115
2024	18,470	2,611	3,954	25,036	27,932	52,968
2025	18,324	2,584	3,928	24,836	27,990	52,826
2026	18,183	2,557	3,903	24,643	28,048	52,691
2027	18,045	2,530	3,879	24,455	28,107	52,561
2028	17,912	2,505	3,856	24,272	28,165	52,437
2029	17,982	2,505	3,868	24,355	28,223	52,578
2030	18,053	2,505	3,880	24,438	28,281	52,719
2031	18,124	2,505	3,892	24,520	28,340	52,860
2032	18,195	2,505	3,904	24,603	28,398	53,001
2033	18,265	2,505	3,916	24,686	28,456	53,142
2034	18,336	2,505	3,928	24,768	28,514	53,283
2035	18,407	2,505	3,940	24,851	28,573	53,424
2036	18,477	2,505	3,952	24,934	28,631	53,565
2037	18,548	2,505	3,964	25,017	28,689	53,706
2038	18,619	2,505	3,976	25,099	28,747	53,847
2039	18,689	2,505	3,988	25,182	28,806	53,988
2040	18,760	2,505	4,000	25,265	28,864	54,128
2041	18,831	2,505	4,012	25,347	28,922	54,269
2042	18,901	2,505	4,024	25,430	28,980	54,410
2043	18,972	2,505	4,036	25,513	29,039	54,551
2044	19,043	2,505	4,048	25,595	29,097	54,692
2045	19,114	2,505	4,060	25,678	29,155	54,833
2046	19,184	2,505	4,072	25,761	29,213	54,974
2047	19,255	2,505	4,084	25,844	29,271	55,115
2048	19,326	2,505	4,096	25,926	29,330	55,256
2049	19,396	2,505	4,108	26,009	29,388	55,397
2050	19,467	2,505	4,120	26,092	29,446	55,538

Appendix E – Commodity Price Forecast Methodology

Energy Commodity Forecasts

Climate Action Planning

Cornell University

White Paper

Prepared by

Energy Strategies, LLC

Rev 0 – May 2009

Energy Commodity Forecasts for
Climate Action Planning
Cornell University

Climate action plans should anticipate federal policy requiring economy-wide reductions in greenhouse gas (GHG) emissions. Under a federally mandated compliance regime, a cost will be attributed to greenhouse gas emissions, and conversely a savings for their avoidance. Energy commodities are a primary source of GHG emissions and have significantly different GHG impacts. Accordingly, future energy commodity prices will be sensitive to the costs attributed to GHG and a projection of such costs is needed as a context for energy price forecasts. Energy Strategies current assumptions with respect to federal climate change regulatory policies and uncertainty ranges with respect to future greenhouse gas allowance prices, expressed as dollars per metric ton of carbon dioxide equivalent, are discussed in detail in “Financial Exposure to U.S. Climate Action Policy”, a white paper initially issued by Energy Strategies in January 2009 and updated in May 2009.

Site specific energy commodity forecasts are required for each of the types of energy that an entity anticipates employing. In the case of Cornell University, forecasts are provided for the following:

- Natural gas (as both a transportation and distribution level customer)
- Coal
- Biomass (raw)
- Distillate fuel oil
- Motor gasoline
- Biodiesel
- Purchased grid electricity
- Purchased green electricity

A third party forecast of future global crude oil prices is provided as additional context for the projections for individual commodity prices. Note, price forecasts are expressed in constant 2009 dollars. Prices are in dollars per million British thermal units (MMBtu) for crude oil, natural gas, coal,

biomass, and distillate fuel oil. Prices are in dollars per megaWatt hour (MWh) for purchased electricity and dollars per gallon for motor gasoline and biodiesel.

There are three general steps in estimating a generic (i.e. not customer specific) “Full Cost” for each energy commodity where Generic Full Cost is defined as the total delivered cost including the economy-wide cost of compliance to GHG regulation:

- Step 1: Prepare a “Baseline” projection of delivered cost under the assumption that GHG emissions are not regulated, i.e. no cost is assigned to GHG emissions.
- Step 2: Calculate the incremental cost a typical customer will bear (or avoid) as a result of economy-wide compliance with GHG regulation.
- Step 3: Adjust the Baseline Cost to reflect judgment as to how the cost of compliance will affect the demand supply equilibrium resulting in a “Generic Baseline Equilibrium” price such that the sum of Generic Baseline Equilibrium price and the cost of compliance results in a Generic Full Cost for each energy type.

A further step is then needed to reflect the unique circumstances of the customer to forecast Customer Baseline Equilibrium prices and Customer Full Costs.

The following more specific steps have been taken in preparing the forecasts for each commodity.

- Develop a “Baseline” forecast at a transparent U.S. pricing point for which market data is readily available:
 - o Analyze historical prices to determine long-term price trends and to estimate an underlying market equilibrium price as of the end of 2008. (The Energy Information Administration (EIA) is a primary source for this data. Capture at least 20 years of data where practical.)
 - o Examine indicative forward pricing and publically available long-term annual forecasts such as those available in the EIA’s 2009 Annual Energy Outlook (AEO).
 - o Develop a full period (2010 through 2050) annual trend forecast for “low”, “mid”, “high” and “expected” trend scenarios (corresponding statistically to P10, P50, P90 and expected value (EV) confidence intervals). The trend forecast is one in which each annual value is 100% correlated with the subsequent annual value in the data series. Long-term trend analysis is useful for the analysis of long-term investments, i.e. having a life of 10 or more years.
 - o For the first five years, develop uncertainty ranges that are independent for each year and therefore more accurately express the range of possible outcomes within

each year. An annual, independent uncertainty range is useful in analyzing short-term initiatives.

- Translate the uncertainty range of Baseline forecasts into an expected value (EV) Baseline forecast.
- For each commodity, estimate the annual expected value (EV) cost of compliance to climate regulation that will be incurred by the customer. The cost of compliance will be a function of the:
 - GHG emissions per unit of the commodity
 - Cost associated with GHG emissions (using Energy Strategies projected EV GHG emission allowance prices)
 - Percent of emissions subject to compliance cost (given Energy “Moderate” federal climate change policy scenario).
- Adjust the EV Baseline forecasts to reflect a Generic EV Baseline Equilibrium forecast that accounts for the impact GHG compliance costs will have on the market prices of commodities as the underlying demand/supply equilibrium adjusts. The adjustment is function of such considerations as:
 - Price elasticity of demand
 - The availability of substitute fuels
 - Marginal cost of production.
- Calculate the EV Generic Full Cost for each commodity as the sum of the EV Generic Baseline Equilibrium price and the compliance cost. Examine resulting commodity prices relative to each other. Adjust and refine.
- With the EV Generic Baseline Equilibrium forecast as a starting point, develop the EV “Customer Baseline Equilibrium” forecast to reflect delivery at the customer’s point of consumption:
 - Examine historical price information over a period that is comparable to that examined for U.S. pricing points for:
 - The regional market (e.g., New York in the case of Cornell University), and
 - The customer itself (i.e., Cornell).

- Compare the historical regional and customer values to those for the U.S. pricing point to determine factors to apply to adjust the EV Generic Baseline Equilibrium forecast to create an EV Customer Baseline Equilibrium forecast.
- Calculate the EV Customer Full Cost for each commodity as the sum of the EV Customer Baseline Equilibrium price and the compliance cost. Examine resulting commodity prices relative to each other. Adjust and refine.

Exhibit 1 provides a table of the resulting EV Customer Baseline Equilibrium and Full Cost projections by commodity along with a forecast for crude oil and the EV forecast for GHG emission allowance prices. Exhibit 2 is a graph of the EV Customer Baseline Equilibrium and Full Cost for those commodities for which prices are expressed in \$/MMBtu. Exhibit 3 is a graph for the remaining commodities.

Exhibit 1: Table of Summary Energy Commodity Cost Projections – Cornell University FYE 2010 -2050

			Fiscal Years					Fiscal Years					Fiscal Years					Fiscal Years				
Energy Type	Type of Forecast Value	Unit (Source)	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045	2050							
Crude Oil	EIA 2009 AEO Ref Case April 09	2009\$/MMBtu (EIA)	\$ 7.27	\$ 9.19	\$ 11.11	\$ 12.68	\$ 14.04	\$ 15.35	\$ 18.82	\$ 19.41	\$ 20.39	Not Available										
Customer Baseline Equilibrium Cost (EV)																						
Natural Gas																						
Transportation Level	2009\$/MMBtu (ES)	\$ 7.7	\$ 8.4	\$ 8.6	\$ 8.6	\$ 8.8	\$ 9.1	\$ 10.7	\$ 12.4	\$ 14.8	\$ 15.1	\$ 15.2	\$ 14.9	\$ 13.6								
Distribution Level	2009\$/MMBtu (ES)	\$ 8.6	\$ 9.3	\$ 9.5	\$ 9.5	\$ 9.7	\$ 10.0	\$ 11.6	\$ 13.3	\$ 15.7	\$ 16.0	\$ 16.1	\$ 15.8	\$ 14.5								
Coal	2009\$/MMBtu (ES)	\$ 4.4	\$ 4.6	\$ 4.7	\$ 4.7	\$ 4.8	\$ 4.8	\$ 4.7	\$ 4.6	\$ 4.5	\$ 4.6	\$ 4.8	\$ 4.9	\$ 5.1								
Raw Biomass	2009\$/MMBtu (ES)	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.6	\$ 5.2	\$ 5.9	\$ 6.8	\$ 7.7	\$ 8.6	\$ 9.6	\$ 11.2								
Dist. Fuel Oil	2009\$/MMBtu (ES)	\$ 13.9	\$ 16.8	\$ 17.6	\$ 17.7	\$ 17.8	\$ 18.0	\$ 19.8	\$ 21.7	\$ 23.4	\$ 24.0	\$ 24.2	\$ 24.0	\$ 22.5								
Motor Gasoline	\$/gallon (ES)	\$ 2.7	\$ 3.0	\$ 3.2	\$ 3.3	\$ 3.3	\$ 3.4	\$ 3.7	\$ 4.0	\$ 4.3	\$ 4.5	\$ 4.6	\$ 4.7	\$ 4.6								
Biodiesel	\$/gallon (ES)	\$ 2.8	\$ 3.1	\$ 3.3	\$ 3.4	\$ 3.4	\$ 3.5	\$ 4.0	\$ 4.4	\$ 4.9	\$ 5.2	\$ 5.5	\$ 5.7	\$ 5.9								
Electricity - Grid	\$/MWh (ES)	\$ 89.0	\$ 90.9	\$ 92.8	\$ 94.9	\$ 97.0	\$ 98.8	\$ 105.6	\$ 113.0	\$ 121.6	\$ 123.3	\$ 128.5	\$ 134.0	\$ 139.5								
Electricity - Green	\$/MWh (ES)	\$ 114.0	\$ 115.9	\$ 117.8	\$ 119.9	\$ 122.0	\$ 122.0	\$ 126.3	\$ 139.1	\$ 154.0	\$ 163.0	\$ 174.8	\$ 186.2	\$ 200.9								
Customer Full Cost (EV)																						
Natural Gas	Transportation Level	2009\$/MMBtu (ES)	\$ 7.7	\$ 8.4	\$ 8.6	\$ 8.6	\$ 8.8	\$ 9.4	\$ 11.6	\$ 13.8	\$ 16.9	\$ 18.1	\$ 18.9	\$ 19.5	\$ 19.6							
Natural Gas	Distribution Level	2009\$/MMBtu (ES)	\$ 8.6	\$ 9.3	\$ 9.5	\$ 9.5	\$ 9.7	\$ 10.3	\$ 12.5	\$ 14.7	\$ 17.8	\$ 19.0	\$ 19.8	\$ 20.4	\$ 20.5							
Coal	2009\$/MMBtu (ES)	\$ 4.4	\$ 4.6	\$ 4.7	\$ 4.7	\$ 4.8	\$ 5.2	\$ 6.3	\$ 7.1	\$ 8.1	\$ 9.7	\$ 11.3	\$ 13.0	\$ 15.6								
Raw Biomass	2009\$/MMBtu (ES)	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.4	\$ 4.6	\$ 5.2	\$ 5.9	\$ 6.8	\$ 7.7	\$ 8.6	\$ 9.6	\$ 11.2								
Dist. Fuel Oil	2009\$/MMBtu (ES)	\$ 13.9	\$ 16.8	\$ 17.6	\$ 17.7	\$ 17.8	\$ 18.4	\$ 21.1	\$ 23.6	\$ 26.3	\$ 28.0	\$ 29.4	\$ 30.4	\$ 30.7								
Motor Gasoline	\$/gallon (ES)	\$ 2.7	\$ 3.0	\$ 3.2	\$ 3.3	\$ 3.3	\$ 3.4	\$ 3.8	\$ 4.2	\$ 4.7	\$ 5.0	\$ 5.2	\$ 5.4	\$ 5.6								
Biodiesel	\$/gallon (ES)	\$ 2.8	\$ 3.1	\$ 3.3	\$ 3.4	\$ 3.4	\$ 3.5	\$ 4.0	\$ 4.4	\$ 4.9	\$ 5.2	\$ 5.5	\$ 5.7	\$ 5.9								
Electricity - Grid	\$/MWh (ES)	\$ 89.0	\$ 90.9	\$ 92.8	\$ 94.9	\$ 97.0	\$ 100.7	\$ 112.3	\$ 123.7	\$ 137.4	\$ 145.2	\$ 156.6	\$ 168.8	\$ 184.5								
Electricity - Green	\$/MWh (ES)	\$ 114.0	\$ 115.9	\$ 117.8	\$ 119.9	\$ 122.0	\$ 122.0	\$ 126.3	\$ 139.1	\$ 154.0	\$ 163.0	\$ 174.8	\$ 186.2	\$ 200.9								
Carbon Price																						
GHG Allowances	2009\$/metric ton CO2e (ES)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 32.7	\$ 40.2	\$ 49.6	\$ 61.4	\$ 76.1	\$ 93.1	\$ 111.3	\$ 139.3							

Exhibit 2: Graph of Summary Energy Commodity Cost Projections – Cornell University FYE 2010 -2050:

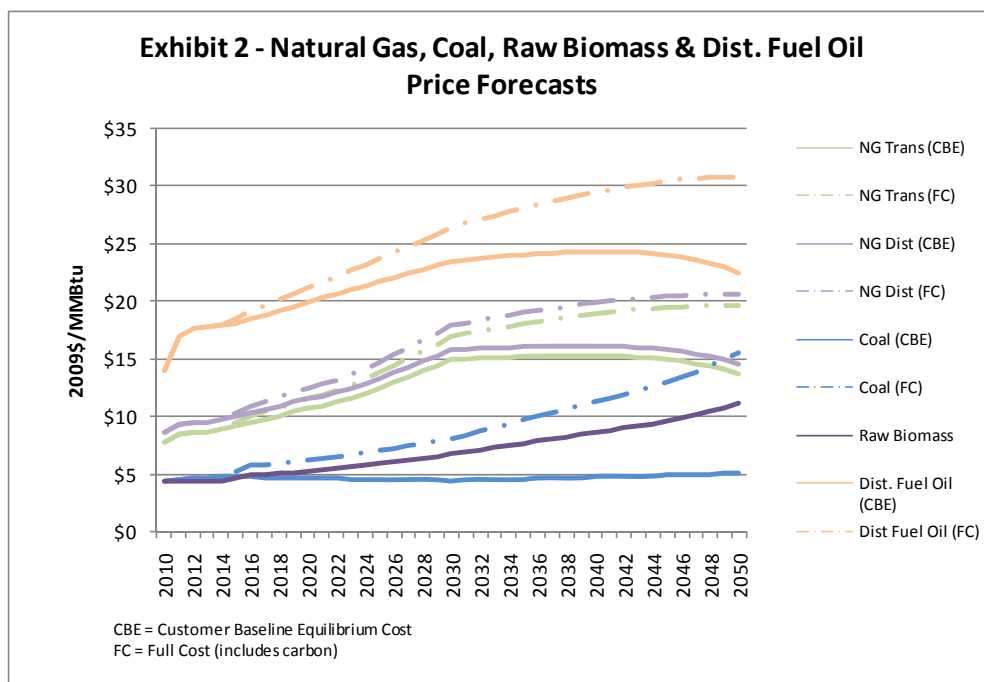


Exhibit 3: Graph of Summary Energy Commodity Cost Projections – Cornell University FYE 2010 -2050:

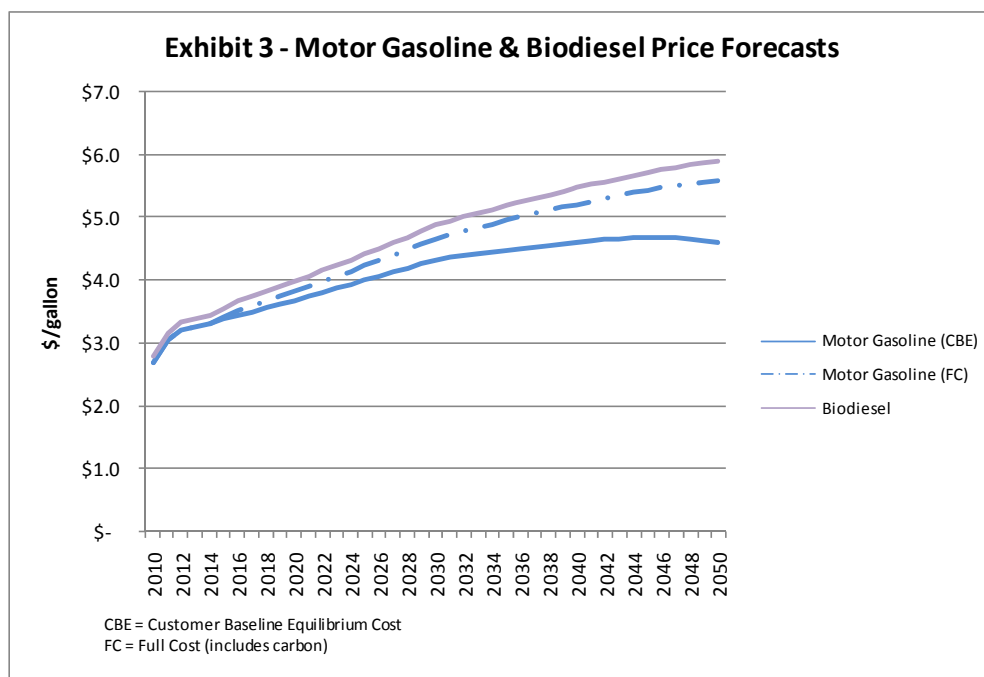
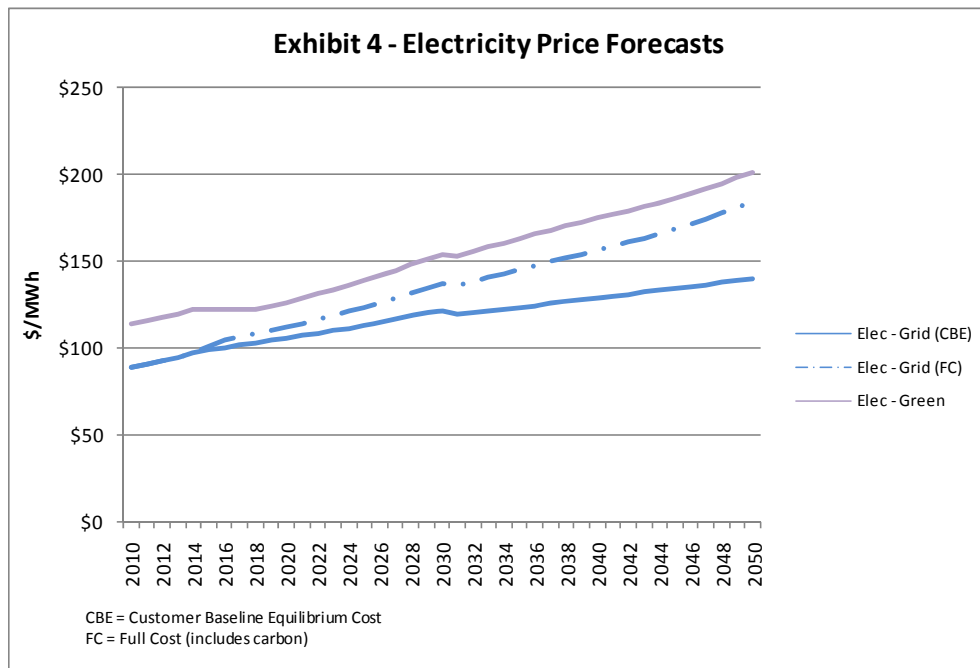


Exhibit 4: Graph of Summary Energy Commodity Cost Projections – Cornell University FYE 2010 -2050:



ⁱ 2008 Campus Master Plan, p. 12, [add URL](#)

ⁱⁱ 2008 Campus Master Plan, p. 12

ⁱⁱⁱ http://c2cbus.cbs.cornell.edu/tgeis/TGEIS_Documents/t-FGEIS_FINAL%20ACCEPTED-121508.pdf, p. 3 of 22.

SUSTAINABILITY

AT CORNELL

Add an Idea

Idea Title

Wedge

Your Name

Theme

E-mail

Source

Your Relationship
to Cornell

Idea Description

Strengths

Weaknesses

Cornell Experts

External Experts

Examples of
Implementation

Comments from
others

[Add another](#)

Information
Sources

Attachment 1 [Browse...](#)

Attachment 2 [Browse...](#)

[Submit Form](#)

now

ideas

CLIMATE
NEUTRALITY

GREEN DEVELOPMENT



- ✓ **Green building policy:** New construction over \$5 million required to be LEED Silver and 30% more energy efficient
- ✓ **Campus Master Plan** to focus on creating a compact, walkable campus

ENERGY CONSERVATION



- ✓ **Energy Conservation Initiative** reduced CO₂ by 50,000 metric tons from 1980–2005 achieving near flat energy purchases since 1990
- ✓ **Lake Source Cooling** project decreases CO₂ emissions by 7,484 metric tons each year

FUEL MIX AND RENEWABLES



- ✓ Cornell Combined Heat-and-Power Plant completed by 2010 to **reduce total CO₂ emissions by 20 percent**
- ✓ **Solar panels** on Day Hall, the Campus Store, and the Hoffmann Challenge Course produce green power on site

ALTERNATIVE TRANSPORTATION



- ✓ Award-winning **Transportation Demand Management** since 1991
- ✓ **Free bus passes** for incoming students
- ✓ Helped launch community-based **Ithaca Carshare and Vanpool** services

CARBON OFFSETS



- ✓ Cornell Cooperative Extension reaches homeowners with **Save Energy, Save Dollars** and **Green Buildings** programs
- ✓ **A wind turbine and solar panels** at Shoals Marine Lab power buildings and lab instruments that monitor chemistry-climate connections for New England

Submit your ideas for the Climate Action Plan online:
WWW.CORNELL.EDU/SUSTAINABILITY



GREEN
DEVELOPMENT



ENERGY
CONSERVATION



FUEL MIX AND
RENEWABLES



ALTERNATIVE
TRANSPORTATION



CARBON
OFFSETS

"Each of us has a part to play."

—David Skorton, Cornell University President



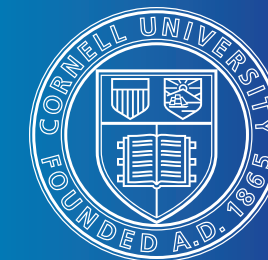
This brochure is printed
on recycled paper.

SUSTAINABILITY
AT CORNELL

STARTS WITH
YOUR
IDEAS

Every carbon-reduction idea brings us
a step closer to climate neutrality.

Share your ideas for the
Climate Action Plan and check
out what others are thinking.



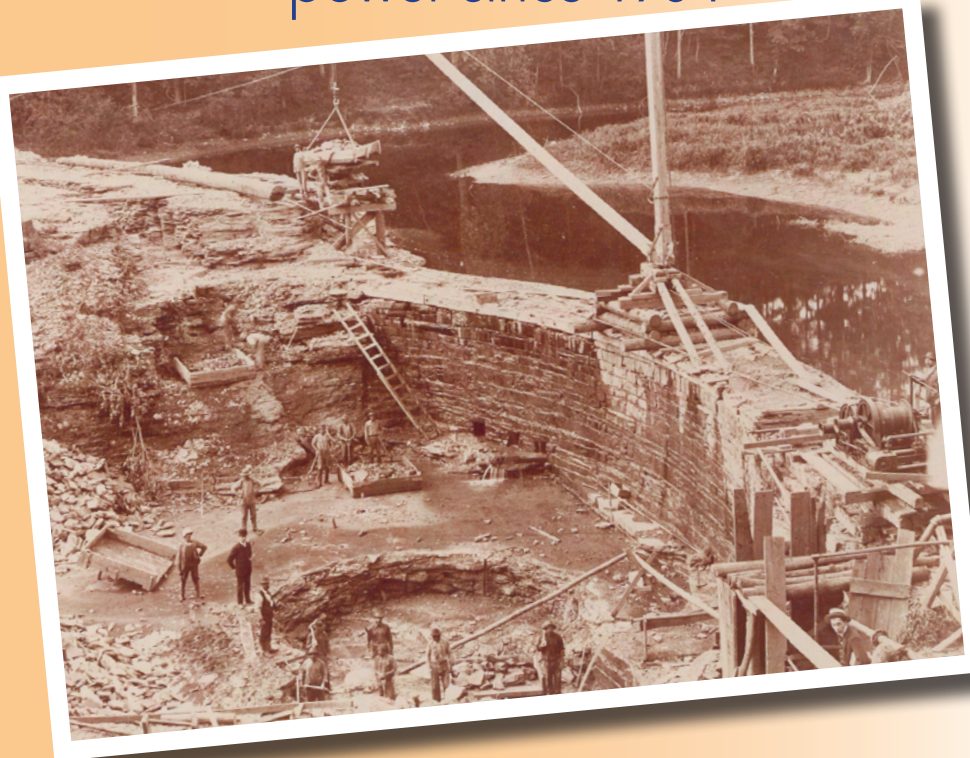
WWW.CORNELL.EDU/SUSTAINABILITY

then

now

Making climate neutrality a reality

Pioneers in hydroelectric
power since 1904

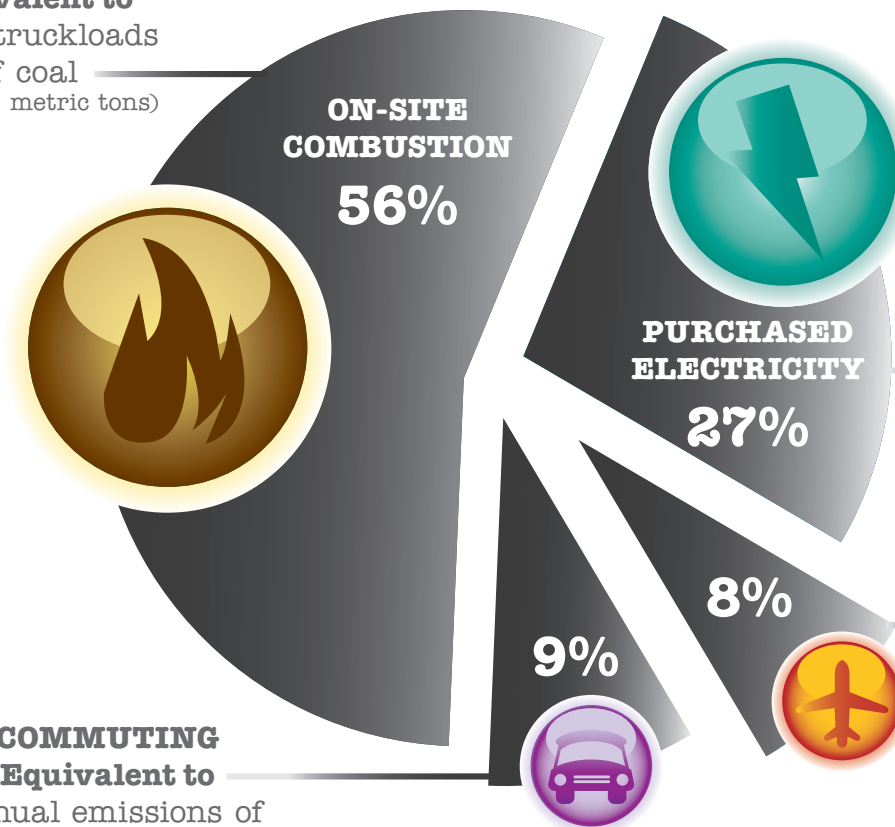


In 1904, from the Fall Creek Power Station Cornell produced nearly double its electric needs and powered Ithaca with the extra energy.

Cornell remains the ONLY college campus in the United States producing its own hydroelectric power, totaling more than 2 percent of campus electricity.

319,000 METRIC TONS:
2008 GREENHOUSE GAS EMISSIONS
FROM CORNELL'S ITHACA CAMPUS
(CO₂-EQUIVALENT EMISSIONS)

Equivalent to
3,000 truckloads
of coal
(176,000 metric tons)



Build
greener



Reduce energy
demand



Use cleaner
fuels



Travel
efficiently



Offset
carbon footprint

progress

In 2010, Cornell will surpass the "Kyoto" goal of 7% below 1990 total greenhouse gas emissions from central utilities, even though the campus has grown 15%.

SUBMIT YOUR IDEAS for the Climate Action Plan online before December: WWW.CORNELL.EDU/SUSTAINABILITY

Every idea BIG or SMALL will be considered.

**NET-ZERO
CARBON
EMISSIONS**

1 Theme Description & Background

Title of Theme Wedge

Theme Summary

Stage 1
Screening
Responsibility

2 Is this Theme a "Given"?

Has a decision already been made regarding this Theme? Please make a selection below. **See Notes section below for additional information on Givens.**

Given

"Given"
Explanation

3 Boundary Conditions

Verify that the opportunity embodied in this theme passes the following conditional tests:

- | | |
|--|---------------------------|
| 1. the primary missions of teaching, research, and outreach are maintained or enhanced. | BC 1 <input type="text"/> |
| 2. critical utility services to support Cornell's loads and the local utility grid are maintained or enhanced. | BC 2 <input type="text"/> |
| 3. net global lifecycle GHG emissions are reduced. | BC 3 <input type="text"/> |
| 4. all waste products resulting from this opportunity can be safely managed. | BC 4 <input type="text"/> |
| 5. net positive impacts to the Ithaca/regional community will balance or exceed net negative impacts. | BC 5 <input type="text"/> |
| 6. overall human health and safety will be maintained or enhanced. | BC 6 <input type="text"/> |
| 7. [For Carbon Offsets Only] This is a generally accepted offset as determined by the Carbon Offset Working Group (see Offset Quality Assessment below). | BC 7 <input type="text"/> |
| 8. there is enough verifiable/credible information available to fairly evaluate this opportunity against other options. | BC 8 <input type="text"/> |

Boundary
Condition Off
Ramp

BC Notes

4 GHG Characterization

GHG Management
Hierarchy

Net GHG Impact

=====

5 Viability Considerations

Readiness -
Technical

When will technical feasibility be demonstrated at scale. (N.A. might apply to behavioral initiatives, for example)

Readiness -
Market

When can you go out and purchase the technology for the commercial application? Includes institutional standards.

Readiness - Social
Acceptance

Includes regulatory...community acceptance.

Readiness Notes

Resource
Availability

Where relevant, are there local resources, e.g. wind, sufficient for feasible implementation?

Consider the following relative to the "base case".

First Cost
(Capital
Budget)

Net Operating
Expense

Operability

Ease of Implementation. Bullet items represent possible considerations.

Ease of
Implementation

Ease of
Implementation -
Notes

Based on the viability considerations above and other information discussed by the team, which time frame is the most relevant for this Theme to be considered for implementation and what is the viability confidence level.

Implementation
Timeframe

Viability
Confidence

Below determine whether the Theme will pass on to the Leadership considerations or if, based on the viability considerations above it will be put in the Compost Pile, Test Tube Rack or Bike Rack, in which case skip to section 7 Stage 1 Disposition below.

Viability Off
Ramp

Viability Notes

6 Qualitative Leadership Criteria

Scores should reflect the opinion of the team as to whether the theme is worthy of more detailed screening and evaluation as a focus theme, accounting for the qualitative leadership criteria included in the notes at the bottom of this page.

Institutional LC

Environmental LC

Social LC

Economic LC

Qualitative
Leadership Notes

=====

7 Stage 1 Disposition (see notes below)

Stage 1
Disposition

Stage 1
Disposition Notes

Stage 1 Decision
Ready ☐

Policy

Program

Process

Research

Include information that was useful in the screening process here.

Screening Level
Information
(Link)

URL:

Screening Level
Information
(Attachment)

=====

Notes

Disposition Options

Based on the opinion and expertise of the Wedge Working Group, choose between the following dispositions:

STAGE 2 FOCUS THEME:

BIKE RACK: This Theme will be temporarily stored while more promising ideas are pursued, but may be considered in Stage 2 as information and analysis proceeds.

TEST TUBE RACK: The Cornell Community will be offered a chance to provide information or conduct a pilot test so this Theme can be considered further (notes should specify what ideas or testing is sought)

COMPOST PILE: Will not be further studied as an Theme (components may be incorporated into other opportunities). This is for Themes which fail one or more boundary conditions or are unlikely to be favorably considered in comparison to other Themes or opportunities which focus on the similar GHG reduction goals.

Given Options

GIVEN - EVALUATE FURTHER: This Theme should be moved onto Stage 2 for further analysis, since we are already moving forward with incorporating this into our operations

GIVEN - NO EVALUATION NECESSARY: Analysis is sufficiently complete to move this Theme to Stage 3, final CAP portfolio development. Stage 2 documentation will be required.

GIVEN - BASE CASE: This Theme is sufficiently implemented already and can be considered part of the way that Cornell operates today. Do not include as part of the CAP.

Qualitative Leadership Criteria

Institutional

Furtheres Cornell Mission: Teaching, Research, Outreach, Public Service, Student Access to Higher Education. Establish Cornell as a thought leader and early adopter. Recognize environmental leadership.

Social

Employee Well Being, Quality of Life in Communities, Business Ethics, Impact on Campus/ Community Aesthetics/ Appeal, Impact on Faculty/ Staff/ Students, Broadly applicable, replicable, transferrable. Will this still seem like a good idea in 20 years?

Environmental

GHG Management Hierarchy, Net GHG Impact, Land Use – Extent to Which Existing or Potential Environmental Service is Compromised, Sustainable Water Use, Enhance Air Quality, Exceed Standards, Sustainable Use of Other Natural Resources, Minimize Hazardous Waste and Handle Safely, Municipal wWaste – Recycle/ Reuse, Universal waste – Recycle/ Reuse, Biodiversity.

Economic

Economic Stewardship, Regional Economic Development, Investing in Sustainable Value.

Technical Brief: Lab and Office/Admin EUI Standards

As derived from Cornell University Lab Building and Office Building Energy Analyses

Lab Building

1. Energy Simulation

This report describes the energy analyses conducted for the design of a Generic Laboratory/Office Building for Cornell University, New York. The construction project involves new construction of approximately 200,000 gross square feet. The building program is primarily laboratory and offices.

2. Inputs and Assumptions

The primary energy modeling effort utilized eQUEST building simulation software, which is based on the DOE-2.2 simulation engine. An ASHRAE 90.1-2007 Baseline building was created; and changes were made to the model based on previously identified Energy Efficient Measurements (EEMs). Two alternative design strategies, “Typical” and “Optimal”, were simulated to determine their impact on energy savings. The design strategies being implemented include envelope, lighting, HVAC systems improvements, and solar hot water resulted in significant energy use reductions.

Utilization schedules are input into eQuest to simulate building energy performance. These schedules represent daily occupant usage patterns for such end uses as lighting, equipment, and service hot water, as well as other operational patterns such as thermostat set points. ASHRAE Standard 90.1-2007 includes schedules for specific occupancy types such as office spaces and Laboratories for the 21st Century (Labs21) has published representative schedules for laboratory buildings. Both of these sources were used to develop the schedules used in the models which were ultimately adjusted based on AEI’s understanding of the building operation (8 am to 4 pm), and usage.

The weather data used for these analyses was the long-term average TMY-3 weather data for Syracuse, New York. The detailed building inputs can be found in Appendix A.

3. Building Evaluation – Generic Lab

The generic lab is a five story building and 200,000 gross square feet (GSF) programmed as laboratory and office space.

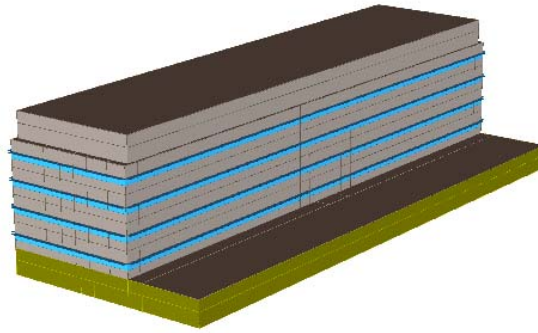


Figure 1 - Lab Building Model

As was previously discussed, for the purposes of energy analysis, an ASHRAE 90.1-2007 Appendix G Baseline building is being used as the starting point. The baseline HVAC system is a Variable Air Volume (VAV) reheat system with chilled water and hot water for reheat and preheat coils. There are also Fan Coil Units (FCUs) serving the LER and various mechanical/electrical spaces. Details of the Baseline, Typical and Optimal cases can be found in Appendix A.

The figures on the following pages display the overall energy performance of the Baseline, Typical and Optimal buildings and the energy end use contributors to that consumption. As indicated in Figure 2, heating energy accounts for the majority of the building energy use which is common for this building type and location due to outside air and reheat requirements.

Energy recovery is often considered for laboratories because of the high outside air ventilation rates. There are several options available for energy recovery with the most prevalent being sensible only runaround coils and enthalpy wheel heat exchangers. A runaround energy recovery coil with 50% effectiveness is considered in the Typical building to recover energy from the lab general exhaust system.

Among the EEMs identified for the Typical Building (Figure 3), reduced energy due to fume hood exhaust turndown to 25% of maximum flow in lieu of the 50% turndown required in the Baseline building, reduced minimum ventilation rates during unoccupied periods (4 ACH) and exhaust energy recovery have significantly reduce cooling and heating energy. Total annual energy use was reduced by 32.6 % compared to Baseline energy use.

On the other hand, the ventilation rates were reduced further for the Optimal building from 8 ACH to 6 ACH during occupied hours, and from 4 ACH to 3 ACH during unoccupied periods. In this case an enthalpy wheel heat exchanger, 75% effectiveness, is used to recover energy. Furthermore, chilled beams are used to condition the lab spaces. Chilled beams utilized chilled water as the heat transfer medium and could potentially reduce overall energy use by decreasing fan energy. As indicated in Table 1, space cooling was reduce by 10 KBTU/sf-yr, space

heating and fan energy uses were 3 KBTU/sf-yr lower than the Typical building energy use. Total annual energy use is 38.6% lower than Baseline building.

An alternative using Solar Hot Water (SHW) to cover part of the reheat energy and Domestic Hot Water (DHW) loads was considered. A solar thermal system of 25,000 sf with a solar flow rate of 160 GPM, and a 60,000 gallon storage tank can cover 33% of the total reheat demand, and a 4,000 sf array and a 100,000 gallon storage tank can cover 90% of the DHW load. As shown in Figure 5, energy use was reduced by 9 KBTU/sf-yr compared to the Optimal building energy use. Total annual energy use is 42% lower than the Baseline building.

Finally, the option of converting 30% of the Lab space to Office space was evaluated. Energy use was reduced by 23 KBTU/sf-yr compared to the Optimal building. Furthermore, the selected SHW systems account for 38% and 90% of the reheat energy and DHW demands in this case. This would result in an additional 11 KBTU/sf-yr energy savings. Total annual energy would be 50.9% lower than the Baseline building.

Table 1: Energy Use of Lab Variants

End Use Type	Annual End Use Consumption (KBtu/ft2-yr)				Annual End Use Savings from Baseline (KBtu/ft2-yr)		
	Base	Typical	Optimal	Optimal with SHW	Typical	Optimal	Optimal with SHW
Ambient Lights	10	7	6	6	3	4	4
Misc. Equipment	56	56	56	56	0	0	0
Space Heating	99	27	24	16	72	75	83
Space Cooling	74	66	56	56	9	18	18
Pumps & Aux.	1.6	2.1	2.4	2.4	-0.5	-0.8	-0.8
Vent Fans	32	25	22	22	7	10	10
Domestic Hot Water	1	1	1	0	0	0	1
Ext. Use	2	2	2	2	0	0	0
Total	277	187	170	161	90	107	116

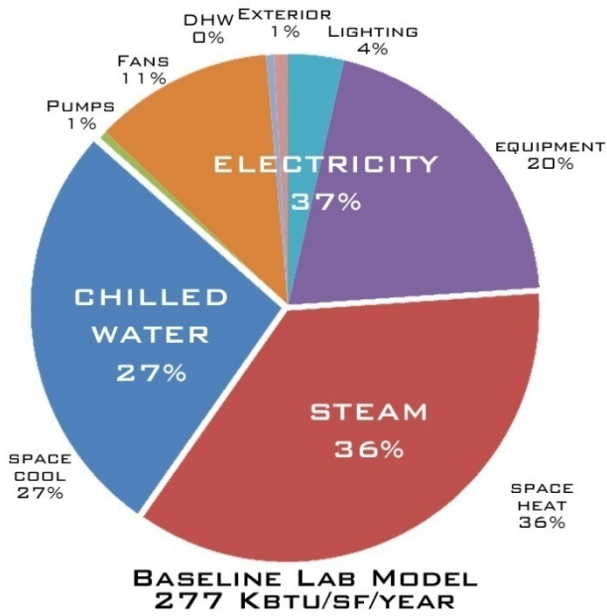


Figure 2 Baseline Model Annual Energy by End Use

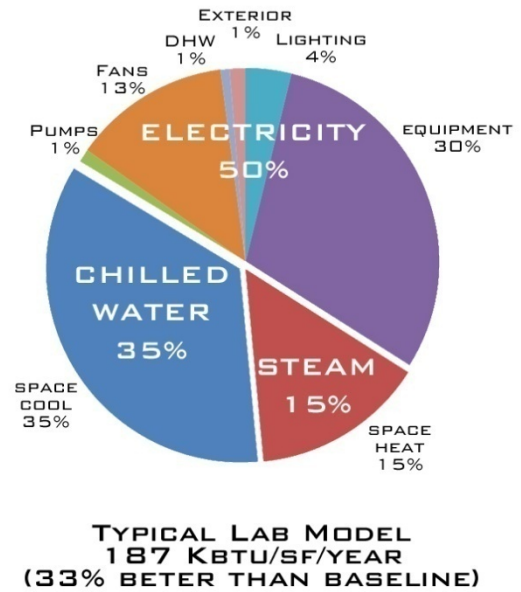


Figure 3 Typical Model Annual Energy by End Use

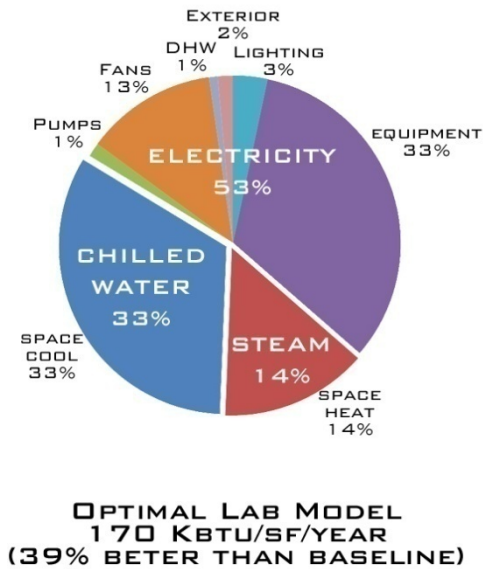


Figure 4 Optimal Model Annual Energy by End Use

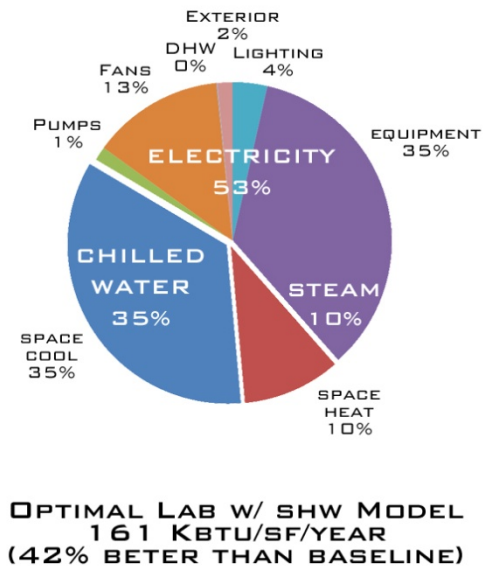


Figure 5 Optimal Model (w/SHW) Annual Energy by End Use

Office Building

1. Energy Simulation

This report describes the energy analyses conducted for the design of a generic office and classroom building for Cornell University, New York. The construction project involves new construction of approximately 100,000 gross square feet. The building program is primarily offices and classrooms with additional study environments, computer labs, and support spaces.

2. Inputs and Assumptions

The primary energy modeling effort utilized eQUEST building simulation software, which is based on the DOE-2.2 simulation engine. An ASHRAE 90.1-2007 Baseline building was created; and changes were made to the model based on previously identified Energy Efficient Measurements (EEMs). Two alternative design strategies, “Typical” and “Optimal”, were simulated to determine their impact on energy savings. The design strategies being implemented include envelope, lighting, and HVAC systems improvements.

ASHRAE Standard 90.1-2007 was used to develop the schedules used in the models which were ultimately adjusted based on AEI’s understanding of the building operation (8 am to 6 pm), and usage. The weather data used for these analyses was the long-term average TMY-3 weather data for Syracuse, New York. The detailed building inputs can be found in Appendix A.

3. Building Evaluation – Generic Office/Classroom Building

The model is a five story building and 100,000 gross square feet (GSF) programmed as previously described.

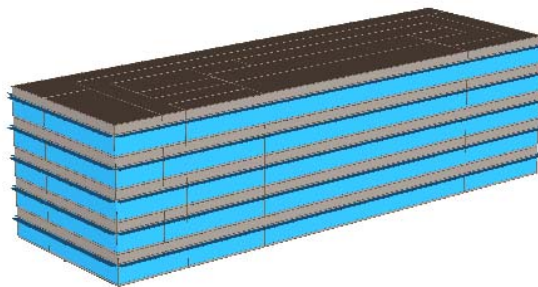


Figure 2 - Office Building Model

An ASHRAE 90.1-2007 Appendix G Baseline building is being used as the starting point. The baseline HVAC system is a Variable Air Volume (VAV) reheat system with chilled water and hot water for reheat and preheat coils. There are also Fan Coil Units (FCUs) serving the mechanical spaces. Details of the Baseline, Typical and Optimal cases can be found in Appendix A.

The figures on the following pages display the overall energy performance of the Baseline, Typical and Optimal buildings and the energy end use contributors to that consumption. As indicated in Figure 6, the heating and reheat requirements of the Ithaca climate make space heating the largest energy consumer annually, but space cooling and electrical consumption are also significant.

While offices buildings do not have the high ventilation requirements of a laboratory building, energy recovery is still important to reduce annual energy use. As in the laboratory models, a runaround energy recovery coil with 50% effectiveness is considered in the Typical building to recover energy.

Among the others EEMs identified for the Typical Building (Figure 7) are demand control ventilation to adjust ventilation rates based on space occupancy, shading for exterior windows, and a 20% reduction in the lighting power density used throughout all spaces. Total annual energy use was reduced by 24% compared to Baseline energy use.

The Optimal building model includes further conservation measures; a heat wheel for energy recovery, a wet bulb economizer, pressure resets, and the ability to modulate ventilation rates down to zero CFM when a space has no occupants. Chilled beams will be used to provide localized cooling, and a dedicated outdoor air system (DAOS) provides for conditioning of the ventilation air. These features, and the others described in Appendix A, result in a 37% reduction in energy use when compared to the baseline model.

It is important to note that the eQuest modeling tool cannot effectively model chilled beams in conjunction with a VAV DAOS system. eQuest models this system as a constant air volume system, so some potential savings are not realized. Therefore, the space cooling and fan energy in the Optimal model should be viewed as conservative values, with the potential for additional savings.

Table 2: Energy Use of Office Variants

End Use Type	Annual End Use Consumption (KBtu/ft2-yr)			Annual End Use Savings from Baseline (KBtu/ft2-yr)	
	Base	Typical	Optimal	Typical	Optimal
Ambient Lights	10.2	8.1	5.3	2.1	5.0
Misc. Equipment	7.9	7.6	7.6	0.3	0.3
Space Heating	35.9	18.2	13.5	17.6	18.2
Space Cooling	17.4	18.2	14.8	-0.9	2.5
Pumps & Aux.	0.6	0.8	0.8	-0.2	-0.2
Vent Fans	5.5	4.2	4.5	1.3	1.1
Domestic Hot Water	4.2	4.2	4.2	0.0	0.0
Ext. Use	2.4	2.4	2.4	0.0	0.0
Total	84.0	63.8	53.0	20.2	26.9

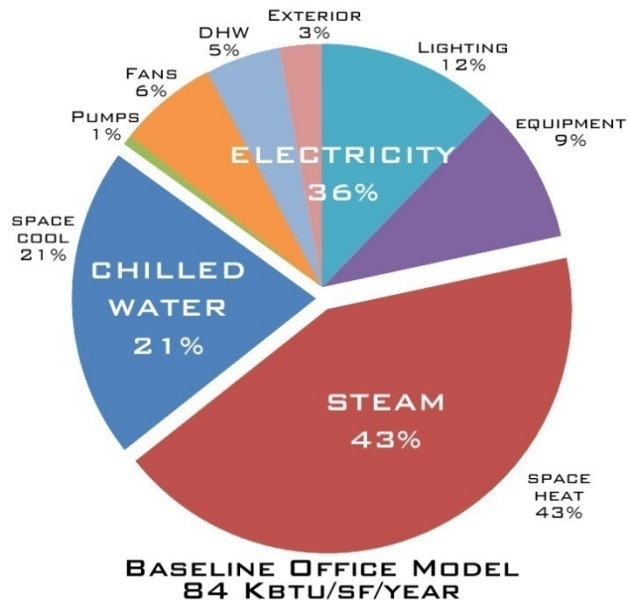


Figure 6 Baseline Model Annual Energy by End Use

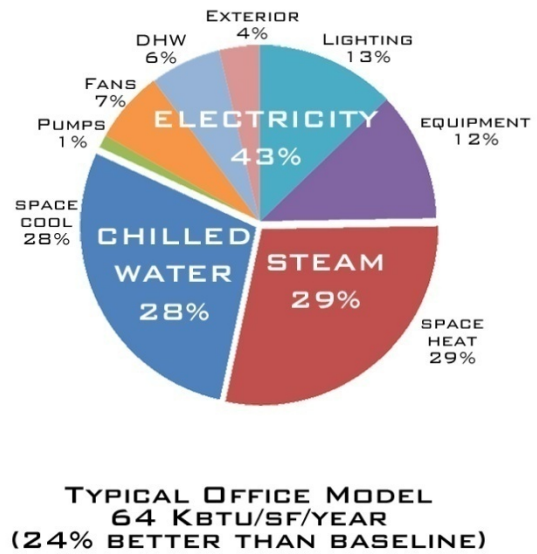


Figure 7 Typical Model Annual Energy by End Use

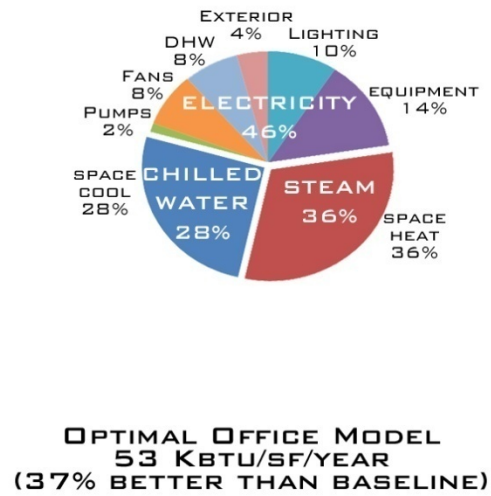


Figure 8 Optimal Model Annual Energy by End Use

Appendix A: Modeling Assumptions

ASSUMPTIONS FOR LAB MODEL

ASSUMPTIONS FOR OFFICE MODEL

ASSUMPTIONS FOR BOTH MODELS

Item	Optimal Design Inputs	Typical Design Inputs	Baseline Design Inputs
Weather Data	<i>(Same as Baseline)</i>	<i>(Same as Baseline)</i>	Zone 5A TMY-3 Weather File, Syracuse, NY <i>(as per Table 5.5-5 of ASHRAE 90.1-2007)</i>
Building Shape	<i>(Same as Baseline)</i> <i>(Same as Baseline)</i>	<i>(Same as Baseline)</i> <i>(Same as Baseline)</i>	199,864 GSF 100,000 GSF <i>(As per drawings provided by Paul Erickson – 01/19/09)</i>
% of Windows	25% of Façade 50% of Façade <i>(As per spreadsheet provided by Paul Erickson – 02/17/09))</i>	55% of Façade 60% of Façade <i>(As per spreadsheet provided by Paul Erickson – 02/17/09))</i>	40% of Facade <i>(as per Table G3.1 of ASHRAE 90.1-2007)</i>
Glass selection (vertical)	<i>(Assumed as 100% better than Baseline)</i>	<i>(Assumed as 50% better than Baseline)</i>	U-Value = 0.55, SHGC = 0.4 _{all} VLT = 81% for Clear Glass, Based upon 40.0% Window to Gross Wall Ratio <i>(as per Table 5.5-5 of ASHRAE 90.1-2007)</i>
Exterior Shade	Overhang (3ft) + Fin	Overhang (3 ft)	NONE
Walls	<i>(Assumed as 100% better than Baseline)</i>	<i>(Assumed as 50% better than Baseline)</i>	Below Grade Wall C-Value 0.119 R-7.5ci Above Grade Wall Steel Framed, U-Value = 0.064 assembly maximum, R-13 + R-7.5ci <i>(As per Table 5.5-5 of ASHRAE 90.1-2007)</i> F-F Height: 16' F-F Height: 14' F-C Height: 10' <i>(As per spreadsheet provided by Paul Erickson – 02/17/09))</i>

Roofs	<i>(Assumed as 100% better than Baseline)</i>	<i>(Assumed as 100% better than Baseline)</i>	U-Value = 0.048 assembly maximum R-20ci based on Roofs with Insulation entirely above Deck <i>(As per Table 5.5-5 of ASHRAE 90.1-2007)</i>
HVAC systems:	<p>Lab/Lab Support: Chilled beams and OA system -VAV-1 w/Preheat coil, Purchased Steam & Chilled Water</p> <p>Office: System 7 –VAV-2 w/Reheat, Purchased Steam & Chilled Water</p> <p>MEP & LER: FCUs Purchased Chilled Water</p> <p>Office/Classes: DOAS w/ Chilled Beams, Purchased Steam & Chilled Water</p> <p>MEP: FCUs, Purchased Steam & Chilled Water</p>	<p>Lab/Lab Support: FCUs and OA system -VAV-1 w/Preheat coil, Purchased Steam & Chilled Water</p> <p>Office: System 7 –VAV-2 w/Reheat, Purchased Steam & Chilled Water</p> <p>MEP & LER: FCUs Purchased Chilled Water</p> <p>Office/Classes: VAV w/Reheat, Purchased Steam & Chilled Water</p> <p>MEP: FCUs, Purchased Steam & Chilled Water</p>	<p>Lab/Lab Support/LER: System 7 –VAV-1 w/Reheat, Purchased Steam & Chilled Water</p> <p>Office: System 7 –VAV-2 w/Reheat, Purchased Steam & Chilled Water</p> <p>MEP: FCUs Purchased Chilled Water</p> <p>Office/Classes: VAV w/Reheat, Purchased Steam & Chilled Water</p> <p>MEP: FCUs, Purchased Steam & Chilled Water</p> <p><i>(As per Table G3.1.1A of ASHRAE 90.1-2007)</i></p>
Outside air	<p><i>(Same as Baseline)</i></p> <p>30% reduction from baseline values</p>	<p><i>(Same as Baseline)</i></p> <p>All areas: 15 CFM/person</p>	<p>Office Areas = 17 CFM/Person, Restrooms = 5 CFM/Person + 0.06 CFM/SF, Corridors = 0 CFM/Person + 0.06 CFM/SF, Mech/Elec Rooms = 0 CFM/Person + 0 CFM/SF, Storage Rooms = 0 CFM/Person + 0.12 CFM/SF</p> <p>Labs/Lab Support = 8 ACH LER = 3 ACH</p> <p><i>(As per spreadsheet provided by Paul Erickson – 02/17/09))</i></p>
Supply Air Temperature Reset	<i>(Same as Baseline)</i>	<i>(Same as Baseline)</i>	<p>Cooling: Reset higher by 5°F under minimum load</p> <p>Heating: NONE</p>

			<i>(As per G3.1.3.12. of Addendum a of ASHRAE 90.1-2007)</i>
Cooling Lockout		NONE	NONE
Night Purge		NONE	NONE
Demand Controlled Ventilation	Set by critical zone Set by sum of zones	Set by critical zone Set by sum of zones	NONE
Economizer	<i>(Same as Baseline)</i> Delta-Enthalpy: 30 BTU High-Limit	<i>(Same as Baseline)</i>	Dry-bulb: 70 °F High-Limit Shutoff <i>(As per Tables G3.1.2.6A,B of ASHRAE 90.1-2007)</i>
Supply Fan	VAV-1-SF: 0.000897 Kw/CFM VAV-2-SF: 0.000561 Kw/CFM FCUs: 0.0004 Kw/CFM Supply Fan Office: 3.5 in. w.g Supply Fan Lab: 5 in w.g. DAOS-SF: 0.000715 Kw/CFM FCUs: 0.000070 Kw/CFM	VAV-1-SF: 0.001245 Kw/CFM VAV-2-SF: 0.000690 Kw/CFM FCUs: 0.0004 Kw/CFM Supply Fan Office: 3.5 in. w.g Supply Fan Lab: 6.5 in w.g. VAV-SF: 0.000871 Kw/CFM FCUs: 0.000070 Kw/CFM	VAV-1-SF: 0.001210 Kw/CFM VAV-2-SF: 0.001246 Kw/CFM FCUs: 0.000780 Kw/CFM FCUs: 0.000830 Kw/CFM VAV-SF: 0.000843 Kw/CFM FCUs: 0.000070 Kw/CFM <i>(As per G3.1.2.9 of ASHRAE 90.1-2007, assumed Ratio 60% Supply and 40% Exhaust)</i>
Return Fan	VAV-2-RF: 0.000552 Kw/CFM Return Fan Office: 1.5 in. w.g	VAV-2-RF: 0.000297 Kw/CFM Return Office: 1.5 in. w.g	VAV-2-RF: 0.000526 Kw/CFM VAV-SF: 0.0007 Kw/CFM <i>(As per G3.1.2.9 of ASHRAE 90.1-2007, assumed Ratio 60% Supply and 40% Return)</i>
General Exhaust Fan	VAV-1-EF: 0.000561 Kw/CFM Exh Fan (staging w/ 4) Exh Fan (VEV to 50%) Exh Fan SP: 3 in. w.g.	VAV-1-EF: 0.000583 Kw/CFM Exh Fan (staging w/ 3) Exh Fan (VEV to 75%) Fan SP: 3.5 in. w.g.	VAV-1-EF: 0.000562 Kw/CFM Exh Fan (CV w/bypass) Exh Fan (CV w/bypass) CV-EF1= 0.000730 KW/CFM. <i>(As per G3.1.2.9 of ASHRAE 90.1-2007)</i>
Fume Hoods (FH)	Fume Hood (VAV)	Fume Hood (VAV)	Fume hood (VAV)
Energy Recovery	Enthalpy Wheel 76% Sensible	Sensible HX 50% Sensible	NONE

	Effectiveness 74% Latent Effectiveness	Effectiveness	<i>(As per 6.5.7.2(a) of ASHRAE 90.1-2007)</i>
Cooling Equipment	<i>(Same as Baseline)</i>	<i>(Same as Baseline)</i>	Purchased Chilled Water
CHW Design	<i>(Same as Baseline)</i>	<i>(Same as Baseline)</i>	44 F Chilled Water Design Supply Temperature, 10 F Loop Design DT - Reset based on outdoor dry bulb temperatures as described in ASHRAE 90.1-2007 Table G.3.1.3.9.
CHW pumps	<i>(Same as Baseline)</i>	<i>(Same as Baseline)</i>	75 ft head with constant speed primary pump and secondary pump riding the pump curve. <i>(As per Table G3.1.3.7 of ASHRAE Standard 90.1-2007)</i>
Heat Rejection	<i>(Same as Baseline)</i>	<i>(Same as Baseline)</i>	NONE
HW Boilers	<i>(Same as Baseline)</i>	<i>(Same as Baseline)</i>	Purchased Steam
HW Design	<i>(Same as Baseline)</i>	<i>(Same as Baseline)</i>	Temp: 180 °F supply 130 °F return Reset: YES <i>(As per G3.1.3.3 of ASHRAE 90.1-2007)</i>
HW Reset	<i>(Same as Baseline)</i>	<i>(Same as Baseline)</i>	180°F at ≤20°F OA Temp 150°F at ≥50°F OA Temp Ramped linearly in between <i>(As per G3.1.3.4 of ASHRAE 90.1-2007)</i>
HW Pumps	<i>(Same as Baseline)</i>	<i>(Same as Baseline)</i>	(1) Primary pump for each boiler. (2) VSD Secondary pumps Size: 19 W/gpm (60 ft) <i>(As per section G3.1.3.5 of ASHRAE Standard 90.1-2007)</i>
VAV Min Flow	Non-Lab: 0.4 CFM/SF Lab: 6/3 ACH Occ/Unoccupied	Non-Lab: 0.4 CFM/SF Lab: 8/4 ACH Occ/Unoccupied	Non-Lab: 0.4 CFM/SF Lab: 8/8 ACH Occ/Unoccupied

	VAV Min Flow: 0% All Areas: CFM/Person 30% above baseline	VAV Min Flow: 30% All Areas: 15 CFM/Person	(As per Section G3.1.3.13 of ASHRAE Standard 90.1-2007)
Ventilation Controls (occupancy)	DCV sensors in zone	DCV sensors in zone	NONE
Domestic HW Heater	(Same as Baseline)	(Same as Baseline)	Number: 1 Equipment Type: Tank Fuel: Natural Gas Efficiency: 80% (As per Table 7.8 of ASHRAE 90.1-2007)
Lighting System	LPD: 30% Better than Baseline	LPD: 20% Better than Baseline	LPD: Space-by-Space Method (W/SF) Atrium: 0.6 Lab: 1.4 Lab Support: 1.4 LER: 1.3 Office: 1.1 Restroom: 0.9 Corridor: 0.5 Mech/Elec: 1.5 Storage: 0.3 Facade – 0.2 W/sf (As per Table 9.5.1 of ASHRAE Standard 90.1-2007)
Plug and Other Miscellaneous Loads		(Same as Baseline)	Equipment Power Density –EPD (W/ft ²) Atrium: 0 Elec./IDF: 10 Lab: 6 Lab Support: 6 LER: 18 Office: 1 Restroom: 0 Corridor: 0 Mech.: 1.5 Storage: 0
Lighting Controls (occupancy)	Occupancy sensor,LPD 10% credit (As per Table G3.2 of	Occupancy sensor, LPD 10% credit (As per Table G3.2 of	NONE

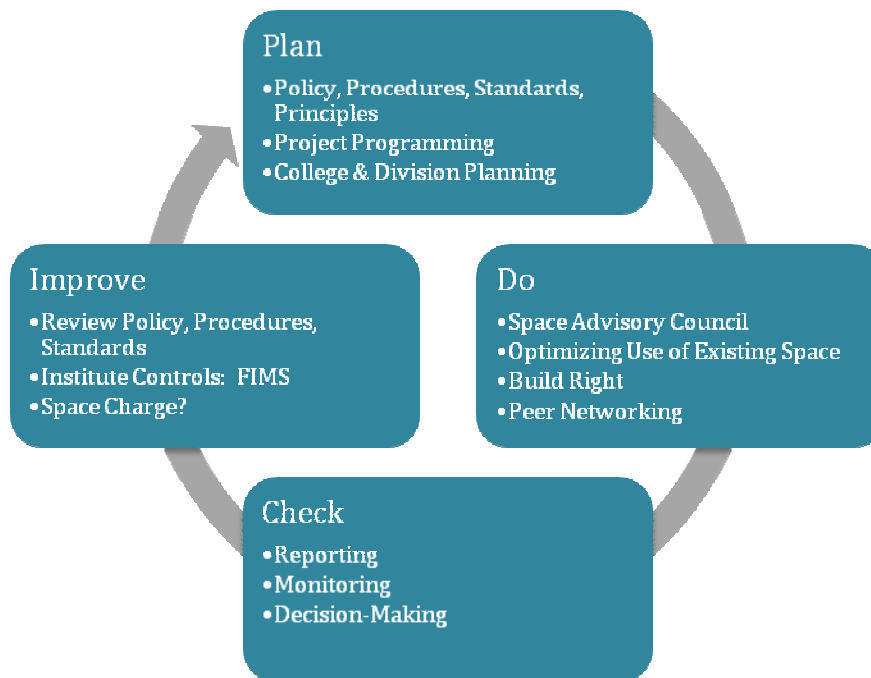
	ASHRAE Standard 90.1-2007)	ASHRAE Standard 90.1-2007)	
Lighting Controls (daylight)	Daylighting Control Office and Lab Spaces All Perimeter Spaces	NONE	NONE (As per Table G3.1 of ASHRAE Standard 90.1-2007)
Schedules	Same as Baseline except for variations on fume hood and air change rate related to monitoring system performance (as per modification of Labs21 schedules based on information from various lab monitoring sources)	Same as Baseline except for variations on fume hood and air change rate related to monitoring system performance (as per modification of Labs21 schedules based on information from various lab monitoring sources)	Lab: Labs21 Occupancy, Lighting, Fume Hood and Miscellaneous Equipment schedules Office: Default eQUEST Building Occupancy, Lighting, and Miscellaneous Equipment schedules. 8 hrs Occupied 10 hrs Occupied
Occupancy	(Same as Baseline)	(Same as Baseline)	Office Areas = 130 SF/Person, Lab/Lab Support Areas = 92 SF/Person, Corridors = 0 SF/Person, Storage Rooms = 0 SF/Person, Mech/Elec Rooms = 0 SF/Person, Restrooms = 100 SF/Person, Atrium = 0 Classrooms = 30 SF/Person Computer Labs= 25 SF/Person (As per Table 403.3 of the International Mechanical Code 2002)

Space Management at Cornell

A Discussion of Current Practice and Opportunities for Improvement

Space is a very visible, fairly permanent, consistent and somewhat finite resource. Space creation is the University's largest single capital investment. Created space obligates the University to significant, on-going operations and maintenance expenses. Yet, despite the costs of space, the University does not manage space in a systematic, purposeful way.

This paper discusses current University practices related to space planning and management and proposes new process elements that collectively create a program that actively manages space as a resource. The proposed space management program has a variety of elements that can be related through a classic Plan-Do-Check-Improve (PDCI) cycle as illustrated here and described in the following text.



~ **PLAN** ~

Policy

Cornell has an existing policy, 2.7 Reporting the Use of Facilities, that requires Cornell units to maintain accurate and complete inventories of space use for purposes of: 1) ensuring the correct indirect cost recovery on sponsored activities and 2) supporting the objective of maximizing space utilization and aiding in the planning of future facilities. Despite the policy, some Cornell occupied spaces, such as all of the rooms at Weill Cornell Medical College, the facilities at Arecibo and many leased spaces, are not inventoried. Further, the inventory itself is not conducive to supporting the second objective of the policy, as the inventory does not contain information about utilization nor does it integrate with other data sets, such as faculty

productivity data, that would enhance facility planning. Therefore, the purpose of the policy needs to be clarified, and if it is important to Cornell to maximize space utilization and improve planning of future facilities, the robustness of the inventory system will need to be reconsidered (see Appendix A: FIMS).

The policy requires thorough review and revision. Certain parts, such as definitions of room types and function codes, are too detailed for policy and should be removed. The requirement to inventory needs to be clarified, and the policy should discuss the use of standards & guidelines, space allocation processes, exception practices, and other structural issues related to space management.

Space Standards

Currently, four types of space standards may be applied to projects at Cornell.

1. Cornell has “Space Planning Guidelines” for the Ithaca campus that were last published in 1994. The Cornell guidelines set expectations for 1) class, seminar and lecture rooms, 2) laboratory and laboratory service, and 3) offices. Many people are not aware of the existence of these guidelines and they are not often used in project development.
2. Several academic units have guidelines that supplement the University guidelines. Unit guidelines should be at least as rigorous as the Cornell guidelines, but unit guidelines are not currently reviewed for conformance with Cornell guidelines.
3. For state projects constructed for the four contract colleges, the State University of New York has out-dated guidelines monitored by a space planner in the State University Construction Fund. The contract colleges have found that the SUCF space planner will often defer to the Cornell guidelines, although budgets are limited by the state based on SUCF guidelines.
4. Sometimes, architects use their own guidelines

The Cornell guidelines are outdated and incomplete; they should be updated to reflect current best practices in higher education related to the size of spaces, utilization rates, and building/space type efficiencies. Revised guidelines should become the preferred standards for all Cornell projects. Exceptions are allowed, but through a documented review process.

Space Principles

Cornell currently lacks a set of agreed upon principles that can guide space management decisions. In addition to standards, Cornell should develop principles to provide a consistent framework to (1) allocate space, (2) plan for future space needs of the organization, and (3) manage Cornell space effectively. A principles document would provide the overarching concepts for space management and describe Cornell’s values with regard to space, such as: which programs should be close to the center, and which programs should be located further from the center; how should Cornell talk about building/space “ownership” and “control”; how

do we think about increasing or decreasing the functionality of spaces, and who ultimately makes the decision for these changes?

Procedures to implement the principles will need to follow from the principles. Ideally, all Cornell space requests and planning efforts will be evaluated using these principles and procedures.

Organizational Strategic Planning

As organizations engage in strategic planning, the space standards should be used to inform current and future plans for allocation of space. Ideally, college and division space plans would be updated during the capital plan development process each year, i.e., as organizations review and update their capital plans, they would also update their space plans. The process would include:

- Review of existing programs, and predicted changes (e.g., staff increases/decreases, functional changes that require new/different space types)
- Review of facilities that support functions
- Assessment of proposed changes, including staffing and enrollments
- Determining relationships with other programs and availability of resources
- Identifying solutions

~ DO ~

Project Initiation

Currently, Cornell does not employ processes that impose rigor on validation of functional programs nor the facility programs developed to meet the needs of the functional programs.

As projects are identified, the program of activity (particularly head count projections and activity projections) needs to be verified by administrators in the unit's chain-of-command. A formal sign-off procedure to verify the functional program should be required before a physical program is initiated. The development of the facility program then needs to be informed by the space standards. Once the facility program is complete, a gap analysis would compare the final program to Cornell standards, and deviations would be noted and discussed. An exceptions process would recognize program uniqueness and allow for justifiable deviations. Programs need to be matched to the existing space inventory portfolio to evaluate the fit of the program to an existing space, before new space is considered. Project teams should include "space champions" who monitor and promote the effective use of the space standards and principles.

Space Advisory Council

Currently, no group exists to make decisions about issues related to space management and space inventory. Facilities Inventory and Indirect Cost jointly interpret policy 2.7. There is no process to identify space that is not inventoried, nor is there an enforcement mechanism to increase inventory completeness. Facilities Inventory and Indirect Cost do the best they can to interpret the policy and answer other questions that arise as a result of the inventory process. However, there are many issues that they don't own and no one is currently empowered to

address such issues. Recent examples include the department assignment of circulation space, increasing transparency of space assigned to support units, and inventory guidelines for leased space. No University-wide consensus regarding resolution of these issues is possible under the current absence of administrative oversight.

The University should empanel a space advisory council, representing the colleges and divisions, to steward revisions to the space guidelines and the space inventory policy, provide advice and counsel to Facilities Inventory and Indirect Cost with regard to interpretation of the policy, make recommendations to improve the quality of space use data and integration with other data sets, and recommend additional data elements that may be of institutional value to track. This group could also serve as the executive group for space utilization studies, to provide uniformity in approach and interpretation. Further, a space advisory council could recommend a University process for reallocation of space and develop MOU templates and procedures to engender trust and transparencies for space transactions.

The Cornell administration should more actively engage in the evaluation of use of existing space, requests for space, and determine space reassignments. Currently, space is brokered on a very ad hoc basis, without standardized procedures nor documentation.

Optimizing Use of Existing Space

Better inventory data and space management processes will make it easier to identify, scope, and implement projects designed to maximize utilization of existing space. New facility programs should always be compared to the existing space inventory before construction of new space is considered. And, the existing space should be reviewed in a systematic way to eliminate poorly utilized and duplicative spaces.

Build Right

It will be necessary, sometimes, to build new. The University should only chose this path after development and approval of a functional program, development and approval of a physical, standard-based, physical program, and elimination of all alternatives in existing space. In order to optimize efficiencies, the design of new construction must conform to the approved physical program as closely as possible.

Peer Networking

Cornell should try to set the example amongst its peers by initiating discussions about the costly impacts of space escalation, often a result of peer competition. Cornell should also develop mechanisms to share best practices within Cornell and with external institutions (e.g., Ivy+, SCUP, APPA, SUNY PPAA).

~ CHECK ~

Reporting, Monitoring and Decision-Making

The current endowed inventory process is a virtual one-way street in that departments provide data to Facilities Inventory but then have no way to subsequently access and use it in meaningful ways. The inventory of record is distributed on paper once a year, occupant

departments make updates by hand, and the electronic inventory is updated centrally. At the end of the cycle, the updated inventory is distributed to the departments again (on paper) for final review, but anecdotal evidence suggests that this inventory of record is not reviewed.

Some units have created shadow systems to make the data more readily available to the unit, and while these systems meet business needs at the local level, their development and maintenance is reflective of poorly functioning central systems. The shadow systems are an inefficient use of financial and labor resources.

The current ASPC¹ project to create a shadow of the inventory system to allow departments to have on-line access to their data is likely to improve the data quality, as people are able to work with their data on-line and see it 24/7/365. The inventory will become more valued as a resource and thus, quality should improve.

Currently, Facilities Inventory cannot provide analysis or reporting of space data to internal stakeholders. With or without a FIMS (see Appendix A), Cornell needs to start providing space use data to colleges and divisions. Simple reports of square footage occupied by room type and by function can be created from existing data sets at department and organization levels. These reports are likely to raise questions, which will create further improvements to the data. The reports will also create transparency about who has what space, and where.

Making data available to organizations will begin to inform management decisions about space use. And as organizations see space data being used in decision-making, they will be motivated to make sure that data is as accurate and complete as possible.

Leased space provides an example of opportunities for improving data, reporting and management of space. The current inventory of leased space is incomplete. Cornell could better coordinate leased space – obtain better pricing, improve space and operational efficiency through co-location, improve lease structures – if the leased space were more easily identifiable.

Because the focus of the inventory is only on the physical attributes of rooms, the use of the inventory by the institution's administration for immediate management decisions or long-term planning is extremely limited. A FIMS (discussed further in Appendix A) will enable more robust reporting, and create critical linkages between faculty, funding, and the use of space. Cornell administrators could begin to ask more challenging questions – such as, where are the most productive faculty located, and how much space do they have? Where are the least productive faculty? Are there correlations between faculty productivity and building condition?

~ IMPROVE ~

Institutionalization

All of the elements of a space management system need to be functionally integrated into business processes of the University. Standards, processes and procedures must be documented. Roles and responsibilities with regard to space management need to be clearly understood and employees in these roles need to be empowered. Data criteria can be

¹ ASPC = Administrative Systems Planning Committee

constantly improved, according to institutional priorities, and data management systems should be enhanced to improve accuracy and integration. Developing and deploying this multi-dimensional model for space management is a prerequisite to improving institutional decision-making for space resources.

Space Charge System

Peer institutions (e.g., Stanford, University of Michigan) are beginning to implement space charges for non-research spaces. For the most part, these peers are under more direct pressure to reduce the rate of growth, due to municipal restrictions or other physical constraints.

While Cornell is not yet feeling such direct pressure, it is clear the current disconnect between control of space and the cost of space does not encourage efficient use of space.

And while Cornell might hope to effect culture change about the use of space through data improvements, policy clarifications and procedural transparency, it is also clear that a space charge system would provide a much stronger incentive to manage space efficiently.

The concept of directly charging users for space is fraught with complications and might even be construed to be in conflict with the mission of the University. However, depending on the ability of the institution to continue to support the use/cost disconnect, and if the implementation of the aforementioned program elements does not produce the desired results, Cornell may want to consider a space charge system.

It could remain true that fiscal constraints, concerns about environmental impacts related to growth (the cost of carbon related to new construction, and the occupancy of an expanding footprint) and failure to impact the growth curve remain as incentives to consider regulation of space beyond implementation of policy and standards. Should this be true, once a space advisory council is empanelled, policy and procedures are revised, and new standards are integrated into work processes, the University should further study the merits and challenges of a space charge system. Earlier work to improve data quality, consistency, implement controls, monitor and report will be foundational to any effort to explore the feasibility of space charges.

Climate Action Plan Issues

An effective space management program can improve the triple plus bottom line:

Environmental. More effective use of existing space holds the potential to reduce the material, energy and land resources consumed by new buildings. And a more compact campus reduces the adverse impacts of motorized vehicle traffic. If BTU/square foot is held constant in existing space while square feet per person is decreased, then BTU/person is reduced.

Economic. The avoided cost of new construction can be substantial, as are savings in institutional time spent in travel on a more compact campus. Over time, operations & maintenance costs exceed the first cost of buildings.

Societal. Space cost savings may be reinvested in other areas of greater individual or collective value. As activity moves from private spaces to more shared spaces, social interactions increase. Equity in the allocation of space resources may ultimately prove a positive social value.

Institutional. Cornell can serve as a leader amongst its peers in establishing best practices for space planning and management.

The extra power. Slowing the rate of growth, as projected in the campus master plan, provides more time to implement carbon abatement technologies, programs and projects.

Appendix A: Facilities Information Management System (FIMS)

A facility information management system (FIMS) is a software tool comprising a centralized database that stores asset data and a graphic user interface used to easily query and access facility-related information.

These systems are frequently divided into two basic components: operations (maintenance) and facilities (space, lease, and move management). The comprehensiveness of each component and degree of integration between these two components varies based on commercially available product.

A FIMS allows authorized users to track and manage a wide variety of facility information, including general building data; room data, including physical and functional attributes; and maintenance data.

The FIMS that Cornell envisions will provide a single repository of physical asset information (inventory & maintenance) integrated with existing Cornell systems for people and funding. Unique views on the performance of Cornell facilities will be created by bringing together space, people, assets, maintenance and funding into a single system, resulting in more informed decision making.

A FIMS will enable Cornell administrators to begin to ask more challenging questions, such as: Where are the most productive faculty located, and how much space do they have? Where are the least productive faculty, and what maintenance issues may be impacting productivity in these locations? Are there correlations between productivity and building condition?

As noted above, the current Cornell space inventory system is used to track physical and functional attributes of rooms at a fairly superficial level. Shortfalls of the existing system include:

- Access to the current electronic data and floor plans is limited to Facilities Inventory staff
- Single point of data entry creates a bottleneck for access to current data and increases the possibility for error.
- Departmental data supporting indirect cost is maintained locally making it difficult to monitor for consistency.
- Space data is only updated once a year, and as a result the system doesn't accommodate on going changes or data that rolls more frequently, or for which an update may be required for purposes of a study or project plan.
- Current process requires turning around 90,000 sheets of paper a year.
- The mainframe is obsolete and expensive to maintain.

Note: The issues above will be mitigated, in part, in late 2009 with the creation of a shadow inventory system that will allow electronic access for units, although use is optional and only required for eight data elements related to inventory; other data elements, including those related to organized research documentation, will remain optional. The system will need to remain on the mainframe until related systems are upgraded (not yet scheduled). Units can still chose to complete a paper-based inventory update.

The following issues will not be mitigated by the new ASPC inventory project:

- Space data does not support other University systems with live links; downloads are required for systems such as 911, Financial Research Administration, Student Records, Campus Life and Facilities systems.
- Departmental data driven by facility code/room number is currently maintained in department shadow systems, duplicating efforts across the university.
- In addition to not being easily accessible floor plans are not linked to the data. Preparing floor plans for adjacency studies is a manual process, limiting resources for College space utilization efforts.
- No integration with personnel or funding systems, so activity in rooms is not easily identified, analyzed or reported.
- No integration with the classroom scheduling software, so attributes of particular interest for classrooms are kept in disparate places.

Benefits of a new Facilities Information Management System, by stakeholder, are outlined in the next sections.

Departments, Colleges & Divisions:

- Allow anyone with access to search for information, within security parameters, i.e. units will be able to search their own data.
- Allow web-based query of the data to be displayed both as a list and through graphic display of the floor plans. (Floor plans can be color coded by data attribute such as departmental occupant, space type and function)
- Support college/division based space utilization by supplying a mechanism to do “what if” space scenarios and displaying that data graphically on the floor plans.
- College/division level access to departmental data enables colleges to better manage space requests.
- Allow web-based entry by managers who are accountable for data content instead of managing paper.
- Institute system that allows departments/divisions/colleges to create their own ad hoc reports, integrity of data improves dramatically; spend less time collecting and more time analyzing

Indirect Cost Review:

- Creating a central database structure is useful to departments for housing locally maintained data, such as data and phone jack location, creates an incentive for using the system and as a result keeping space data and floor plans more accurate. An incentive driven responsive system that empowers users is more effective than mandates and requirements.
- 24/7 access will allow updating at any time, as opposed to responding to a request for data once a year.

- Embedded parameters (“business rules”) will ensure greater accuracy of data and improve consistency across units.
- Provides on-screen documentation to support space coded to organized research (more consistent data can smooth the audit process)
- Central repository for data that documents organized research space enables monitoring and easier auditing for consistency.
- Reduce audit risk from grant-making entities.

University:

- Ability to monitor implementation of space standards.
- Improved reporting, improved transparency, better decision-making
- Reduce the number of departmental shadow systems of facility code/room number by supporting locally maintained data (i.e. key control, biological safety cabinets, fume hoods, and location and supply of HVAC systems).
- Centrally support college efforts with a single system.
- Provide data for emergency planning and response (i.e. hazardous chemicals, HVAC systems and safety equipment, occupancy data can provide location of personnel).
- Support live links to other university systems such as 911, Financial Research Administration, Capital Assets, Human Resources, Student Records, Campus Life, Environmental Health & Safety, Environmental Compliance and Facilities systems.
- Support better utilization of space on the college level will optimize space use across the University and save construction costs of building new space.
- Empowering departments and colleges to better manage space will reduce costs of consultants when an outside view of space is required.
- A new client server system for Facilities Inventory would support of CIT’s effort to remove systems from the mainframe. Inventory system was designed in 1985 and has remained operationally the same since then.
- Closer alignment with registrar’s office regarding classrooms & scheduling events and activities in University facilities

Development of a RFP to specify a FIMS should be guided by the space advisory council, assigned with the responsibility to clearly identify the data needs, the purposes for which the data will be used, and what system and business processes will be integrated.

Energy Conservation Wedge Working Group Phase 2 Report

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Overview

Energy conservation will yield continuing financial benefits in avoided costs; and through behavior change, the Cornell community can directly participate in reducing GHG emissions. The Energy Conservation Wedge Working Group recommends the following:

1. an expansion of proven energy systems maintenance & retrofit efforts that have kept Cornell's energy consumption flat in the face of 15% growth from 1990-2008.
2. technology-specific solutions for energy-intensive applications such as laboratory fume hoods, greenhouses, & growth chambers.
3. expanded outreach efforts to promote individual *responsibility* and collective *response* – the kind of culture change that lay at the heart of the American College & University President's Climate Commitment.
4. policy and process changes to complement and reinforce the above initiatives, and
5. specific opportunities for our climate actions to inform – and be informed by – education and research at Cornell.

Opportunities to reduce emissions are divided into two broad energy conservation strategies: (1) options to improve efficiency of energy-using equipment, and (2) options to reduce demand by encouraging users to operate equipment properly and only as needed. Within each strategy, options are staged over three periods:

- for the first five years, a \$25 million continuation of conservation studies and projects, along with an expansion of conservation focused will reduce energy use by 5%. These efficiency improvements will be complemented by a campus-wide program of student/staff "Eco-Reps" to support and encourage energy-conserving user behaviors.
- during years 6-15, a second round of efficiency improvements valued at \$100 million will strive toward another 15% reduction in energy use. More efficient use of space will yield another 5-10% reduction, through with avoided new construction.
- after year 15, a century-long \$4 billion effort to replace fenestration, lighting, and major mechanical systems for Cornell's heritage buildings will yield another 15-20% reduction in energy use. A quarter of those buildings will be completed by 2050.

To be effective, these program expenditures will be complemented by enforceable energy performance standards for both buildings *and* the equipment therein.

A Context for Energy Conservation at Cornell

Cornell University has a history of pursuing energy conservation dating back to 1970's. The Kyoto commitment was kept and is planned to be exceeded by 2012.

Since 2002, the Energy Conservation Initiative has been the framework for our campus energy-saving efforts. The largest program since Cornell began formally budgeting, staffing, and executing conservation in the early 1970's, it's an aggressive \$50 million, 15 year program to strategically reduce Cornell's fiscal year 2000 campus energy use by 20%.

Utilities and Energy Management (U&EM) has a history of initiating education and outreach efforts. However, we now need to expand these efforts, and draw the broader university community into our conservation efforts. With active involvement of all and reward for success, we can achieve the greatest reduction in energy use.

An Energy Conservation Strategy

Two Paths

There are parallel paths on the road to energy conservation. One path focuses on efforts to improve efficiency of energy-using systems. The other strives to reduce demand by encouraging practices that use equipment and facilities optimally and only when needed.

We have focused heavily on system improvements since their scale is large and cost-to-benefit ratios are predictable. It is much harder to change people's habits. U&EM has had the responsibility to conserve energy on behalf of the Cornell community and that effort must not only continue, but it must be significantly increased and made much more visible by involving the users of the energy – the researchers, staff, and students in our buildings....

Engaging the Cornell community as active participants in our campus conservation efforts is necessary to reduce demand. Poor user behaviors – be it an energy-recovery fume hood left open or a compact-fluorescent lamp left on – will undermine investments in energy-efficient systems.

So we propose a paradigm shift driven by an operating principle: While it is the responsibility of the institution to provide efficient equipment within facilities that afford a safe and comfortable environment, it is the responsibility of the user to operate them efficiently and only when needed. It should also be the user's responsibility to purchase efficient plug loads. Climate neutrality will thus be a *shared* endeavor.

To affect this interdependent relationship, we will need a functional division of labor within Cornell's administrative structure. The Utilities and Energy Management function is already tasked with improving the efficiency of building systems. To complement that role, efforts to reduce demand will need to engage the functions and stakeholders associated with the Provost, Budget Office, Campus Life, and Human Resources.

A Commitment

This approach implies that achieving climate neutrality is not simply about deploying technologies. Nor is it solely about achieving *operational* climate neutrality. Indeed, the American College & University President's Climate Commitment states that signatories...

"will develop an institutional action plan for becoming climate neutral, which will include; actions to make climate neutrality and sustainability a part of the curriculum and other educational experience for all students and to expand research or other efforts necessary to achieve climate neutrality."

Our proposed efforts to reduce demand for energy by changing the underlying culture at Cornell speak directly to this mandate. It will permit Cornell to fulfill its further responsibility under the Commitment to help our students "meet their social mandate to create a thriving, ethical and civil society."

Buildings, equipment, and facilities and how they operate are the result of decisions by people. By making better choices, we can significantly reduce how much energy we use to accomplish Cornell's research, teaching, and outreach missions.

Some Observations

Here are some insights and observations that deserve mention as a sidebar to our specific recommendations:

The Payback Problem

Decisions driven by fixed simple paybacks and current utility billing rates yield conservation programs that vary with the changing cost of energy and availability of capital funding, and eventually work will stop. Results from the program will vary over time and may not achieve long term reduction goals that go well beyond “single bottom line” thinking.

Exceptional energy savings will require innovation, user participation, and eventually full system replacement. If that replacement is required well before a system’s life is reached, significant capital expense will be required.

A Shift in Focus from System to Environment and Whole Building

More aggressive efforts to conserved energy tend to shift our focus: from the system to the environment, from technology to design. Some examples:

- *High-performance lab safety focuses on air quality and effective ventilation – which are unique to every space – rather than fixed minimum quantities of air flow.*
- *High-performance lighting focuses less on the fixture’s lumens/watt efficiency and more on the user’s visual experience, comfort, and delight.*
- *A high-performance retrofit will include a number of project elements with extended paybacks such as windows and wall insulation that in total go beyond our current 20% reduction goal.*

A Big Idea Merits a Big Effort

Achieving climate neutrality by 2050 will require an extraordinary effort. So we propose a goal of 30% energy reductions from our existing 2008 facilities energy use. This will require both aggressive efficiency upgrades and creative approaches to behaviors and practices to reduce demand. It will require intermediate goals for efficiency so that progress can be tracked. And it will also require a progression of funding that will begin with a payback that meets or exceeds the endowment’s return, and over time will extend to longer and longer paybacks.

Organization of Technical Briefs

On the pages that follow, actions to advance energy conservation are organized under nine themes. There are two facing pages for each theme, and each falls within one of two energy conservation strategies.

1. Improve Efficiency

Actions to improve system efficiencies address the responsibility of the institution to provide efficient equipment within facilities that afford a safe and comfortable environment. These actions are divided among five themes: *lighting, stationary equipment, heating, ventilating & air conditioning, building envelope, and whole building.*

One-time capital expenditures to improve energy efficiency are never sufficient to achieve energy savings. Energy-efficient systems require ongoing maintenance – along with proper operation by the user – to assure that projected energy savings and the attendant CO2e reductions are realized and delivered into the future. Thus, we need parallel actions to ...

2. Reduce Demand

Actions to reduce demand address the responsibility of the user to operate Cornell facilities and equipment efficiently and only when needed, and purchase high efficiency plug-load and research equipment. These actions are divided among four themes:

1. User Behaviors
2. Plug Loads
3. Flexible Work Arrangements
4. Space Use

Actions to promote reduced demand have less “surety” (assurance that energy reductions will be realized) compared to system changes. But user behaviors have the *potential* to achieve results at lower cost. If something needed to be done immediately, it is easier to change behaviors than to change building systems.

A good portion of the work in years 1-5 is directed at characterizing this potential to yield energy savings/carbon reductions for behavior change, and ascertaining the most effective mechanisms to deliver those results.

Ideas

1. green lighting
2. more integrated “Smarter Lighting for a Greener Campus” project
3. create & enforce lighting standards
4. enforceable lighting policies
5. ban incandescent lamps
6. lighting design & fixture selection standards (e.g., lighting levels at task, ambient light levels, accommodating daylight)
7. food-serving area lighting
8. develop solutions/best practices for existing spaces that may not be subject to retrofit
9. lighting standard and controls in labs
10. spec common lamps
11. controls on athletic field lighting
12. daylight-dimming control w/ programmable dimming ballasts
13. install control lighting parallel to façade to allow layers of control
14. replace entire fixtures
15. fixture reflector & ballast retrofits
16. multi-level occupancy sensor-based control of public area & hallway lighting
17. complete campus lighting projects
18. complete campus switch labeling program
19. research human factors associated with lower ambient lighting

Policy Actions

-

Process Actions

- develop & enforce campus-wide lighting/control design standards by occupancy type

Opportunities for Researchers & Educators

- research human factors associated with lower ambient lighting levels
- develop more holistic lighting design guidelines that focus on visual comfort (rather than quantitative lighting levels alone)
- evaluate and recommend new lighting technologies for greenhouses and growth chambers to improve efficiency of the light source and management of the light energy delivered to the plants

Single Bottom-Line Costs & Benefits

campus lighting projects

Annual Costs

(yrs 1-10) complete existing projects \$ 1,000,000
(yrs 16-40) 2nd generation retrofit \$1,200,000

Benefits

(yrs 1-10) 25% reduction in lighting energy use
(yrs 16-40) 50% reduction in lighting energy use

greenhouse lighting project

One-Time Cost

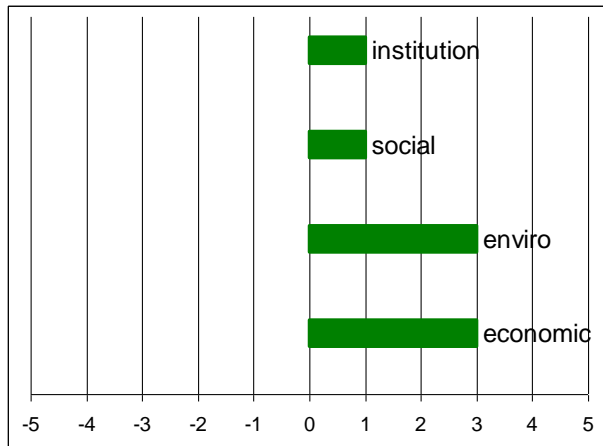
(yrs 1-5) Guterman & Ken Post \$ 4,000,000

Benefits

annual electrical savings \$ 900,000

Triple Bottom-Line + Analysis

Lighting retrofits are a common institutional response to energy conservation, yielding relatively quick paybacks, and displacing carbon-intense purchased electricity.



Lighting

complete campus lighting projects

Since 2000, a third of all campus buildings have been retrofit with energy-efficient lighting and controls. These projects built on the lighting projects of the 1990's that eliminated transformer ballasts and T12 lamps. Completing the remaining buildings at a cost of \$1 per square foot will take \$10 million and 10 years.

We assume that the next generation of lighting technology will yield a 50% reduction in lighting energy consumption (reduction from about 1 watt/sq ft to .5 watt/sq ft typical peak). During years 16-40, all campus buildings will be retrofit at a cost of \$2/square foot (twice the cost of our existing retrofit projects) and be completed at a rate of \$1,200,000 annually.

Guterman & Ken Post lighting projects

These greenhouses have per-square-foot annual energy costs higher than all other College of Agriculture and Life Sciences (CALS) facilities. Much of this is attributed to lighting. Lighting fixture and control upgrades will create lighting that is more efficient, more uniform, and dims in response to increased daylight ...and yield a simple payback of less than 5 years.

These improvements will occur at Cornell's 200,000 NSF of greenhouse space at Ithaca, and can be replicated at Geneva and Long Island at a cost of \$3,000,000 during years 6-15 (... though these latter two sites are outside the footprint of the present Cornell GHG Inventory, and are not included in the costs/benefits for this analysis).

Ideas

1. computer room cooling design standards
2. ultrasonic humidifiers w/ DI water to replace heat-driven humidification in computer rooms
3. hot & cold aisle separation to reduce mixing/airflow and increase return CHW temp in computer rooms
4. use rack cooling in computer rooms
5. relax control set-point dead band to reduce run time in growth chambers
6. improve efficiency on existing refrigeration loads
7. optimize elevator operation (e.g., only send 1 car to answer call button)
8. check out elevator drive system efficiencies
9. incentives to encourage energy-efficient equipment upgrades
10. synchrotron conservation & energy recovery opportunities
11. centralize growth chambers & use central utilities
12. solar-powered pumps for waterfalls

Policy Actions

- develop a university-wide policy mandating that research departments labs with multiple fume hoods consolidate fumes hoods whenever possible

Process Actions

- develop computer room/data center cooling design standards
- engage in a collaborative effort to identify the kinds of policies and guidelines needed to reduce energy use associated with computers, peripherals and network systems.

Opportunities for Researchers & Educators

- explore spatial design implications of centralized loads (refrigeration, growth chambers, etc.)
- investigate energy conservation/recovery opportunities at the Wilson Synchrotron
- investigate other equipment-specific energy conservation opportunities

Single Bottom-Line Costs & Benefits

Fume Hood Reduction Program

<u>One-Time Costs</u>	
de-activate 125 Fume Hoods	\$ 250,000
<u>5-year Annual Costs</u>	
EH&S support	\$ 120,000
U&EM support	\$ 50,000
total	\$170,000

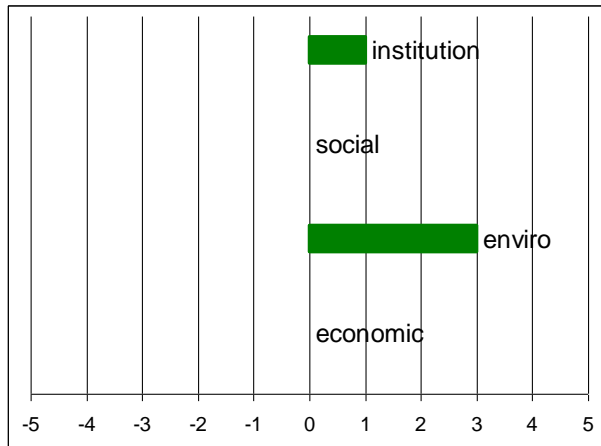
<u>Benefits</u>	
annual energy savings (10% electric, 45% heating, 45% cooling)	\$ 625,000

Growth Chamber Controls Program

<u>One-Time Costs</u>	
retrofit 500 Growth Chambers	\$ 3,500,000
<u>Benefits</u>	
annual electric-only use savings + improved control of research environments	\$ 2,250,000

Triple Bottom-Line + Analysis

This is energy-intensive research equipment, so the environmental and economic benefits are substantial.



Stationary Equipment

Cornell has a variety of energy-intensive research equipment. During years 1-5, we will focus financial resources on simple, quick-payback strategies to ...

- de-activate unneeded equipment
- improve controls to turn off equipment when it need not be operating
- improve the efficiency of operating equipment.

Also during years 1-5, a parallel effort will inventory and evaluate opportunities associated with equipment that is more complex (i.e. the Wilson Synchrotron) or more ubiquitous (computers, peripherals and our IT network).

Fume Hood Reduction Program

There are over 1,500 fume hoods on campus, each using \$5,000 of energy per year. Overall, fume hoods use 10% of Cornell's total cost of energy, or \$7,500,000 annually. This program would focus on multi-fume hood labs, where hoods are often used for chemical storage. Unused fume hoods would be de-activated, and chemicals relocated to storage cabinets. The program would be collaboratively run and funded by Utilities and Energy Management and Environmental Health and Safety (EHS).

The unused hood would be deactivated until the department demonstrates that a deactivated hood must be re-activated to enable active research in that lab. Planning, Design, and Construction (PDC) Shops would then re-activate the fume hood, rebalance the supply and exhaust air in the lab, and have EHS verify that the fume hood operation is acceptable.

The total cost to de-activate and re-activate a fume hood is \$500 - \$2,000. If 25% of the 500+ fume hoods in the 250+ multi-fume hood labs were deactivated, Cornell would save \$5,000 per fume hood (or \$625,000 annually).

Growth Chamber Controls Program

Growth Chambers use refrigeration, heating and lighting to simulate growing environments for research. There are 500 walk-in Growth Chambers on campus, each consuming \$6,000 in annual billed energy. Collectively, they use 10% of Cornell's electric energy. Pilot projects have demonstrated that lighting and controls retrofits can reduce energy use by 75% or more.

This program would retrofit lighting and controls in 100 Growth Chambers per year during years 1-5. During that period, savings would accumulate at a rate of \$450,000 each year.

Ideas

1. develop new lab air ventilation rates based on chemical, biological, radiological, and material use & control banding hazard class/assessment
2. scheduled occ/unocc air flow & temp setpoint control w/ user override push buttons
3. policies to encourage proper design/use of fume hoods
4. develop & enforce a thermostat policy (define role of Eco Reps, maintenance staff; rules to guide work done by maintenance staff)
5. VAV fume hoods in labs
6. separate ventilation from sensible heating/cooling
7. variable-flow air and hydronic controls/systems
8. occupancy sensor & sash position control of lab air flows
9. optimize central HVAC controls
10. better maintenance (both preventive and routine) of building HVAC systems
11. repair & improve insulation in mechanical rooms
12. install fan coils units in rooms using OA to cool heavy plug loads
13. utilize summer waste heat (desiccant dehumidification) to dehumidify library spaces
14. replace pneumatic space controls with digital
15. complete controls retrofits across campus; 1st & 2nd generation controls replacement
16. dew point control of cooling set-points on vent-driven loads to minimize cooling/reheat
17. occupancy sensor controls (with 8/4 ACH vent rates)
18. occupancy-based temperature offsets
19. unassigned mode for rooms & hoods
20. retrofit energy recovery (energy recovery @ BTI, energy recovery in Duffield Hall)
21. gas boilers retrofits to campus steam in Weill Hall, ECRF Biotech
22. repair leaky steam valves
23. more sophisticated control strategies
24. research re human factors & energy use: ("black box vs user control", limited vs full user control, strategies for re-zoning)
25. lab education re counter-intuitive operation of systems
26. evaluate existing buildings/retro-commissioning

Policy Actions

- develop policy on thermostat control set-points (see also "User Behaviors" theme)
- review policy on laboratory ventilation rates

Process Actions

- resolve the current lack of a firm relationship between conservation focused maintenance and energy funding on the CCF campus, thus permitting space controls preventive maintenance work for CCF facilities
- expand ECI programming to include Campus Life, the professional schools, and off central campus (vendor billed) facilities

Opportunities for Researchers & Educators

- assess how reductions in ventilation flow rates may undermine the economic benefits of system efficiency improvements.
- Laboratory ventilation and makeup air accounts for roughly 50% of Cornell central campus energy use. How might research and space design in existing buildings be changed to significantly reduce ventilation air?

(... need to assess whether other ideas should be folded into this list)

Single Bottom-Line Costs & Benefits

Energy Conservation Initiative

1-5 yrs

ECI Phase I Capital Cost \$ 25,000,000
Annual Benefits = 5% energy reduction
(20% electric, 40% heating, 40% cooling)

6-15 yrs

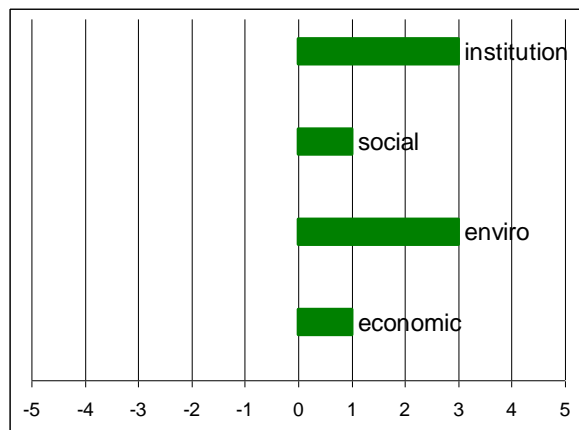
ECI Phase II Capital Cost \$ 100,000,000
Annual Costs \$ 2,000,000
Total Cost = \$110,000,000
Annual Benefits = 15% energy reduction
(20% electric, 40% heating, 40% cooling)
(include \$150k annual expense new for extra staff)

16+ yrs

Major System Replacement Capital Cost \$1,000,000,000
Annual Benefits = 15-20% energy reduction (in that space, not
of campus total as on the first two)
(20% electric, 40% heating, 40% cooling)
(add another project manager at \$150k)

Triple Bottom-Line + Analysis

This theme shows institutional leadership and yields significant environmental impacts. ECI Phase II work will require triple bottom line thinking, and Phase III work will require hard reduction goals and significant capital with much smaller relative savings.



Heating, Ventilating & Air Conditioning

Energy Conservation Initiative: Phase I (1-5 yrs)

ECI will be continued and expanded to cover all Ithaca Campus facilities, significantly increasing maintenance and doubling capital conservation projects. Conservation focused maintenance will be expanded to include space controls conservation focused preventive maintenance (PM) for Contract College Facilities. A new conservation-focused PM program will be added for Campus Life, and the professional schools. Energy studies and resulting projects will continue and include most major central campus buildings by 2015. We will continue to strive toward a 20% reduction in each building after PM and capital conservation projects are completed. The 5% total campus reduction in energy use resulting from this effort will have capital costs of \$25,000,000, along with \$750,000 in annual operating costs (CCF PM @ \$400k, Campus Life PM @ \$300k and Professional Schools PM @ \$50k).

Energy Conservation Initiative: Phase II (6-15 yrs)

A second round of ECI improvements, along with continued preventive maintenance, will be done on all campus buildings. The program will be further expanded to include off central campus facilities in this time period (not currently budgeted). However, since lower-cost, quicker-payback measures were completed during Phase I, this round of work will cost twice as much to yield the same 15% total campus savings as Phase I.

Major System Replacement (16+ yrs)

In the long-term, major building systems will need to be replaced. These extend beyond mechanical systems to include the potential for major upgrades of the building envelope (e.g., new fenestration discussed under the "Building Envelope" theme and the addition of new wall and roof insulation).

While no one can be certain of the technologies and their cost, we assume a one billion-dollar program at an estimated cost of \$300 per square foot. This cost is based on the Olin Hall and Vet Research Tower mechanical/electrical upgrade projects underway in 2009, both of which include envelope upgrades and innovative HVAC systems. This would cover one quarter of our present campus buildings, implying that a major upgrade of all campus buildings will be a *century-long effort* costing \$4 billion and would be in addition to but complementary with maintenance renewal of our buildings that would be separately funded by the university through Maintenance Management.

To incrementally build our internal capacity, the pace of spending is incrementally increased through each of the three periods of the CAP: (\$5 million/year for years 1-5, \$10 million annually for year 6-15, \$40 million annually for 25 years commencing in year 16).

Ideas

1. increase insulation in old Cornell buildings
2. operable windows for building climate control
3. passive cooling w/ openable windows & stack ventilation of vertical spaces
4. develop re-roofing strategy
5. transition from black roofs to light-colored roofs
6. envelope improvements
7. solar shades to reduce cooling load
8. glazing/fenestration replacement
9. reduce infiltration
10. use of passive solar heating & daylight

Policy Actions

Process Actions

- use pressurized blower door testing of building spaces to inform infiltration-reduction work to be done

Opportunities for Researchers & Educators

- assess the trade-offs associated with the choice to do thermal envelope vs.HVAC improvements to reduce energy used to temper building spaces; use the results of that assessment to inform building energy conservation strategies used after the first five years
- evaluate production-based strategies to reduce the cost – and shorten the payback periods – of major window replacement
- student modeling of building thermal envelope measures to evaluate the efficacy of alternative options
- evaluate integrated rooftop strategies

Single Bottom-Line Costs & Benefits

Building Weatherization Program

<u>One-time Costs</u>	
40 buildings @ \$10,000 each	\$ 400,000
<u>Benefits</u>	
per-building savings in annual energy = \$2,000 (20% electric, 40% heating, 40% cooling) + improved thermal comfort for occupants	

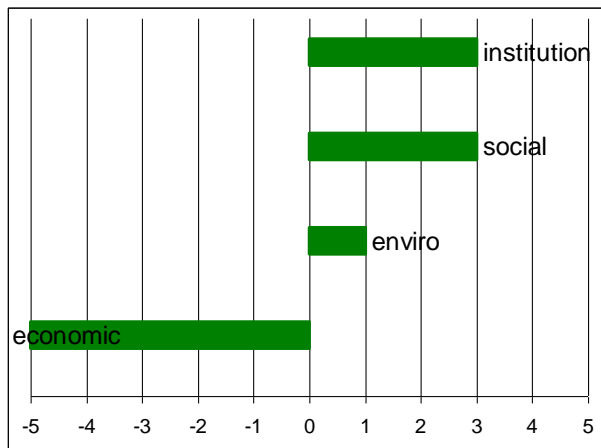
Major Fenestration Replacement

Costs and benefits are calculated as part of the “major system replacement” under the HVAC theme.

Triple Bottom-Line + Analysis

Window upgrades would improve thermal comfort and send a more visual signal of energy efficiency efforts. But this would be very expensive, and require triple bottom line justification.

By contrast, weatherization work will have modest costs and yield quick paybacks.



Building Envelope

It is challenging to justify building envelope improvements based on simple economics. Typical Cornell windows and exteriors are architecturally significant and very expensive to modify. Paybacks will often exceed 20 years, well beyond our current mandate for cost effectiveness. Further, energy use in Cornell's most energy-intensive buildings is driven by ventilation flows rather than the quality of the thermal envelope.

However, leaky windows substantially affect user comfort at a campus dominated by winter conditions. So we recommend a short-term effort to reduce infiltration via effect simple, low-cost measures, combined with a plan to assess ways to make more expansive – and expensive – fenestration upgrades more cost-effective.

Building Weatherization Program (1-5 yrs)

This low-cost program would caulk and weatherstrip windows and doors to reduce outside air infiltration. Windows required for ventilation would be weatherstripped, but remain operable.

The first year's pilot effort will focus on the 10 worst buildings from the older areas of campus (Arts and Sciences, Campus Life, Engineering, and the College of Agriculture and Life Sciences). The pilot will identify the most effective package of measures and means to deliver them. That package will then be used to improve 30 buildings the following year.

Based on a fixed budget of \$10,000 per building, infiltration work will be driven by blower-door pressurization that will help locate areas to be sealed. (This may prove difficult in a building with inter-floor/inter-room bypasses.) Infiltration-reduction work will be terminated when a maximum leakage rate is attained.

Major Fenestration Replacement and Insulation Upgrade (16+ yrs)

The very windows and doors that define the character of Cornell's older buildings will eventually need to be replaced. In many of our older buildings, they create areas of thermal discomfort for occupants.

Given the significant cost and architectural impact of major window upgrades, we need to evaluate how we might undertake this work as a large-scale production enterprise that exploits volume to reduce cost.

The exterior walls and roofs of many Cornell buildings have minimal insulation. Over time as we reach to longer paybacks, adding insulation to roofs and walls will become possible....

Ideas

1. develop energy budgets for every project
2. don't overbuild for future ventilation and plug load
3. add a carbon value in decision-making for conservation projects when doing payback & cost/benefit calcs
4. allow longer paybacks on energy projects
5. energy performance enforcement policy for PAR's
6. policy to allow buildings to be closed down (locked) during certain hours
7. improved inspection & continuous commissioning
8. drawing & spec review focused on conservation
9. update University Design & Construction Standards
10. modeling to support conservation
11. improved data tracking & analysis; near real-time analysis of load vs. OA & time-of-day to alert of energy use changes vs modeled/expected energy use
12. energy audit on campus buildings (e.g., those managed by Real Estate)
13. effects of orientation & massing on passive strategies
14. financial incentives to A/E consultants for designs that achieve various energy goals
15. unused lab space & animal facilities put to a low energy level; lock-out & labelled
16. dedicated building energy managers
17. greenhouse improvements (lighting controls; heating & cooling controls; blankets; replacement)
18. continuous commissioning with building-interval data
19. formal third-party commissioning & HVAC Shop Cx support
20. conservation & management program for campus housing & dining modeled on rest of campus (Greening the Straight)
21. go back to 1st pass ECI buildings
22. move faster through the poor performing spaces
23. focus on kitchen energy use
24. Energy Performance Contracts off Central Campus
25. new tools to speed creation of energy models; quick & dirty tools
26. student energy stewards/Eco-Reps; energy-efficiency army

Policy Actions

- develop enforceable energy budgets for each construction or renovation project
- develop a close-down/lock-down policy ... (1) during weekends, (2) when classes are not in session, and (3) for unused lab spaces & animal facilities

Process Actions

- require that all projects undergo an energy review; assure that program change comes back through U&EM for review
- notify U&EM when major equipment is replaced.
- have design decisions driven by energy modeling analysis.
- improve the "design -> commissioning -> maintenance" hand-off for each project.

Opportunities for Researchers & Educators

- cultivate education & research projects that help Cornell's operations staff keep up-to-speed on evolving technologies that will help us – and the world – achieve climate neutrality ... in turn, have operations staff create education & research opportunities as part of the design process for innovative applications
- promote courses that integrate across disciplines (e.g., business school & engineering school), so the next generation of business leaders have greater technical acumen, and the next generation of technology leaders have greater business acumen.
- use Cornell's proliferation of laboratory spaces across multiple disciplines as an international test bed to develop design strategies for low-energy, high-performance lab environments.
- get students to model buildings on campus, as a means of helping them understand multivariate analysis and the underlying ecology of building systems.
- Facilities staff should offer *more* campus talks with building coordinators
- evaluate the viability of retro-commissioning Cornell's existing buildings

Single Bottom-Line Costs & Benefits

Building Energy & Analysis Improvements

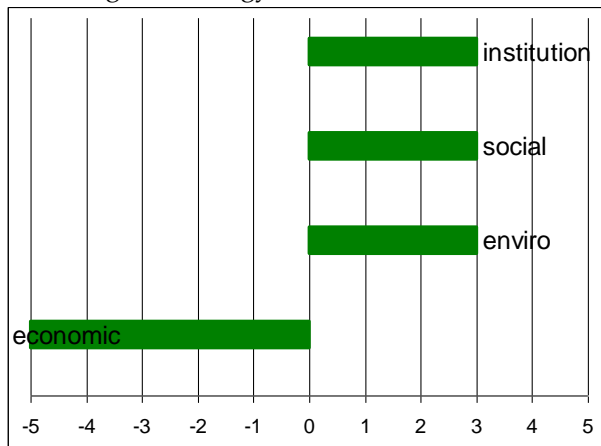
<u>Annual Costs</u>	
Data Steward	\$ 140,000
Energy Analyst	\$ 120,000
Software	\$ 60,000
Total	\$ 300,000
<u>Benefits</u>	
reduce annual energy use 2%+ = \$ 1,400,000+	
(20% electric, 40% heating, 40% cooling)	

Improve Quality of Air Flows in Lab Spaces

<u>5-year Annual Costs</u>	
EH&S FTE	\$ 120,000
re-commission 200 labs/year	\$ 250,000
Total	\$ 370,000
<u>5-year Benefits</u>	
energy savings = \$5,000,000	
(10% electric, 45% heating, 45% cooling)	
+ improved lab safety & environmental quality	

Triple Bottom-Line + Analysis

The energy reductions are quite substantial, with the analytical and lab themes positioning Cornell to show leadership among peers. Economic returns are good for a strategy that deploys human capital to leverage technology.



Whole Building

This theme exploits opportunities in Cornell's existing processes and operations.

Building Energy & Analysis Improvements

Each building has heating, ventilating and air conditioning systems nearly all of which are digital today. Building Automation and Control System(s) develop tremendous volumes of data. At this time, most of that data is lost because we fail to archive it. And we don't have the capacity to analyze massive quantities of data to inform operational and design decisions.

We will create an interval data database with analysis software and provide staff support to operate and maintain it. Analysis tools will direct conservation-focused maintenance efforts.

Data for the top 50 buildings will be uploaded within two years, with all 150 major buildings to be completed within four years. Analysis and optimization of building systems will begin as soon as they are loaded into the system. Data and analysis tools will be widely available to PDC Control and Refrigeration Shop staff, building management, energy engineers, and design engineers.

We anticipate being able to reduce building energy use 2-5%. Each 1% of building energy use costs \$700,000. Annual return on this investment would range from \$1.4-\$3.5 million.

Improve Effectiveness of Air Flows in Lab Spaces

Fully half of Cornell's energy bill pays the cost to move and temper ventilation air for our 3,000 lab spaces. There is professional consensus that a higher *quality* air flow, properly controlled, creates a safer work space with lower *quantities* of air. We should help advance the state-of-the-art in this area to show institutional leadership, and then use the energy savings for monitoring and testing to prove that lab environments will indeed be safer.

To that end, we propose to pay for all staff necessary to effect this initiative with a portion of the savings that will be harvested before the end of pilot period. Higher-quality air flows will allow us to safely reduce ventilation rates from 8/4 air change per hour (occupied/unoccupied) to 6/3, saving \$1 annually for every square foot of Cornell's 2-million square feet of lab space. The first 5 years of this program will re-commission half of that space.

One new, dedicated staff position in EH&S will create and support a new laboratory ventilation, safety and conservation program. The new staff person will work with Utilities and Energy Management to create ventilation rates for all spaces on campus, create a program to reset rates, and then monitor and evaluate spaces over time. ECOS will be involved to assure the building exhaust systems do not degrade outside air conditions because of inadequate dispersion. New administrative programs, enforcement, and monitoring will yield *increased* safety in lab environments.

Ideas

1. restrict loads at peak times
2. develop load-shifting incentive program
3. define a range of temperature setpoints
4. limit access to space controls
5. develop holiday conservation policy
6. submeter unmetered dining facilities & bill to units
7. break out & bill utility costs by building
8. develop SOP on equipment use (for kitchen equipment, lab equipment, etc.)
9. develop SOP on residential hall thermostat adjustments
10. use demo projects to test user acceptance of new technologies
11. loading dock conservation retrofits
12. energy conservation competitions
13. student involvement in pushing conservation
14. develop outreach/awareness program
15. hire student Eco-Reps to turn out lights, close hood sashes & promote energy-conserving behaviors
16. bio-safety labeling program
17. enhanced light switch labeling program
18. web-accessible meter/sub-meter data
19. integrate sustainability into educational programming
20. educate users & occupants
21. build a web site with lots of content & conservation tips
22. lab energy use education program
23. promote cultural change at Cornell
24. education & outreach to reduce plug loads
25. energy conservation training
26. Cornell certification for building & facility managers
27. involve Deans & Department heads in paying utility costs
28. develop an Energy Incentive Plan

Policy Actions

- 1-5 yrs: develop a university-wide temperature set-point policy
- 16+ yrs: implement energy charges

Process Actions

- the operating schedule of the set-point policy should be incorporated into energy models that inform the design of new or renovated campus facilities.
- brief new faculty, students & staff on Cornell's conservation policies
- develop holiday/break procedures to shut down spaces that don't need to be tempered and/or ventilated.

Research & Education Opportunities

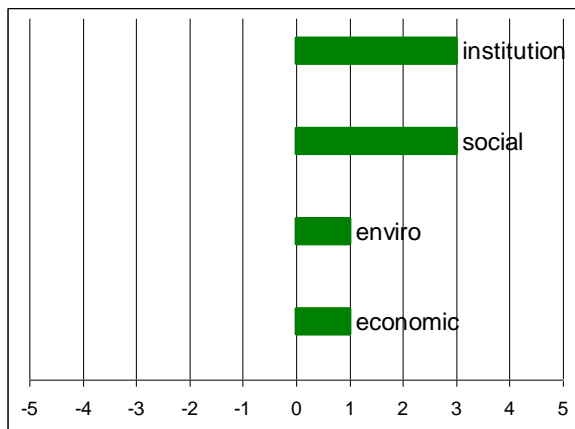
- evaluate institutional business structures to equitably allocate energy costs
- research energy charge policies at other institutions & run pilot projects to ascertain approaches that work
- evaluate the economic costs & benefits of load-shifting
- evaluate the efficacy of institutional programs to incentivize energy-conserving behaviors (e.g., rewards, shared savings, cap-and-trade mechanisms, energy charges)
- test user acceptance of new energy-saving technologies

Single Bottom-Line Costs & Benefits

<u>Annual Costs</u>	
technical support from U&EM staff	\$50,000
program support from ECOS staff	\$50,000
student Eco-Reps	<u>\$50,000</u>
total	\$150,000
<u>Benefits</u>	
annual electricity cost savings	\$400,000

Triple Bottom-Line + Analysis

This theme's focus on culture change has strong social impacts, and evidences institutional leadership in cultivating the next generation of leaders. However, the near-term economic & environmental impacts are modest compared to system improvements.



User Behaviors

Conservation Outreach Program

During the 2009-10 academic year, a pilot program will educate users and build a culture of conservation at Cornell. An inventory of Best Practices will be developed for each occupancy type (classroom, office, lab, etc.). Student "Eco-Reps" will advise, encourage, and conduct periodic checks to ascertain whether Best Practices are being followed.

Each Eco-Rep will be supervised by a Building Manager/Coordinator (for academic buildings) or a House Dean/Resident Manager (for campus housing). Technical support will be provided by Utilities & Energy Management Staff, while programmatic support will be provided by Cornell's Sustainability Coordinator in ECOS.

Pilot programs presently being planned for the 2009-10 academic year will (1) characterize potential energy savings/CO₂e reductions and (2) ascertain the most effective ways to staff, support and manage a campus-wide effort in subsequent years.

Assuming that 10% of university-wide electrical load is within the control of individuals, and that improved user behaviors will reduce that by 15%, the net reduction in electrical load will be a modest 1.5% of annual electrical costs, or \$400,000 annually (based on 2008/09 billed rates).

Energy Charges

Unless administrative units bear their energy costs – or share in the savings – they have little reason to conserve energy. The challenge is to match metered use to an administrative unit with control of that space. That will be a difficult in buildings with more than one "tenant." So we must explore creative, yet fair, structures to incentivize conservation. To that end, we propose to research alternative systems to impose energy charges/conservation rewards during years 1-5, in preparation for pilot programs for selected buildings during years 6-15. An energy charge/conservation reward policy will be prepared for implementation in years 16+.

The solution need not involve energy charges for everyone. An alternative approach may involve sub-metering and a surcharge only for those functions (labs, computer servers, greenhouses, etc.) that require energy above a base level for, say, an office space. Likewise, the solution may not involve the metering of all spaces, but rather metering only spaces and/or devices that are charged for using larger amounts of energy above that base level.

Another alternative would create a baseline energy use each year from which a building/user is either charged/paid for usage above/below the baseline. This last strategy has been used successfully by Campus Life in the residential buildings on the combined electricity and water cost. Campus Life expects to reinstitute this energy competition program Fall 2009.

Ideas

1. green computing across campus
2. develop a policy re vending machine energy use & consumption
3. shut down refrigerators when not in use
4. develop policy re refrigerators (faculty & staff personal refrigerators, student micro-fridges in housing & labs)
5. control use of space heaters
6. revise computer back-up strategy
7. shut equipment OFF!
8. spec Energy Star office equipment
9. improve efficiency of microwave ovens
10. rebate program to get rid of personal space heaters; timer switch to shut off when not needed
11. plug load conservation program
12. remove old equipment & replace with more efficient model
13. create a database of equipment efficiencies
14. SOP for purchasing high-efficiency products
15. evaluate vending machine energy use, consumption technology, and policy solutions
16. web-based tools on high-efficiency equipment purchasing

Policy Actions

- develop policies to reduce energy consumed by larger plug loads on campus (computers & peripherals, refrigeration, etc.)
- develop a vending-machine policy & performance specification

Process Actions

- building on the existing Purchasing (Supply Management) policy, specify/mandate/incentivize Energy Star-rated equipment purchases campus-wide
- shut down refrigerators and other high energy-intensity equipment when not in use

Opportunities for Researchers & Educators

- assess energy-saving opportunities for both individual computers and network systems that inform the development of specifications for both computers *and* peripheral equipment
- assess vending-machine technology and program options, then develop a university-wide policy and performance specification for vendors
- determine what causes electric load in buildings and create ways to cost effectively give users real time data associated with loads in their control (plug load and lighting, occupancy of laboratory spaces)

Single Bottom-Line Costs & Benefits

Space Heater Replacement Program

One-Time Costs

1400 radiant heaters @ \$100 each \$ 140,000

Benefits

billed electrical savings over 5 years \$ 450,000

Triple Bottom-Line + Analysis

Since plug loads are not a significant portion of electrical use, the actual impact of behavior changes may be modest. That change may be very cost effective, and using plug load wisely is a very important part of culture change.

Plug Loads

Since plug loads are added or subtracted by people, they are part of the User Behavior theme (on the previous page). However, there needs to be a parallel effort to improve the efficiency of equipment that is plugged into electrical receptacles.

As a point of departure, we must build on the Purchasing (Supply Management) Department's policy requiring the purchase of energy-efficient equipment. We should assess how those existing requirements may be improved, expand that policy to include a mandate with incentive/penalty features, and then assure that people are briefed and the policy is enforced. Among the plug loads for which a policy and specifications should be developed:

- research equipment
- vending machines
- computing equipment and peripherals
- personal appliances (refrigerators, microwaves, etc.)
- task lighting & lamps

Space Heater Replacement Program

Students, faculty and staff frequently use personal convection heaters beneath their desks. These 1,000-watt units, if operated during daily work hours, have an operating cost of \$200 per year. A \$100 radiant panel uses 1/10th of the electricity, saving \$180 per year. The financial return would justify giving out the radiant units via an exchange program.

Prior to the exchange, Facilities staff will assess whether modest envelope or HVAC improvements may help avoid the need for a personal heater. This work would be done as part of the Conservation-Focused Maintenance already funded by Cornell.

If 10% of Cornell's 14,000 staff and grad students use personal convection heaters and would replace them, we'd need 1400 units at a cost of \$140,000. We propose a program to replace 200 units in the first year, then replace 300 units per year during the following four years. This would yield over \$450,000 in savings over five years. Thus, this program would pay for itself even if people use their personal heaters only 1/3 of their daily working hours.

Ideas

1. develop alternative work strategies
2. allow longer work days for 4 days each week
3. flexible work spaces
4. flexible work hours
5. explore distance learning tools to cut down on travel
6. make investments in home offices
7. integrate new work strategies specific to programs
8. implement a tele-work program
9. implement a variable work-hours program
10. explore the potential to increase online courses for students

Policy Actions

- 6-15 yrs: develop and institutionalize a Flexible Work Arrangement (FWA) policy

Process Actions

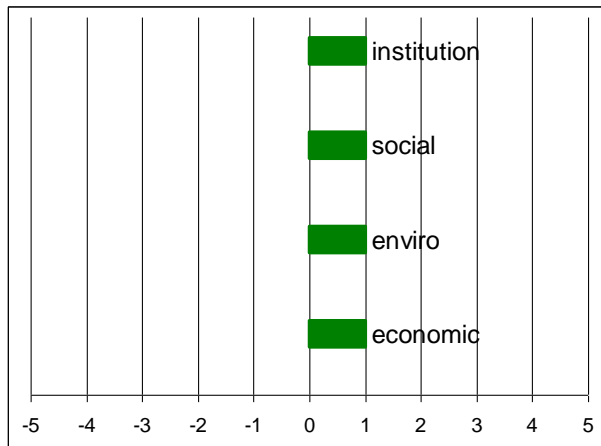
- identify and support supervisors who are willing to consider FWA's for their employees

Opportunities for Researchers & Educators

- develop designs for office environments that (1) offer more amenity in return for smaller work stations, or (2) provide a shared working space for two or more job-share/flex-time/tele-commute employees
- evaluate potential design/technology solutions for shutting down office spaces for short-term periods
- inventory potential inducements to use smaller or shared spaces ... for both employees *and* supervisors.

Single Bottom-Line Costs & Benefits

Triple Bottom-Line + Analysis



Flexible Work Arrangements

for staff

A flexible work arrangement (FWA) allows employees to telecommute (work from home or nearby satellite location), work flexible hours, or share a job.

The original intent was to create more options to recruit and retain employees. Energy and facilities space savings flowing from these arrangements were secondary, if they were to be had at all. However, when combined with the policy thrust of Space Management (see the following section), there are opportunities to create functional and programmatic synergies. The capacity to harvest the employee's home or a satellite location holds the potential to offset on-campus space needs.

So perhaps Cornell might consider not simply permitting FWA's, but *encouraging* them.

Approximately 92 employees (36 of whom live outside Tompkins County) are now telecommuting at least one day each week. A survey is currently being conducted to assess the attributes and preferences of this population.

FWA's are a proven means to increase employee satisfaction. However, we need to assess their efficacy as a means to save money and reduce CO₂e emissions. So we recommend that Cornell undertake a series of pilot projects and studies during years 1-5.

for students

Similar opportunities exist for students. So there should be a parallel effort during years 1-5 to inventory and evaluate opportunities for online courses.

Ideas

1. isolate work spaces from lab work spaces
2. remove lab hoods that aren't needed
3. share high-energy lab equipment
4. share lab space
5. clean outour & consolidate refrigerated specimens
6. give out chemical storage cabinets to help reduce ventilation needs
7. relocate & aggregate high-load equipment (e.g., centrally locate ultra-lows & freezers)
8. integrate teaching & space-scheduling software with building automation system
9. use space controls to shut back unassigned spaces
10. implement a space charge system
11. update classroom utilization standards
12. put more classroom under central scheduling
13. update & implement space guidelines
14. consider using OR/IE industrial department resources to help evaluate carbon-reduction options

Policy Actions

- 1-5 yrs: empanel an Advisory Council (selected to build a constituency) to develop space use policies
- 6-15 yrs: consider space/penalty charges, if there is insufficient voluntary compliance with space-use policies

Process Actions

To enforce the new space-use policies, there will need to be ... (1) changes to design guidelines for both new construction and major renovation work, (2) a better space inventory, along with a means to track and report changes (which is needed in order to monitor & control space use), and (3) a means by which Deansdeans and division leaders may track space use and manage their space.

Opportunities for Researchers & Educators

- explore strategies to incentivize more efficient uses of space; in particular, there is a need to investigate institutional space/penalty charges
- evaluate the viability of a change in the academic schedule, shifting class sessions away from winter (when energy use and carbon intensity is greatest) and into the summer season (when spaces are tempered by less carbon-intensive Lake Source Cooling).

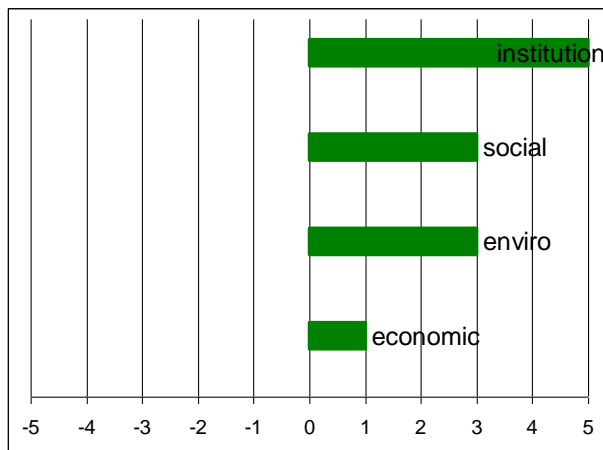
Single Bottom-Line Costs & Benefits

<u>One-Time Costs</u>	
Space Inventory	\$ 1,000,000
Total Space Management System	\$ <u>1,000,000</u>
	\$ 2,000,000
<u>Annual Costs</u>	
Facilities Inventory Office staffing	\$ 100,000
<u>Benefits</u>	
2%-8% reduction in use of existing space	

Triple Bottom-Line + Analysis

The potential to avoid construction of a new building yields significant environmental impacts. Documenting that avoided building – while affording growth within our existing building footprint – would show significant leadership among peer institutions.

Design solutions that give people a smaller, but higher-quality working space, would be important visual representations of a culture of conservation at Cornell.



Space Use

More effective use of Cornell's existing facilities will conserve both energy *and* physical resources. For example, if only 2% of Cornell's existing building space could be harvested, we would avoid the need for one new building equivalent to Weill Hall. And greater density holds the potential to leverage investments in mass transit, thus reducing transit-related emissions.

This initiative comprises three parts: (1) develop space-use guidelines, and (2) develop good data on actual space use, then (3) monitor and control space use.

Space Use Policy

An Advisory Council – impaneled with an eye toward building a constituency for this effort – will develop space use guidelines for the design of new buildings and the reconfiguration of existing spaces. To secure compliance, people will need to understand “why,” rather than simply being told to “do it.” So the space-use policy will need to be complemented by a transparent system that documents *actual* space use.

Space Inventory

Cornell won't be able to manage its space without good data on how it's currently used. So a \$1,000,000 inventory of all campus facilities will be done while the space use policy is being developed.

Total Space Management System

Once we have good data on how our space is used, we'll need a means to report, monitor and control changes in space use. A \$1,000,000 Space Facilities Information Management System will be operated by the Facilities Provost's Inventory Office at an annual cost of \$100,000. A standardized “dashboard for Deans and division leaders” will permit them access to the database to report, monitor and control space use.

This system will permit better cost recovery on extramural external funding, while reducing the risk associated with audits.

The above programming will take place during the first five years of the CAP. This will set the stage for the reconfiguration (“defragmentation”) of space use that will occur via a phased implementation over the following decade (years 6-15).

It is our hope that a fair and equitable policy, combined with reporting, monitoring and control will yield the desired result. However, space charges will also be evaluated during years 6-15 in the event they may be needed – whether to induce behaviors, support program costs or be part of a broader package of combined space/energy charges.

Fuel Mix and Renewables Wedge

Technical Briefs

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Overview

Greenhouse gas (GHG) emissions from Cornell's central plant and electricity purchased by Cornell represent the vast majority of Cornell's carbon footprint. Under the "business as usual" scenario (which includes Cornell's Combined Heat and Power Project (CCHPP)), GHG emissions from the central plant and purchased electricity are expected to grow to about 260,000 metric tons of CO₂ equivalents (MTCO₂e) by 2025 and to well over 300,000 MTCO₂e by 2050. Therefore, the lion's share of both the burden and opportunity for GHG reduction falls directly on the Fuel Mix and Renewables wedge of Cornell's CAP.

Due to the capital investment required to make major changes in the infrastructure Cornell uses to produce heat and power for the campus and the fact that the technology options to produce the required amount of energy without a carbon footprint does may not be economically viable at present, the Fuel Mix and Renewables wedge group recommends a phased approach to the implementation of the endorsed alternatives:

- Short-term (1-5 years)
- Mid-term (6-15 years)
- Long-term (16+ years)

This phased approach will implement low-cost and proven alternatives first while high-cost and/or unproven technologies are developed and optimized in the coming years. However, some of the choices made in the short term will impact decisions made in the long term. The CAP portfolio group will have to consider such interrelations when deciding which path to follow and which set(s) of alternatives to implement. For instance, Cornell may decide in the short- or mid-term to convert existing boilers to burn natural gas in an effort to eliminate coal. However, the cost to make that change may not be justified if Cornell's long-term plan is to eliminate fossil fuel combustion completely.

With those considerations in mind, the Fuel Mix and Renewables wedge working group endorses the following alternatives for possible inclusion in Cornell's CAP Portfolio:

- Short-term (1-5 years):
 - Upgrades to Cornell's existing hydroelectric plant
 - Penstock Upgrades
 - Turbine Rebuild
 - Intake Restructuring
 - Draft Tubes
 - Upgrades to the existing central plant
 - Replace Turbine Generator #1
 - Reduce losses from steam distribution system (Guterman loop)
 - Co-fire wood with coal in existing boilers
 - Utilize landfill gas energy for Cornell's Geneva campus
 - Large scale wind energy (12 MW with direct connection to campus)
 - Engineered Geothermal System (EGS) – Demonstration Scale

- Mid-term (6-15 years)
 - Utilize biomass from Cornell lands through the Cornell University Renewable Bioenergy Initiative (CURBI) project
 - Co-fire wood-based product (e.g., torrefied wood) with coal in existing boilers
 - Early conversion to natural gas (eliminate coal)
- Long-term (16+ years)
 - Expanded engineered geothermal system with biomass peaking
 - Large scale biomass gasification
 - Carbon capture and sequestration (CCS)

Short-Term Alternatives

Hydroelectric Plant Upgrades

Cornell's hydroelectric plant on Fall Creek was built in 1904 and operated until 1969 with few changes. The plant was retired in 1969 and remained shut down until 1981 when it was put back into operation with two Ossberger cross-flow turbines rated at 740 kW and 1,200 kW for a total rated capacity of 1,950 kW. Water is supplied to the turbines from Beebe Lake through a 1,670 foot penstock providing 138.4 feet of available head (see Figures 1 and 2). The penstock was not upgraded with the rest of the plant when it was brought back online in 1981 and remains as it was originally constructed in 1904.

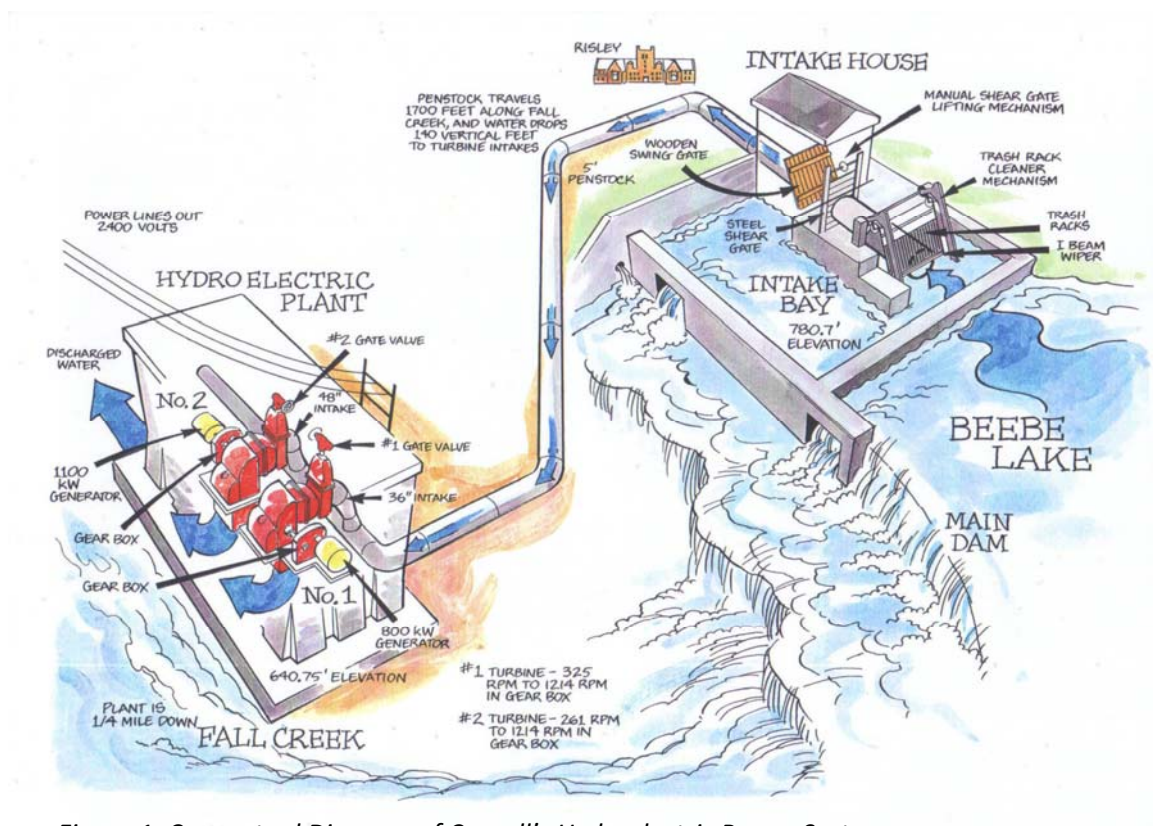


Figure 1. Conceptual Diagram of Cornell's Hydroelectric Power System

The plant currently operates 20 to 30 percent below its maximum capacity with the current penstock. Numerous studies have been performed on the hydroelectric plant over the past several years in an effort to identify opportunities for optimizing output from the plant. These studies provided recommendations for upgrades to the intake structure at Beebe Lake, the penstock, and within the powerplant.

Controls Upgrade

An upgrade to the powerplant controls was completed in the summer of 2008. An Allen Bradley SLC 500 PLC system was installed to improve overall system operation and efficiency, especially during periods of low-flow. The cost of this upgrade was approximately \$80,000 and is projected to raise the average output of the plant to 6,000 MWh per year.

Penstock Upgrades

The existing penstock has not been significantly updated since it was originally constructed in 1904. It runs 1,670 between Beebe Lake and the powerhouse at a diameter of five feet (see Figure 2). The majority of the penstock is constructed of concrete and a small portion (176 feet) is steel. The penstock is nearly level through most of its length and even slopes upward slightly in one section (presumably due to errors during original installation). The primary issues with the penstock that affect plant performance are this upward sloping section, air infiltration, friction losses, and the overall size of the penstock which limits production. It is estimated that 20 feet of head is currently lost through the penstock at a flow rate of 10 feet per second.

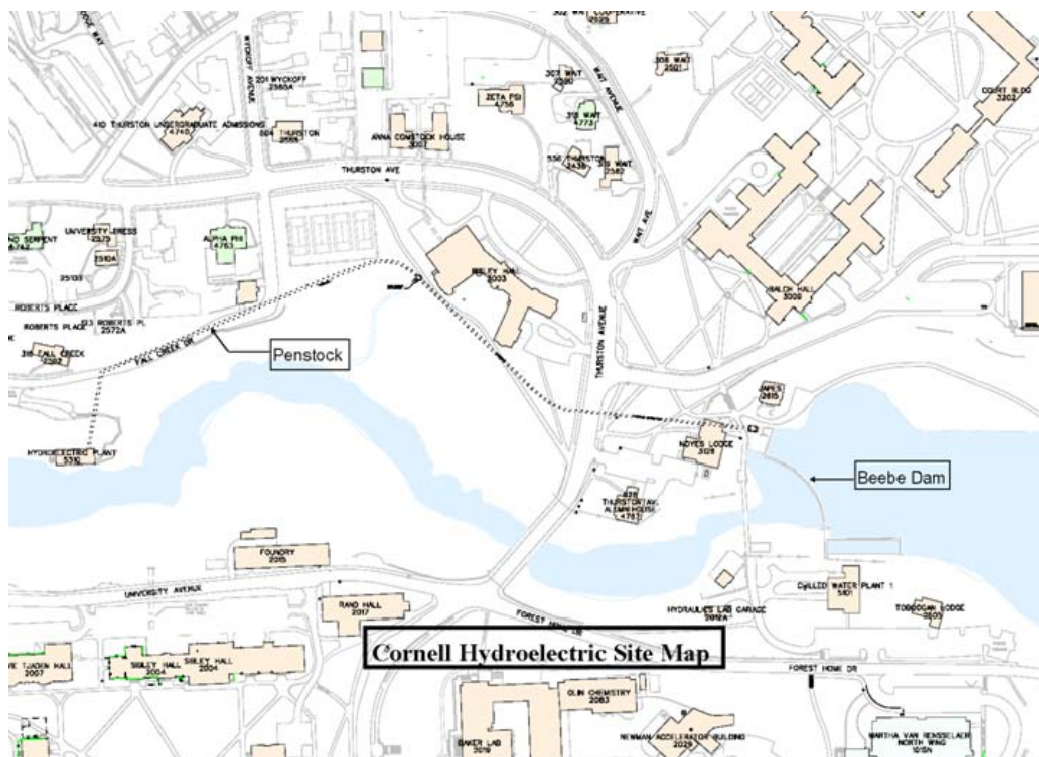


Figure 2. Cornell Hydroelectric Site Map

Kleinschmidt has prepared multiple reports with numerous options for repairing, relining, and/or replacing the penstock. Repairing specific sections of the penstock to prevent leakage and air infiltration is estimated to cost between \$90,000 and \$180,000 (2001 dollars). Options for relining the oldest sections of pipe to reduce friction losses were estimated at \$750,000 to \$1.6 million. And estimates for replacing the oldest sections of pipe to correct the upward slope ranged from \$2.5 million (precast concrete) to \$2.9 million (steel).

For the purposes of this analysis and based on conversations with Frank Perry (Associate Project Manager from the Utilities and Energy Management Department at Cornell), we assumed relining the existing penstock with HDPE would reduce head loss due to friction by 5 feet at an estimated cost of \$1 million. A 5-foot reduction in head loss would provide a 4.2 percent increase in output or 250 MWh per year. Assuming this additional power will offset electricity purchased from NYSEG with a GHG emission

factor of 0.4 MTCO₂e per MWh, this project would decrease Cornell's GHG footprint by 100 MTCO₂e per year. Note that some work on the penstock will likely be required as part of regular maintenance in the near future.

Turbine Rebuild

Kleinschmidt's report from February 2007 suggests that the guide vane bearings on both turbines may be worn out and should be replaced. Frank Perry estimates that about \$150,000 will be required to update both turbines. The turbines currently operate at about 65 percent efficiency – considerably lower than their rated efficiency of 80 percent. This 15 percent increase in efficiency equates to about 900 MWh per year in additional output or about 370 MTCO₂e per year in GHG emission reductions.

Replacing the turbines with more efficient models may also be an option. The existing Ossberger turbines have relatively low efficiencies, but maintain that efficiency over a wide operating range. New turbines may also require civil and structural modifications. The cost of replacing the turbines may outweigh the potential benefits from higher efficiency, so these costs have not been included.

Intake Restructuring

Although it has been updated since the hydroelectric plant was originally constructed, the intake structure was designed for lower flows than currently required for optimum output. Measurements have indicated as much as five feet of head loss from the trash rack to the penstock.

The Feb. 2007 Kleinschmidt report offered the following suggested improvements to reduce head loss through the intake structure:

- Replace trashracks and intake with a hydraulically smooth bellmouth entrance with a wider rake section and a trashrack designed to eliminate icing;
- Eliminate the intake flapper gate; and/or
- Replace the entrance gate with a new gate capable of closing against hydrostatic head.

Kleinschmidt's cost estimate for these upgrades was \$600,000 (2006 dollars). Frank Perry, however, believes that a simplified version of Kleinschmidt's proposed upgrades (reconfiguring the bellmouth entrance and replacing the entrance gate within the existing intake structure) could achieve a 3 foot improvement in head loss at a much lower cost (\$200,000). This 3-foot improvement in head loss would equate to about 150 additional MWh per year produced by the plant. Additionally, downtime due to plugging/icing of the trashracks also has the potential to raise annual output by 150 MWh and save about \$10,000 per year in labor costs required to maintain the system. Total annual GHG emission reductions will be approximately 120 MTCO₂e.

Draft Tubes

By connecting tubes to the turbine exits and extending them below the tailwater surface, the theoretical net head of the system could increase. According to Kleinschmidt, however, there are some factors that could limit the feasibility of this option. Specifically, the performance curves of the existing turbines should be checked to make sure they are not at or near their calibration limits. Cavitation in the turbines is also a concern. Additionally, there may be physical restrictions under the powerhouse which

could require structural modifications. More research is required to determine the answers to these outstanding questions.

Assuming the project is feasible, the cost of this option should be relatively low (under \$100,000) barring any structural modifications. Assuming an additional 7 feet of head could be achieved by implementing draft tubes, output from the plant could increase by as much as 350 MWh per year and reduce Cornell GHG emissions by about 140 MTCO₂e per year.

Hydroelectric Upgrades Summary

The average theoretical net output from Cornell's hydroelectric plant between 1984 and 2006 was 7,270 MWh per year. The actual average output of the plant during that time was 4,350 MWh per year. According to Cornell, the controls upgrade performed in the summer of 2008 should raise the average output of the hydroelectric plant to 6,000 MWh per year. From that baseline, the upgrades described above could raise output from the plant by up to about 1,650 MWh per year and reduce Cornell's GHG footprint by about 660 MTCO₂e per year. A summary of the individual options and costs is presented in the following table:

	Capital Cost (\$)	Increased Output (MWh/yr)	GHG Reduction (MTCO ₂ e/yr)
Penstock Upgrades	\$1,000,000	250	100
Turbine Rebuild	\$150,000	900	360
Intake Restructuring	\$200,000	300	120
Draft Tubes	\$100,000	350	140
Total	\$1,450,000	1,800	720

Central Plant Upgrades

Replace Turbine Generator #1

Replacing the outdated turbine generator #1 (TG-1) with a newer multi-stage model could increase cogeneration capacity from the central plant boilers. The selection parameters for the existing and a proposed new steam turbine are as follows:

	Existing TG-1 Data	New Turbine Generator
Inlet Pressure	400 PSIG	400 PSIG
Inlet Temperature	600°F	600°F
Exhaust Pressure	60 PSIG	60 PSIG
Throttle Flow	75,000 pph	75,000 pph
Turbine Speed	4,552 RPM	6,000 RPM
Number of Stages	One	Five
Power Output	1,810 kW	2,363 kW

Based on the new selection, it is estimated that the power output could be increased by approximately 550 kW at peak load conditions. We have assumed this will operate 3,500 hours per year at an 80

percent utilization factor. This results in additional generation of approximately 1,900 MWh per year. This additional generation will result in a degradation of steam quality required for campus heating during the winter months. Additional steam generation will be required to make up for this loss at a rate of about 2,000 mmBtu per year (based on reduced enthalpy of steam through the new turbine and assuming 25 percent of the annual use of TG-1 will occur during the winter when additional steam is required).

Assuming that increased capacity would offset electricity purchased from NYSEG (with a GHG emission factor of 0.4 MTCO₂e per MWh), the reduction in Cornell's GHG footprint would be about 650 MTCO₂e per year. The estimated capital cost of this alternative is \$1.5 million.

Reduce Losses from Steam Distribution System – Guterman Loop

There are no direct measurements of steam distribution system losses, but estimates show that losses range from 8 to 12 percent throughout the entire campus system. Newer installations at Cornell are very energy efficient and well insulated, so losses are fairly low. However, there is a significant amount of older piping in place that likely has fairly high heat loss and should be a candidate for repair/upgrade. This is particularly true of the system to the east of the central plant extending out to Guterman and the Veterinary College.

Cornell estimates that insulation on the Guterman loop has a current R-value of approximately R-2. If this 12-inch pipe were replaced with R-16 insulation, the heat loss would be reduced by about 340 Btu per hour per linear foot. The loop is estimated to be roughly 8,000 feet long which equates to about 24,000 mmBtu per year in heat savings. This savings will result in lower coal consumption for steam production until coal is replaced by natural gas in 2030. The estimated cost for replacing 8,000 feet of direct-buried steam line is \$12 million at \$1,500 per lineal foot.

Co-fire Wood in Existing Boilers

Cornell estimates that up to 10 percent of the coal burned in boilers #1 and #8 could be replaced with wood (on a weight basis) without major modifications to the boilers. Some modifications would be required, however, primarily with regard to additional or upgraded solid fuel handling and storage. The capital cost required for these upgrades is estimated at \$300,000.

Co-firing 10 percent wood on a weight basis equates to about 4.5 percent on a Btu basis assuming 5,400 Btu/lb wood at 40 percent moisture. That moisture contained in the wood requires additional energy to heat and boil and effectively lowers the heating value of the wood by about 1,100 Btu/lb to about 4,300 Btu/lb. Faculty from Cornell's College of Agriculture and Life Sciences have estimated the cost of sustainable wood for biofuel at \$53.50 per ton (includes cost of wood, harvesting, sustainable forest management, and transportation)

In addition to the capital required for fuel storage and handling upgrades, an additional 0.5 full-time employee (FTE) will be required to manage the additional complexity of the systems. This option will only be viable as long as coal is burned at Cornell – 2030 according to the base case.

Landfill Gas Energy at Geneva Campus

Cornell's College of Agriculture and Life Sciences New York State Agricultural Experiment Station is located in Geneva, NY, approximately 40 miles northwest of Ithaca at the northern end of Seneca Lake. Although this campus is not currently part of Cornell's GHG inventory, it will be added in the near future. This project would therefore not impact the current inventory, but would provide reductions in the future.

According to USEPA's Landfill Methane Outreach Program (LMOP), there are two landfills within 10 miles of the Geneva campus with landfill gas available for beneficial use. Both landfills have gas collection systems in place and the rights to the gas are owned by Innovative Energy Systems (IES). Methane destruction credits are not available at either landfill since both landfills are required to collect and combust their gas under Federal New Source Performance Standards (NSPS).

The first is the Ontario County Sanitary Landfill, located 4 miles west of Geneva in Stanley, NY. This landfill currently collects gas and produces 5.6 MW of electricity in addition to some heat in an onsite boiler. Ontario county has excess gas available, however, and plans to expand its electrical generating capacity to 12 MW. LMOP states that the Ontario County landfill is expected to continue accepting waste until closure in 2030.

The second landfill is the Seneca Meadows Landfill in Waterloo, NY, located 9 miles northeast of Geneva. This landfill currently produces 17.6 MW of electricity and has plans to expand its output to 24 MW. For the purposes of this analysis, we have only considered the Ontario County landfill as it is significantly closer to the Geneva campus.

The Geneva campus uses an average of about 1 MW of electricity and has an annual heating load of about 90,000 mmBtu. Although there are a few options Cornell could consider for utilizing landfill gas at the Geneva campus, option modeled for the CAP is a direct use project in which gas is piped from the landfill to the Geneva for use in the boiler that current exists on campus. We have assumed that most of the capital required for this project would be paid for by an outside entity (e.g., a project developer) and added to the price Cornell pays for the landfill gas. The only direct capital cost to Cornell would be approximately \$500,000 for modifications to the existing boiler and connecting the landfill gas service to the boiler. The cost of the landfill gas is assumed to be 90 percent of projected natural gas costs plus the cost of capital required for the pipeline, minus \$3 per mmBtu for avoiding the NYSEG LDC cost. This project would offset the natural gas currently used to heat the campus and would reduce GHG emissions by about 4,800 MTCO₂e per year.

Another option (not modeled for the CAP) would be to pipe the landfill gas to Geneva as described above, but install a new combined heat and power system in place of the existing boiler. This project would require significant capital to purchase and install the CHP system, but has the potential to satisfy all of the electricity and steam requirements of the campus.

A third option (also not modeled for the CAP) would be for Cornell to enter in to a power purchase agreement (PPA) with IES for electricity produced at the landfill or perhaps a direct electrical connection from the generators at the landfill to the Geneva campus. Since a PPA might be considered an offset

rather than a direct reduction of GHG emission, this option has not been fully explored. For the purposes of this analysis, we are recommending the first option as a starting point for Cornell's consideration. A more detailed analysis will be required to determine which option would provide the most environmental, economic, social, and institutional benefit.

Large Scale Wind Energy

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. After announcing the feasibility study, a number of public meetings were held and university officials met with stakeholders in the vicinity of the proposed site. As a result of those meetings and the identification of many technical challenges associated with the construction and operation of a wind farm, the university decided to stop the feasibility study. Such a project, however, may have renewed life as part of Cornell's Climate Action Plan so the preliminary results of that feasibility study are presented here for consideration.

The proposed project included eight 1.5 MW wind turbines with a combined rated capacity of 12 MW. In 2005, the estimated cost of these turbines was \$1,500 per kW installed for a total project cost of \$18 million. Today, that cost is closer to \$2,500 per kW installed for a total installed cost of about \$30 million. That cost does not include the cost of relocating a radio tower that currently exists at the Mt. Pleasant site nor does it include the cost of running power approximately 4 miles back to campus (~\$4 million @ \$200 per lineal foot) and connecting to a substation. The total capital cost for this project will likely approach \$35 million.

Assuming a capacity factor of 29 percent, annual output from the turbines would total about 30,500 MWh. The majority of that production will occur during October through April when Ithaca experiences the most wind. Unfortunately, this is the time of year when CCHPP is expected to run for steam production and it will be cogenerating electricity as well. Cornell will not have enough demand to use electricity from both CCHPP and the wind turbines during the winter months. In the future, CCHPP may be curtailed or shut down in favor of other renewable energy systems and electricity from wind energy may be needed. For the purpose of this analysis, we have assumed that all the electricity would be sold back to NYSEG at the wholesale rate (approximately \$0.01 per kWh below retail).

Engineered Geothermal System – Demonstration Scale

Cornell and Ithaca sit atop a relatively shallow low-grade geothermal resource compared to other areas of New York and the northeast U.S. (see Figure 3). While not nearly as shallow or as high quality as geothermal resources found in the western U.S., the resource below the Ithaca area presents a unique opportunity for Cornell to develop an engineered geothermal system (EGS) and capture the carbon-neutral energy from these “deep hot rocks.”

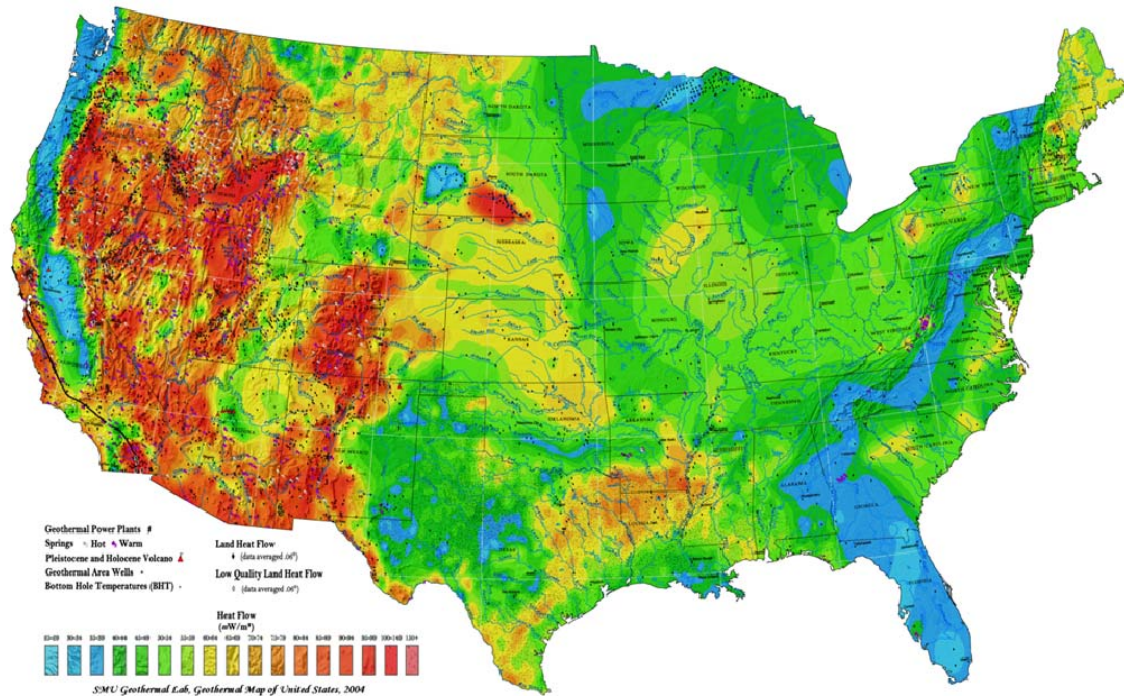


Figure 3. U.S. Geothermal Resources

According to Jeff Tester, Cornell's Croll Professor of Sustainable Energy Systems in the College of Engineering and expert in EGS, a two-well binary system (see Figure 4) could produce approximately 20 MW of thermal energy – about 600,000 mmBtu per year. This equates to about half of Cornell's current annual thermal demand.

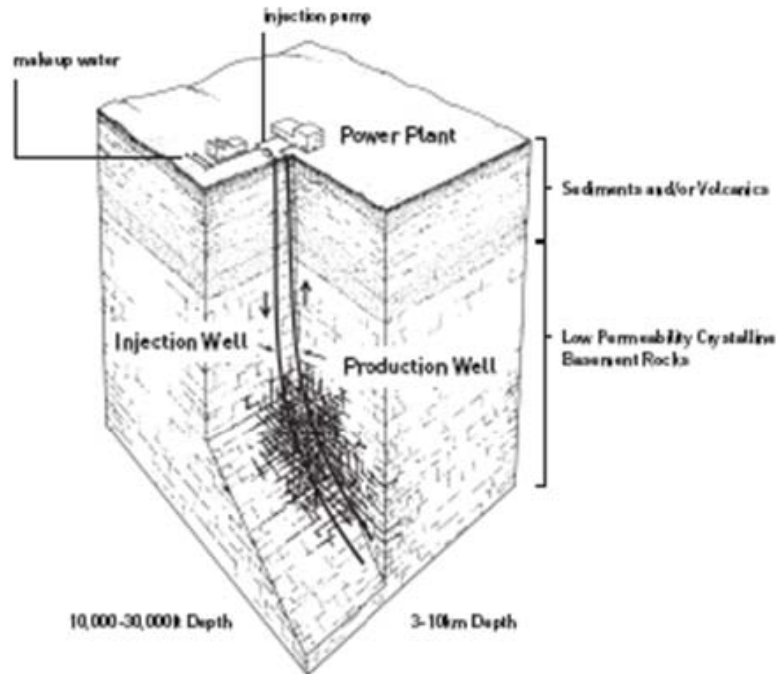


Figure 4. Schematic of a Conceptual Two-Well Engineered Geothermal System

A two-well system like the one shown in Figure 4 would likely be a binary system using a geofluid (water) and a working (heat transfer) fluid. The geofluid is pumped into the injection well to be heated by the geothermal resource and returns to the surface through the production well. The hot geofluid is run through a heat exchanger to heat the working fluid which is used to produce hot water, steam and/or electricity. The geofluid is returned to the injection well in an essentially closed-loop system.

The majority of the cost for such a system will come from the exceptionally deep bores required to access a usable amount of heat. In the Ithaca area, this depth is estimated to be approximately 6 to 10 km, although the exact amount of heat and depths cannot be known until test wells are drilled. At 6 km, the estimated cost per well is about \$10 million (\$20 million for both wells). Additional cost would be required to construct the power plant. Depending on the location chosen for such a system, the total cost would likely be approximately \$25 million.

For a low-grade geothermal resource like the one present in the Ithaca area, it may not be economical to produce electricity or steam. A hot water system would provide the most efficient use of the thermal resource assuming the hot water could be used by Cornell. Currently, only the North Campus has a hot water loop, although the possibility of converting other portions of the campus to hot water has been discussed. Figure 5 shows a basic schematic diagram of a hot water engineered geothermal system.

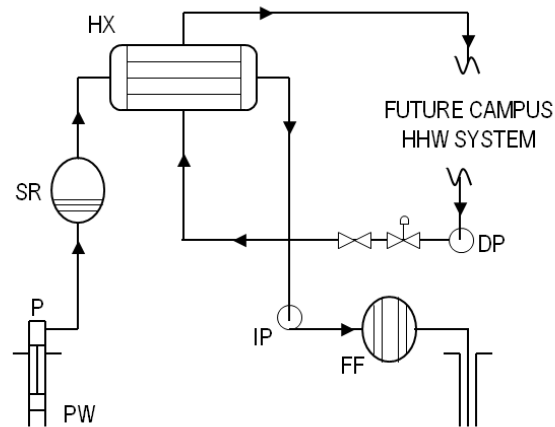


Figure 5. Schematic of a Hot Water EGS

The existing steam distribution line that serves the eastern portion of campus, including the Guterman lab and the Vet School is in need of replacement (see Figure 6). As an alternative to replacing these lines, Cornell may decide to convert the system to hot water for use with an engineered geothermal system. The cost of converting this portion of Cornell's steam distribution system to hot water is estimated at \$25 million (assuming a total hot water conversion cost of \$250 million and estimating that this loop would constitute about 10 percent of the total campus heating system).

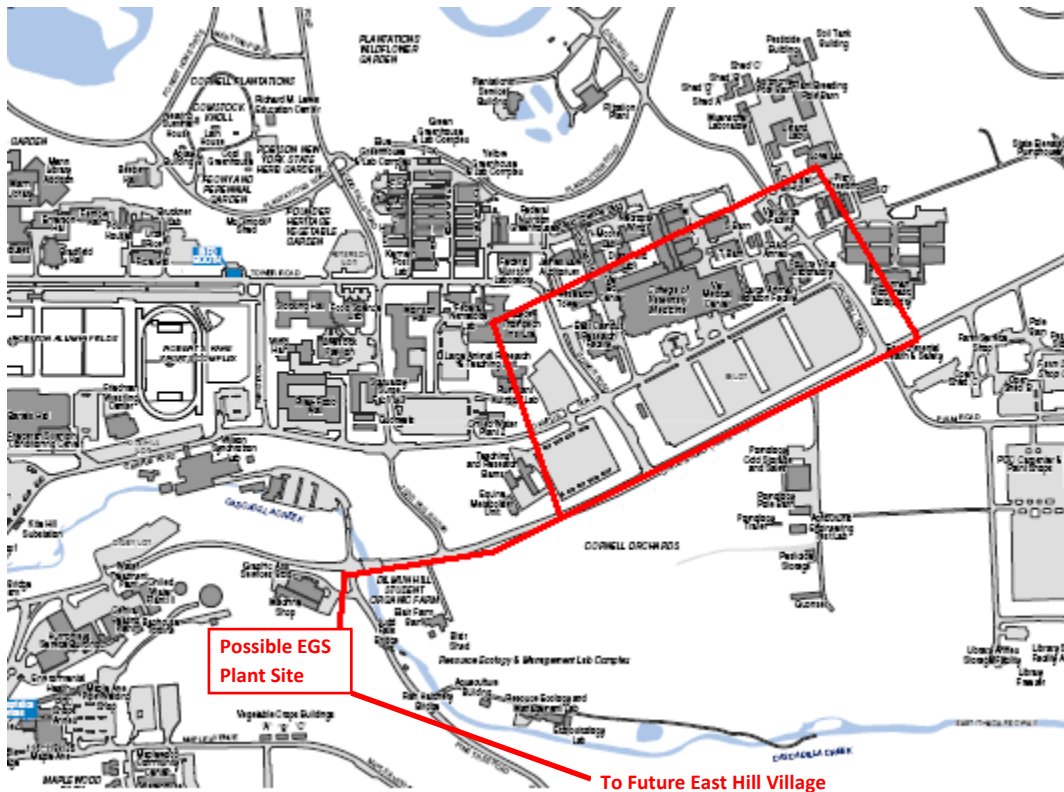


Figure 6. Possible EGS Plant Location and Hot Water Loop

The total estimated cost of the project is \$50 million: \$25 million for the wells and the heat exchange plant plus an additional \$25 million for converting a portion of Cornell's steam distribution system to hot water. Assuming a 20 percent cost share for Cornell as specified in the U.S. Department of Energy (DOE) grant RFP, Cornell would be responsible for up to \$10 million. A portion of this requirement may also be met by outside funding opportunities.

Although the low-grade energy assumed to be available in the Ithaca area is not ideally suited to power generation, some generation may be possible during the summer months when heat from the system is not required by campus. Assuming a 10:1 thermal-to-power generation ratio, a 2MW organic rankine cycle power generator could be installed at a cost of about \$7 million. This analysis assumes a 10 percent cost share for Cornell or about \$700,000.

Cornell estimates the Guterman/Vet School area of campus accounts for only about 10 percent of Cornell's peak steam load or about 120,000 mmBtu per year. This is equivalent to about 20 percent of the thermal energy available from the proposed EGS system. While coal combustion is being displaced by this energy (through 2030), Cornell's GHG footprint will be reduced by about 15,000 MTCO₂e per year. After 2030, when Cornell is expected to be using natural gas for steam production, the avoided emissions will drop to about 6,400 MTCO₂e per year. The average annual GHG reduction out to 2050 would be approximately 8,900 MTCO₂e per year.

One benefit to using such a low percentage of the thermal energy available from an engineered geothermal system is that the expected useful life of the resource should be increased. Since only about 20 percent of the energy available from the EGS will be used (at least initially), the useful life of those wells could potentially be extended by a factor of 5 – up to 50 years – thus delaying the need for expensive redrilling. For the purpose of this analysis, we have assumed no redrilling would be required before 2050.

In the future, additional areas of campus might be converted to take further advantage of the geothermal resource. Also, new development such as the planned East Hill Village could be designed to use hot water from the EGS.

Mid-Term Alternatives

Biomass (CURBI)

The Cornell University Renewable Bioenergy Initiative (CURBI) is in the initial stages of a feasibility study that will determine how best to use 57 campus waste streams and other university-owned biomass resources to generate renewable energy for the university. The feasibility study is considering several options, including direct combustion, anaerobic digestion, and pyrolysis as potentially “stackable” technologies so that waste products from one system can be used by another. For example, switchgrass could be used as a feedstock for a cellulosic ethanol process. The waste bagasse from that process could then be used in an anaerobic digester to produce a useable fuel. And finally, the waste from the digester could feed a pyrolysis/gasification process to produce a combination of syngas and biochar as shown in Figure 7.

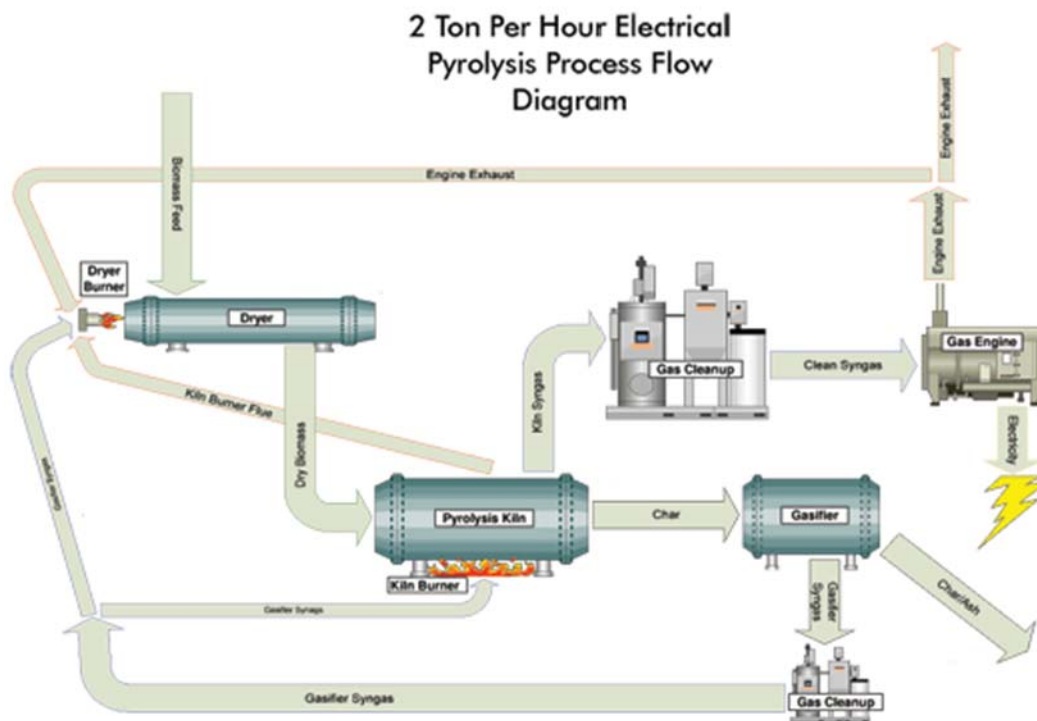


Figure 7. Pyrolysis/Gasification Process Flow Diagram

According to Drew Lewis, Operations Director of the Cornell University Agricultural Experiment Station (CUAES), Cornell currently produces (or, in the case of a biomass crop, has the ability to produce) the following amounts of organic waste:

	Woody Biomass	Compost	Biomass Crop
Annual Production	~6,000 dry tons	~6,000 tons	~8,000 dry tons
Heat Content	9,000 Btu/lb	5,000 Btu/lb	8,000 Btu/lb
Annual Energy Available	108,000 mmBtu	60,000 mmBtu	128,000 mmBtu

Woody biomass refers to waste wood that is harvested or cleared from forested Cornell lands from year to year. Compost is generated by Cornell dining halls and agricultural operations at a rate of 20 tons per day. The production of a biomass crop assumes a yield of 4 tons per acre (a conservative estimate for switchgrass production in the northeast U.S.) on 2,000 acres of Cornell land. At the production rate and energy content for each fuel shown in the table above, Cornell produces almost 300,000 mmBtu of usable biomass fuel each year from its own lands.

Although the exact combination and utilization of energy conversion technologies is yet to be determined by the CURBI feasibility study, a conservative estimate of 50 percent efficiency translates to about 150,000 mmBtu of fossil fuels offset by these biomass resources. Assuming that energy offsets the use of natural gas for steam production, CURBI has a carbon reduction potential of about 8,700 MTCO₂e per year. Additional carbon reduction may be achieved by production of biochar which both sequesters carbon and promotes the growth of new biomass when applied to soil.

In terms of cost, it is assumed the majority of the capital required to implement these technologies will be paid for by grants and outside funding not associated with the CAP or Cornell's capital budget. For the purposes of this analysis, only a \$5 million cost to connect the CURBI technologies to the central plant and steam distribution system is included.

Co-Fire Wood-Based Products in Existing Boilers

Cornell estimates that up to 20 percent (Btu basis) of the coal burned in boilers #1 and #8 could be replaced with a wood-based product (e.g., E-coal, torrefied wood) without major modifications to the boilers. Some modifications would be required, however, primarily with regard to additional or upgraded solid fuel handling and storage. The capital cost required for these upgrades is estimated at \$1 million and are incremental to any upgrades associated with handling wood as part of the short-term alternative described previously. An additional \$100,000 would be required for permitting this fuel for use in the boilers.

This torrefied wood fuel is estimated to cost about 15 percent more than coal and will require about 1 additional FTE to manage and operate the system. This project is only viable as long as coal is burned by Cornell (through 2030 according to the base case).

Early Conversion to Natural Gas

Eliminating coal from Cornell's fuel mix for power and steam generation will require substantial changes to infrastructure and operations. With the addition of CCHPP, there will be enough steam production capacity using natural gas to satisfy the needs of the university year round. However, in the event of a natural gas outage, there is not currently enough steam production capacity using oil to handle peak loads in the winter. Therefore, coal is still required under existing conditions and due to the operational constraints of coal combustion (e.g., long startup times), coal is burned to produce steam throughout the winter months.

Eliminating coal, therefore, is not a matter of adding (or converting) to natural gas-fired steam production capacity. Rather, Cornell must convert or add boilers with oil-fired steam production to allow for adequate capacity during a natural gas outage. Oil-fired boilers, unlike coal, can be started up quicker in the event of an outage to serve as backup to the existing natural gas systems which would produce steam under normal operating conditions.

This conversion is already assumed to be in Cornell's future as part of the base case in 2030. The base case assumes that two additional 100 kpph dual-fuel (natural gas/oil) boilers will be installed in 2030 when the coal boilers are retired. The total cost of these two additional boilers is estimated at \$40 million (\$20 million per boiler). This alternative, therefore, represents an acceleration of that schedule to 2020 and models the costs associated with spending that capital earlier. The estimated GHG emission reduction of this alternative is about 32,000 MTCO₂e per year, but only 10 years of these reductions is attributable to this early conversion relative to the base case

Long-Term Alternatives

Expanded Engineered Geothermal System with Biomass Peaking

Assuming the demonstration scale project proves the feasibility of EGS at Cornell, it could be possible to produce all of the university's heating needs and possibly some of its electrical demands. For the purposes of this analysis, however, we have assumed thermal energy generation only. Drilling more wells and/or deeper wells and expanding the heat exchange plant described previously in the demonstration scale alternative will be required to bring sufficient heat to the surface.

The assumption of using this heat in the form of hot water still stands unless the demonstration scale project proves that the geothermal resource under Ithaca is of a higher quality than currently estimated. If it is of higher quality, Cornell may be able to more efficiently produce steam and/or electricity using the geothermal energy. For now, however, we have assumed it will be in the form of hot water.

Assuming 600,000 mmBtu of thermal energy per year per well pair as outlined in the demonstration scale project description, it would require three well pairs to meet Cornell's expected thermal demand in 2030. Even with three well pairs, the system might not be able to handle Cornell's peak loads so we have assumed an expanded EGS could provide 90 percent of Cornell's thermal energy on an annual basis. All electrical requirements will be purchased from NYSEG or generated by onsite renewable resources such as the large scale wind project.

Since the demonstration scale project is assumed to be in operation, we assume that two additional well pairs would be required to meet campus heating demand. The cost of these four additional wells, drilled to a depth of 6-7 km and based on today's drilling costs, is expected to be in the range of \$40 million. Additionally, we have estimated \$10 million for a new or upgraded heat exchange plant.

As described in the demonstration scale alternative, the issue of Cornell's ability to utilize hot water heating still exists, except in those areas of campus already using hot water (North Campus and presumably the Guterman/Vet School loop converted to hot water as part of the demonstration scale project, and perhaps the future East Hill Village). The total estimated cost of converting the entire campus to hot water is \$250 million. Assuming the Guterman/Vet School loop was already converted at a cost of \$25 million, the incremental cost associated with converting heat distribution systems for this alternative is \$225 million. The total estimated capital required for this alternative, including the wells, the heat exchange plant, and converting the campus to hot water is \$275 million.

The geothermal resources may deplete over time and the wells will require periodic redrilling to tap new pockets of energy. We have assumed 50 percent of the original drilling cost will be required every ten years. We have included the original demonstration scale wells in these redrilling costs since they may deplete faster after expansion of the system to heat the entire campus. For six wells, redrilling is estimated at \$30 million every ten years – with the first redrilling required in 2040.

Using the assumption that an expanded EGS system would provide 90 percent of Cornell's annual thermal energy demand, but only about half of the peak demand, additional heat production capacity would be required during the winter months. We have assumed this peak demand would be satisfied by

a biomass gasification system. At 240 kpph capacity, the cost of a biomass gasification system is estimated at \$50 million. We have assumed that Cornell's existing boilers could be used to fire the syngas to produce hot water to heat the campus.

Large Scale Biomass Gasification

If the EGS demonstration project proves that geothermal energy is not a viable option for heating the entire campus, Cornell may consider a biomass energy system to provide a carbon neutral alternative for heat and possibly power generation. Cornell's long-term heat demand is estimated to be about 400 kpph after demand-side reduction alternatives from the CAP are implemented. Although not proven at this size, today's cost for cogenerating biomass gasification plants is about \$240,000 per kpph (not including boilers). A plant large enough to provide heat to Cornell would therefore cost about \$100 million assuming that Cornell's existing boilers could be used to generate steam using the syngas produced by the biomass gasification system.

One of the key concerns for a biomass energy plant of this size is a reliable fuel supply. Faculty from Cornell's College of Agriculture and Life Sciences (CALS) have estimated that biomass availability within 25 miles of Ithaca is more than enough to satisfy the needs of a gasification plant of this size. The CALS estimates show well over 300,000 dry tons of biomass available from woody waste and biocrop production in the form of willow, switchgrass, and natural meadow. Cornell would require about 100,000 dry tons per year to satisfy the campus heating demand.

Carbon Capture and Sequestration

Effective use of carbon capture and sequestration (CCS) technologies would allow Cornell to continue burning fossil fuels with existing infrastructure. However, the technologies used to capture and sequester carbon are evolving and do not appear to be viable yet.

A study by Professor Andrew Hunter from Cornell's Chemical Engineering Department analyzed the possibility of employing CCS technology on the CCHPP. The study modeled the capture of 90 percent of the CO₂ from the CCHPP (56,000 lb CO₂/hr) using an amine process and then piping it 40 miles north of Ithaca to some gas fields southwest of Syracuse. The estimated capital cost for the capture and sequestration was up to \$80 million. Additionally, the process requires \$7 million annually in chemical costs and 6 MW of electricity – 20 percent of the output from the CCHPP.

TECHNICAL BRIEF FOR LARGE SCALE BIOMASS FOR DIRECT COMBUSTION

Introduction

The purpose of this technical brief is to describe the amount of biomass that would be available for direct combustion, potentially to replace fossil fuels as an energy source, from the region within a 25 mile radius of Cornell. Three sources of biomass would be available for purchase for Cornell: (1) biomass removed from forests in excess of what is marketable timber, including tree tops and smaller culled trees, (2) biomass available from afforestation plantations after 20 years of growth, and (3) biomass grown on agricultural lands, including annual plantings of switchgrass, native meadow grass, and hybrid willow, harvestable after three years of growth.

Land availability

Within a 25 mile radius of Cornell there are 1,256,636 acres. A 25 mile radius is a reasonable distance from which Cornell could draw its biomass supplies because competition with other biomass users would be minimal within this area and because this represents a reasonable compromise between the costs of transporting material and the advantages of a large buyer.

Using regional land use statistics the acres available in each major landuse category are identified in the following table:

	25 mile radius	30% avail.	50% available
Crop land	260456		
Inactive agriculture	76889		38445
Pasture	45261	13578	
Forest and grassland	673136	201941	
Developed and other	195928	58778	

Cropland is defined as tillable land used for growing cultivated field crops, forage crops, grain, beans, etc. (Tompkins County Land Use). Pasture includes areas used for grazing. Inactive areas are farmland and fields that appear to be no longer used for farming practices. Fields may appear to be growing over with tall grasses and small shrubs.

There is 673,136 acres of forest land in the 25 mile radius area. Analysis of trends of recent logging activity in areas of similar population densities suggests 30% of forested land area could be used to produce biomass (Woodbury, personal communication). Consequently, 201,941 acres of forest would be available for extraction of non-marketable (tree tops and cull) wood. However, 43% of this land is in state forests and parks, with 60% contained in some protected or regulated condition. Consequently, it is likely that only 80,000 to 115,000 of the 201,941 acres would be available to sustainable harvest. The 13,578 acres of pasture would be available for afforestation, the planting of new forests on land where no forest currently exists.

Of the 260,456 acres of cropland in the 25 mile radius, all will most likely continue to be used for the current use production and will not be available for biomass crops. It is a reasonable

assumption that 50% of the inactive agricultural land will be available for switchgrass, native meadow grass, and willow production, 38,445 acres.

Forest biomass

An increase of 0.63 tons dry biomass per acre per year is anticipated on the 201,941 available acres of forest lands. This increase represents the amount of biomass that could be extracted from these lands without diminishing the standing stock of biomass on these lands. Two thirds of the biomass that could be sustainably extracted from the forests is sawtimber, too valuable for combustion. Therefore, for combustion, the remaining third, the proportion in excess of the marketable timber, including tree tops and smaller culled trees, or 83,953 wet tons, could sustainably extracted from these forests per year. Removing the state and protected lands from this total would reduce the extractable amount by approximately 40,000 wet tons. More biomass could be extracted from these forests if necessary, since the current standing stock of forested land averages 212 wet tons per acre, considerably higher than average for mature forest land. Reducing these forests by 1% of their standing stock would yield an additional 141,797 wet tons of biomass tops and cull.

The cost of this extraction at anticipated future rates of delivered chipped material would be \$52.50 per wet ton biomass, or \$4,407,548 per year.

Acreage available for forests	201,941
Annual production (dry tons per acre)	0.63
Annual Total Production, tree tops and culled trees (wet tons)	83,953
Cost per wet ton, chipped and delivered	\$52.50
Annual Total cost	\$4,407,548

Afforestation

The available 13,578 acres of the pasture land could be used for afforestation, or new forest plantings. A mixture of hardwoods, including oaks and hickories, would be planted as seedlings. The reason that pasture land is most appropriate for afforestation (instead of willow or grass plantings, for example) is that typically these lands are steeper, making the use of harvesting equipment problematic. In addition, pasture lands likely have poorer soil, on which native tree plantings have better growth than biomass crops.

Over the first 20 years following establishment of these new forests, they would accumulate 102.1 wet tons of biomass per acre, which would be harvestable in year 20. Establishing new forests on one-twentieth of the available acreage each year for 20 years would allow one-twentieth of these new forests to be harvested and replanted each year after year 20, yielding 69,318 wet tons of biomass per year. The costs would be approximately \$425 per acre, including the cost of the trees, planting costs, and the costs of maintenance and verification. For the 13,578 acres, this cost would be \$288,541 each year for the first 20 years. After year 20 one-

twentieth of the forests could be harvested and replanted, at an annual cost for logging, chipping, and delivering at \$52,50 per wet ton of \$3,639,220.

Acreage available for afforestation	13,578
Cumulative 20 year production (wet tons biomass per acre)	102.1
Cumulative Total Production, 20 yrs (wet tons)	1,386,370
Annual Production after 20 yrs (wet tons biomass)	69,318
Cost per acre to establish plantations	\$425
Annual total cost to establish plantations	\$288,541
Annual total cost after 20 years, logged, chipped and delivered at \$52.50 per wet ton	\$3,639,220

Biomass crops

The 38,445 acres of cropland (inactive agricultural lands) would be available for planting in switchgrass, native meadow, or willow. Half of this land is expected to be planted in a woody biofuel (willow), 25% in switchgrass, and 25% in native meadow. Other biofuel crops could potentially be planted, but their yields are likely to be similar to one of these three crops, so these three can be used as representative. Willow is planted on a three year rotation, so that one third of the acres will be available to be harvested in any one year. Switchgrass is harvested once per year, usually in the fall, while native meadow grass can be harvested twice per year.

The expected yields for switchgrass would be 4 dry tons per acre per year, native meadow 2.1 tons per acre per year, and willow 4.7 tons per acre per year. With regard to willow, according to Volk et al. 2000 (<http://bioenergy.ornl.gov/papers/bioen00/volk.html>), "First rotation, unirrigated trials in central New York have produced yields of 8.4 to 11.6 oven dry tons per hectare per yr (3.7 to 5.2 oven dry tons per acre per yr) (Adegbidi 1999). Unirrigated, second rotation yields of the five best producing willow clones have increased by 18 - 62% compared to the first rotation (Volk, unpublished data). It is anticipated that commercial yields will be slightly lower due to variability in field conditions."

The establishment costs of grass and meadow are \$210 per acre, while for willow they are \$1100 per acre, including seed, machinery operating costs, fertilizer, and chemical treatments. It is assumed that the cost to Cornell to purchase these biomass crops would be near their breakeven price, the price at which growers begin to achieve a profit. This price for willow is estimated at \$71/ton, switchgrass at \$77/ton, and native meadow (low fertility) at \$110 per ton.

Acreage available for willow	19222
Acreage available for switchgrass	9611
Acreage available for native meadow	9611

Production for willow (dry tons per acre)	4.7
Production for switchgrass (dry tons per acre)	4
Production for native meadow (dry tons per acre)	2.1

Total Production for willow, wet tons	180,689
Total Production for switchgrass, wet tons	42,289
Total Production for native meadow, wet tons	22,202
Breakeven Cost for willow, per wet ton (50% moisture)	\$36
Breakeven Cost for switchgrass per wet ton (10% moisture)	\$70
Breakeven Cost for native meadow per wet ton (10% moisture)	\$100
Total Cost for willow	\$6,414,473
Total Cost for switchgrass	\$2,960,230
Total Cost for native meadow	\$2,220,173
TOTAL	\$11,594,876

The total production of these three biomass crops would be 245,180 wet tons, at a cost of \$11,594,876, or \$47.29 per wet ton.

Total

Sum total of wet biomass for forest extraction, afforestation, and willow and grass production would be 398,452 wet tons of biomass), at a cost of \$19,641,644, or \$49.29 per wet ton biomass.

Continuing Analyses

Continuation of the use of land to produce biomass crops such as switchgrass and hybrid willow will necessitate the use of nitrogen fertilizer, which creates considerable emissions of CO₂ to manufacture. This emission will be included in the eventual analysis and will diminish the net gains of CO₂ that are achieved by substituting renewable biomass crops for fossil fuels as sources of energy. Although transportation costs are factored into the cost of delivering material to the combustion facility, the analysis needs to be corrected to take into account the greater carbon emissions associated with material that has to be transported farther to Cornell.

References

Adegbidi, H.G. 1999. Organic residuals as soil amendments for willow biomass crops: Impact on biomass production and soil nitrogen dynamics. Ph.D. Thesis, SUNY - ESF, Syracuse, NY. 222pp.

Lazarus, B. Energy crop production costs and breakeven prices, University of Minn.
www.apec.umn.edu/faculty/wlazarus/documents/EnergybudStaff_Paper.pdf

T.A. Volk, L.P. Abrahamson, E.H. White, E. Neuhauser, E. Gray, C. Demeter, C. Lindsey, J. Jarnefeld, D.J. Aneshansley, R. Pellerin and S. Edick. 2000. Developing a Willow Biomass Crop Enterprise for Bioenergy and Bioproducts in the United States. Proceedings of Bioenergy 2000, Buffalo, NY. Available on web site: <http://bioenergy.ornl.gov/papers/bioen00/volk.html>

Cornell University CAP

Technical Brief Commuter Travel

Summary

Cornell commuter travel is responsible for roughly 29,000 tons of CO₂-e emissions annually. This represents just over 9 percent of total university emissions and is roughly equal to those related to air travel. These emissions include all regular travel to and from the Ithaca campus for Cornell related trips but do not include personal errands or similar trips originating from the campus.

Cornell has a long-running program in transportation demand management (TDM) which seeks to provide commuters with options other than the single-occupant vehicle (SOV). Just under half of all employee commuters regularly travel to campus by a means other than SOV; the rates are much higher for students with roughly four-fifths of graduate students using an alternative mode and nearly all undergraduate students.

Despite the strong commitment to TDM, however, participation rates have remained relatively constant for many years, implying that for many, the current offering of programs and modes does not meet their needs. The primary means of reducing the carbon footprint of commuting, however, is to decrease the reliance on the SOV in favor of less carbon-intensive travel modes. The recently-completed transportation-focused Generic Environmental Impact Statement¹ (t-GEIS) identified a variety of ways to improve the transportation infrastructure on campus and in the community to support the use of alternative modes and has resulted in the identification of the Transportation Impact Mitigation Strategies (TIMS), the university's roadmap for transportation improvement projects over the next decade. A central component of TIMS is the goal of increasing participation rates in TDM. According to the TIMS, the population growth rates utilized in the CAP could be entirely accommodated by the use of alternative modes, resulting in no net increase in commuter vehicle trips.

The challenge to the CAP, then, is to identify additional strategies that would result in additional declines in commuter-related emissions, particularly those that would provide benefits beyond the 10-year horizon of the TIMS. This wedge group has identified a range of potential changes in mode split, depending upon the targeted reduction in greenhouse gas emissions as well as the accompanying commitment of additional resources to support these efforts. The table below identifies the current employee mode split as well as the targets associated with the TIMS, a low-reach goal and a high-reach goal. The group did not feel confident that the "50 percent vehicle trips"

¹ The t-GEIS was a multi-year effort to identify the potential transportation impacts of the university's population growth. The study examined three hypothetical growth scenarios in addition to the "no growth" or background growth scenario. The document was the outcome of extensive community involvement including a resource committee consisting of local, regional, and state staff representatives. The Town of Ithaca was the lead agency and adopted a findings statement in February of 2009.

scenario (which represents a halving of commuter vehicle trips relative to today) was realistically achievable within 15 years but has included it for reference. The right-most column represents the change in employee population utilizing the given mode between today and the “50 percent vehicle trips” goal. Numbers are not given for student population as the impact of their trips is quite minor relative to employees and is primarily a function of available housing, an issue outside of this wedge.

Faculty/Staff Mode Split Targets

	Today (n=10,000)	Future: +15 years (n=10,750)				Change in # Using
	Today	TIMS	Low	High	50% Veh Trips	50%
SOV	56% (5,600)	47	42 (4,500)	29 (3,100)	23 (2,500)	-3,100
Carpool/ Drop-off	17%	18	18 (1,900)	18	18	+200
Vanpool	0%	2	2 (225)	3 (325)	5 (550)	+550
Transit (+P&R)	14%	18	21 (2,250)	29 (3,200)	31 (3,300)	+1,900
Walk	9%	9	9 (950)	11 (1,200)	11	+200
Bike	3%	4	5 (525)	6 (650)	6	+300
Other	1%	1	1	1	1	0
Telecommute	*	*	2	3	5	+500

Mode splits are shown in percentage (approximate numbers of staff using a given mode are shown in parentheses)

* Telecommuting was not included as an option in the travel surveys nor was it included in the mode split targets established in the TIMS.

The estimated change in GHG emissions varies noticeably between each of these scenarios and is summarized in the table below. Note that these estimates are highly dependent upon not only the overall mode split, but the relationship between mode used and distance of residence from campus. All else being equal, a switch out of an SOV by a commuter living out-of-county, has a much larger impact on GHG emissions than does one that lives two miles from campus.

Approximate GHG Change For Faculty/Staff Mode Split Scenarios (+15y)

Existing	TIMS	Low	High	50% Veh Trips
+7%	+1%	-2%	-8%	-15%

It should be noted that additional reductions in commuter GHG emissions are likely to occur as a result of actions beyond the university. Stricter CAFE standards will reduce private auto fuel consumption by 25 to 30 percent when fully incorporated into the fleet. It is likely that up to three-quarters of these benefits will have accrued within 15 years. Additional purchases of hybrid buses for the TCAT fleet could result in reduced fuel consumption of perhaps 20 percent. Overall, these improvements will likely represent a roughly 20 percent reduction in fuel consumption across all modes within 15 years. This reduction would occur largely independent of the scenario pursued.

Endorsed Alternatives

The themes that emerged as endorsed alternatives can be broadly classified into two categories: improvements and expansion of TDM programs; and improvements to non-motorized programs and infrastructure.

Improvements and expansion of TDM programs would take many shapes. One change would be to expand benefits for those participating solely in non-motorized modes who do not currently receive any TDM benefit. This could include vouchers or some form of “cash out.” The development of a “mix and match” system of TDM benefits allowing much greater flexibility in program participation. An individual could, for example, park on campus one day, take the bus the next and carpool the next, each time receiving the benefits of what are today, largely mutually exclusive programs. This would be accomplished by improving methods of tracking program participation.

Identified improvements to non-motorized modes, particularly for bicyclists and pedestrians, would include a range of opportunities. In the short term, this would include improved support facilities, such as showers and bike parking on the campus. A central component would be the establishment of campus-wide standards on the inclusion of showers and adequate bike parking in all new construction or major renovation; such standards also assist in the attainment of LEED certification. A high level of commitment would include a substantial increase in covered bike parking on the campus, though some increase would be expected under any scenario. In the medium term (i.e. 1 to 5 years), a program to expand access to bicycles would be developed. This would include both long-term rentals to promote use by commuters as well as a bike share or similar program to promote the use of bicycles for intra-campus transportation. The extent of the programs would depend upon the targeted mode split.

Improvements to the related infrastructure, such as sidewalks, paths and bike lanes, would be accomplished through ongoing cooperation with local agencies and municipalities. Pursuit of the concept of “complete streets” on campus as well as the promotion of this type of infrastructure off-campus would continue. All of these programs not only support the day-to-day commute of those using non-motorized modes, they raise awareness and acceptance of these modes within the broader community and help build a supportive culture.

Transit is expected to play a large role in reducing greenhouse gases associated with commuting. Plans are currently underway to develop a park and ride system at Ithaca’s urban periphery. Cornell should continue to support and assist TCAT in this endeavor. While this initiative will shift the focus to the new park and ride locations, the rural park and ride system should not be abandoned; Cornell and TCAT should continue to enhance this system where appropriate, particularly where it can improve out-of-county ridership. The lack of information makes many commuters feel uncomfortable using transit. Cornell and TCAT should commit to improving information, particularly real-time data on bus status and location. Improving amenities for bus users, such as shelters and bike racks at stops, will also add to the attractiveness of the service.

In addition to the TDM programs themselves, several supporting components should be improved. Emergency ride home (ERH) is one of the most oft-cited reasons for feeling comfortable not driving to campus: further expansion of its hours would help to better accommodate those with atypical schedules. The opportunity to take a bike safety class during worktime would benefit many employees. Similarly, work release could support the use of other alternative modes such as organizing a vanpool. Cornell's continued support of Ithaca Carshare for both personal and business uses will provide a viable alternative for many who require access to a vehicle during their work hours.

To be effective, all programs must be promoted with expanded education, awareness and marketing. Such efforts would not only highlight the improved and expanded programs, but also the carbon implications of travel. Components could include carbon contests in which residence halls, units or even whole departments compete to see who could most decrease the carbon footprint of their travel.

Cornell should look to use parking pricing as a means to provide further disincentive to the use of SOVs for the commute and increase the benefits of using a less carbon-intensive mode of commuting. Parking pricing, in combination with a wide array of alternatives, is highly effective in its ability to change commuting behavior. Support of senior administration is essential for the implementation of such changes.

Resource Requirements

For each of the various components discussed above, we have estimated costs for each of the target scenarios. Based upon estimated roll-out and implementation timeframes, a summary of average yearly expenditures by time period is shown below where amounts are in thousands of dollars.

Average Yearly Expenditure (\$1,000's)

Year	Low	High
1-5	820	1,210
6-10	580	1,390
11-15	870	1,860
Total	11,350	22,300
Avoided Parking Spaces	-25,000	-65,000
Net Cost	-13,650	-42,700

Additionally, a successful commuter program would reduce the amount of parking required on campus. If it assumed the delay between a vehicle no longer coming to campus and an eliminated need to rebuild/replace that space is 5 years and the average cost of a replacement space would be \$50,000, the avoided cost of replacement parking is substantial. Over the 15 year period, it could amount to some \$25 million in the low target scenario and \$65 million in the high target scenario.

Staffing requirements for the expansion of these programs are, overall, estimated to be relatively minimal. Initial program development and roll-out could consist of ½ to 1 FTE for roughly a year. Ongoing staff support of expanded programs and support could range from perhaps up to 2 FTE in the low target scenario to up to 4 FTE in the high target scenario. This staff would include program administration, support to users and provision of increased awareness and education as well as the potential addition of a small amount of staff to support an expanded ERH program.

Other Costs & Benefits

There are many benefits beyond the reduced greenhouse gas emissions and parking construction cost savings associated with many of the programs discussed above. The expansion of programs and raised awareness helps to build a culture of use of “alternative modes.” In many cases once a certain critical mass is reached, use of these modes becomes the accepted norm within the university and usage will continue to grow almost without additional action on the part of the university. These users often develop a greater sense of community through the shared experience. Even today, regular users often cite these personal connections as an important part of the commute.

Usage of a non-SOV mode typically carries co-benefits of increased health and wellness. Particularly the use of non-motorized modes, but even the use of the bus, typically results in more walking than the use of an SOV.

Implementation

Implementation of programs would begin immediately and continue to develop on an ongoing basis. It is estimated that the mode shift would be roughly linear between current trends and the future target following a one to two year period of initial development and implementation.

Achievement of the mode split targets identified above, particularly the high reduction scenarios, will require more than just financial commitment. Because many of these changes go against long-entrenched cultural norms, strong resolve from the highest levels of the university will be required. Key to this success will be offering a full range of transportation choices and maintaining an open dialog with our customers to ensure we meet the variety of needs and abilities of Cornell community members.

A True Halving of Commuter Emissions

As shown above, even a reduction in vehicle trips by half, does not represent a true halving of commuter emissions. To this end, several scenarios were explored to find what would be required to reduce commuter emissions by half, independent of improvements in vehicle technology. A scenario capturing the desired GHG emission reduction target is summarized below.

Faculty/Staff Mode Split

	Today (n=10,000)	Future: +15 years (n=10,750)				
	Today	TIMS	Low	High	50% Veh Trips	50% CO ₂
SOV	56% (5,600)	47	42 (4,500)	29 (3,100)	23 (2,500)	11 (1,150)
Carpool/ Drop-off	17%	18	18 (1,900)	18	18	16 (1,700)
Vanpool	0%	2	2 (225)	3 (325)	5 (550)	2 (225)
Transit (+P&R)	14%	18	21 (2,250)	29 (3,200)	31 (3,300)	34 (3,650)
Walk	9%	9	9 (950)	11 (1,200)	11	24 (2,550)
Bike	3%	4	5 (525)	6 (650)	6	8 (850)
Other	1%	1	1	1	1	1
Telecommute	*	*	2	3	5	6

This scenario would require a significant mode shift, one not reasonable to expect with just the treatments offered in this brief. In order to achieve such a substantial reduction in GHG emissions, substantial changes in employee residence patterns must be assumed as well. Without this shift in housing, a reduction in commuting GHG emissions of this magnitude is unachievable. As shown in the table below, over 3,300 employees would have to move from their current residences more than five miles from the campus to within two miles of the campus, with roughly half of those living within a mile of the campus.

Faculty/Staff Residence Location

Distance from Campus	< ½ mi	½ mi to < 1 mi	1 mi to < 2 mi	2 mi to < 5 mi	5 mi to < 10 mi	10 mi to < 25 mi	> 25 mi
Today*	2.4%	7.0%	14.1%	29.1%	19.3%	20.9%	7.2%
50% CO ₂ Reduction	5.0%	20.0%	29.5%	30.0%	9.0%	4.0%	2.5%

* In all scenarios discussed in previous sections, residence location was assumed fixed and identical to existing.

Such shifts in residence location would only be achievable by substantial changes in land use, a theme addressed by the Green Development wedge. The costs of achieving such a change are largely unknown as they represent a tremendous effort on both the part of the university and the broader community, developers, etc to expand the housing availability and choice immediately adjacent to the university.

Elements for Future Consideration

Recent federal legislation has mandated a substantial improvement in the fuel economy of the passenger vehicle fleet. The legislation mandates a combined corporate average fuel economy of 35 mpg (for new vehicles) by 2020. This effect will be included in the modeling of the base case. It is

reasonable to expect further gains will be mandated over time, although they cannot currently be estimated.

Just as there is the potential for the carbon-intensity of passenger vehicles to decrease, so too, may the intensity of TCAT buses. The few hybrid buses in the fleet have shown a substantial improvement in fuel economy over the regular fleet. As alternative fuel sources and more efficient designs become available, Cornell can work with TCAT to help reduce the greenhouse gas emissions from its fleet, particularly as transit is anticipated to become an increasingly important component of travel by Cornell commuters.

Cornell University CAP

Technical Brief

Fleet Services

Summary

Cornell-owned vehicles represent approximately 3,500 metric tons of CO₂ emissions, almost exclusively from the combustion of liquid fuels to power the fleet. This includes all liquid fuels consumed by the university for transportation, including fuel used by the contract college fleet as well as those vehicles owned and operated by units of the university, such as grounds, police and farm services.

Given that business travel and service use is critical to the operations of the university, the primary potential for reduction of greenhouse gas emissions lies in the improvement of the fleet average fuel economy. Currently, average fuel economy for the contract college fleet is just below 20mpg. The fuel economy of the remainder of the Cornell-owned vehicles is less well known, because of lesser reporting requirements, though it is estimated to be in the upper teens, perhaps 16-17mpg. Improvement of the contract college fleet average fuel economy to 35 mpg would result in nearly a 50% reduction in fuel consumption and thus greenhouse gas (GHG) emissions. Similar improvements for the remainder of the university-owned vehicles could be pursued as well. Federal legislation in 2008 mandated that the estimated corporate average fuel economy (CAFE) for new vehicles be 35mpg by 2020 so Cornell's achievement of such a goal is not impractical.¹ However, these improvements in CAFE standards will be considered in the base case so that the part of the reduction 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 which focus on higher efficiency vehicles, often meaning 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 possible, the potential success of such an initiative is less certain, particularly in the near-term. Fast-fill compressed natural gas (CNG) and hydrogen fuel-cell (HFC) stations are expensive and without a wider national roll-out of filling stations, much of the fleet would need to remain on conventional fuels to allow off-site refueling. Similar problems exist with electric vehicles and their limited ranges, long charging times and substantial marginal purchase price. Conversion to a bio-fuel is possible though currently there is not a sufficiently large and continuous supply to provide substantial impact. This approach, however, will likely be the focus of efforts for further fleet reductions beginning in 10 to 15 years as relevant technologies have further matured.

¹ The European mandate is for a fleet average of 40 mpg in a similar timeframe.

Resource Requirements

As discussed above, the primary means of reducing university-owned vehicle emissions is via the purchase of more fuel efficient vehicles. The primary related expense is the marginal cost of these vehicles. Depending upon model and vehicle type, typical costs for more fuel efficient vehicles today (that serve a similar function to those currently part of the fleet) range from roughly \$0 to \$5,000 per vehicle. In some cases, the cost may actually be lower because the substitute model is smaller, has a smaller engine, etc and thus is cheaper to manufacture and operate. It is anticipated that as fuel economy standards improve, this marginal cost for more efficient vehicles will decrease. While the amount will vary based on Cornell's future standard, it is likely that this amount would not exceed \$2,000 per vehicle. Depending upon the mix of vehicles purchased, particularly if a large percentage utilize a hybrid drivetrain, it is possible that there will need to be a shift in maintenance personnel specializations, though there would not likely be a substantial increase in maintenance costs.

There will be initial staff costs to develop the program, though it is unlikely that additional staff will be required to implement the program. It is estimated that it would take perhaps 0.5 FTE for one year to develop the program.

Other Costs & Benefits

Rightsizing the fleet to improve average fuel economy will almost certainly result in a different mix of vehicle types. While in some cases this may simply be the substitution of vehicles with smaller engines and/or smaller vehicles, in other cases this may reduce the purchase of certain classes of vehicles. For the most part, this will simply imply some initial inconvenience to users of fleet vehicles as they adapt to the new mix of vehicles available and aspects such as reduced cabin room and acceleration. In some cases, though, it is possible that users may find they have to adapt their usage patterns as vehicles formerly readily available are now more restricted and users need to more carefully plan which vehicle best meets their needs for a given trip and/or carpooling when appropriate. It is not intended that this program would be so severe as to directly inhibit critical business or education functions of the university.

A central component of the plan includes purchasing guidelines which would apply to all vehicles owned and operated by the university, including departmental vehicles. One possible implementation would be a centralized vehicle purchasing function that would be responsible for ensuring that new purchases were in line with fuel consumption standards and the needed vehicle mix on campus. This could also include recommendations for consolidated vehicle purchases (to reduce duplicate vehicles) or even the elimination of departmental vehicles in favor of a broader fleet and usage of Ithaca Carshare. Any of these changes, in addition to implementation staff and costs, would affect departments and researchers who are largely used to having broad ability to purchase and little restriction on the use of or access to these vehicles.

Beyond the carbon savings, the program has the additional benefit of raising awareness of the Cornell community of the availability and qualities of more fuel efficient vehicles. This increased

awareness could translate into modified purchasing habits of these individuals and could help to improve the average fuel economy of Cornell commuters' vehicles.

Implementation timeline

It is estimated that it would take roughly 1 year to establish the policies and any related support infrastructure and programs.

The low target would be to reach a contract college fleet average fuel economy of 30 mpg within 5 years. The high target would be to reach a contract college fleet average fuel economy of 35 mpg within the same timeframe. Within roughly the same timeline, the goal would be to improve the fuel economy of the remainder of other university-owned vehicles to 25 mpg and 30 mpg for the low and high goals, respectively. This target should be exclusive of heavy equipment such as farm services vehicles and other grounds and maintenance vehicles: the low and high goals for these heavy vehicles would be a reduction in fuel consumption of 10 to 20 percent, respectively.

In the low target approach, after the initial target, the goal would be a 10 percent reduction in fuel consumption every 5 years (2 percent per year); in the high target approach, the goal would be a 25 percent reduction in fuel consumption every 5 years (5 percent per year). These ongoing targets would be met through a mix of improved fuel economy and transfer to less carbon-intensive fuel sources. The ability to meet these goals will be affected by university policy, the regulatory environment and the availability of appropriate technologies and vehicles.

Cornell University CAP

Technical Brief

Business Travel

Summary

Cornell air travel is responsible for roughly 27,000 tons of CO₂-e emissions annually. This represents nearly 9 percent of total university emissions and is roughly equal to those related to commuting.

Reductions in business travel emissions are difficult for two reasons: first, business travel is not centrally controlled or regulated by the university – generally the main limitation being individual budgetary restrictions. Second, business travel complements Cornell's educational mission whether by researchers attending conferences or by staff supporting the ongoing operations of the university.

The recommended approach to reducing this sector's carbon footprint is the development of a business travel modal decision system. This program would assist travelers in understanding the impacts of their travel and seeking a less carbon-intensive alternative where feasible. Depending upon the level of commitment, the program could range from purely informational with largely static information to a real-time, dynamic, interactive, web-based, decision-making and travel-booking tool. At a high level of commitment, this tool would also include staff support to assist with travel planning and booking, including recommending teleconferencing in lieu of travel.

Regardless of the form of the program, education and awareness will be central to achieving reductions in business travel-related emissions. This will include raising awareness about not only the impacts of such travel, but also the array of less carbon-intensive options available. This education component will tie in closely with other education, awareness and marketing efforts undertaken for commuter and fleet travel.

Another key component of this plan would be increased investment in and reliance on teleconferencing. Travelers would be encouraged to consider teleconferencing in place of an actual trip. To this end, teleconferencing capability standards would be established for individual computers as well as for centralized meeting facilities. Any policy or plan must recognize the value of in-person interaction and on-site experience, research, and collaboration.

Overall, the working group feels the following scenarios are possible for reductions in emissions:

Targeted Reductions in Business Travel Emissions Below Current Levels

Goal	2015	2030	Beyond
Low	-5%	-10%	- 1/4 % per year
Mid	-8%	-15%	- 1/3 % per year
High	-10%	-25%	- 1/2 % per year

Much of this reduction may occur within the next several years as a result of the current fiscal conditions. If the above programs can be implemented in a short time frame, they can capitalize on these trends and help to establish new travel norms.

Resource Requirements

As these programs are scalable, the resource requirements vary with the targeted goal. There would be little staff requirement with an informational program. The creation of a modal decision system function is estimated to require between 2 and 4 FTE to operate on an ongoing basis. The initial development would take one to two years and require up to 2 FTE of staff to develop. Central to the achievement of the medium and high goal scenarios is a software solution, and related hardware, to support the function and costing upwards of \$100,000.

While the teleconferencing component would seek to capitalize on existing resources, it would require additional investment. Such a program would likely require up to 4 FTE of support staff, primarily to provide technical support to end users across campus. Capital costs will vary widely depending upon the targeted level of use, technologies and level of commitment; ranging from \$30,000 to \$100,000 per facility.

Other Costs & Benefits

A reduction in travel emissions will most likely be achieved by a reduction in number of trips. While some interactions lend themselves well to electronic forms of communication such as teleconferencing, others do not. In particular, nuances of human interaction do not translate well.

Over half of the air travel emissions result from international travel yet these trips make up less than one quarter of total trips. However, it is important to consider that much of this travel is directly related to Cornell's institutional mission.

One possible positive benefit of an increased presence and awareness of the university's teleconferencing capabilities is an actual increase in interactions. With improved technology and connectivity available, staff and faculty will likely increase the frequency of communication, particularly the use of rich interactive environments.

Implementation timeline

It is estimated that it would take roughly 1 to 2 years to establish the policies and any related support infrastructure and programs. Presumably some of the efforts could be made public immediately after the decision to proceed (such as the desire for increased use of teleconference resources). It is anticipated that initial reductions attributable to these programs would be low but build over the following 1-2 years as the programs and their awareness grew.

If these programs are implemented immediately, they will complement and reinforce behaviors of reduced travel resulting from the current financial situation. If they are delayed, the targets proposed above will likely be more difficult to achieve.

Areas for Future Investigation

Although not included in the current inventory, additional emissions result from other purchased transportation as well as private vehicles used for business travel; these emissions could be estimated for future inventories. While emissions resulting from business travel by private contractors working for Cornell are considered part of Scope 3 emissions, they are not included in the ACUPCC reporting requirements and are not included in the inventory.

Additionally, many of the reductions in carbon emissions in business travel will result from changes outside of Cornell's control such as improvements in aircraft fleet efficiency. Such improvements are largely driven by market forces at present but may be legislated at some future point.

It is important to note that several additional ideas for reducing the carbon footprint of university business travel have been identified but are not, at present, sufficiently mature to be considered within the CAP. These items have been identified within the Test Tube Rack and indicate areas of potential research. Successful research on one or more of these ideas would add to the options available to the university and possibly require reevaluation of the current goals and approach for reducing business travel-related emissions.

In the long term, a carbon cap on travel could be implemented. However there are many complications in the actual implementation, particularly with respect to potential issues of equity and trading of allowances. Thus, it likely would be many years before any such policy were developed.

Intracampus Business Travel

The most common form of business-related travel is not the long distance travel to off-site locations but rather movement within the campus itself. This travel is extremely difficult to track and thus little is currently known about the associated emissions. Future inventories should work to improve the understanding of the impact of this travel.

The initiatives identified in this brief, in conjunction with the briefs on commuter travel and university-owned vehicles, offer several means of reducing the carbon impact of intracampus travel. In general, these include promoting and enabling the use of more sustainable modes such as walking biking and transit.

Background

This memo is one of six (6) technical background memos that present information for the six carbon offset actionable alternatives which have been retained for Stage 2 analysis in developing the Cornell University Climate Action Plan (CAP). The six carbon offset alternatives included in this series of technical memos include:

1. Afforestation
2. Forest Management
3. Biochar
4. Soils/tillage practices
5. Agricultural methane
6. Market Purchases of Offsets

The purpose of this memo is to summarize the offset actionable alternative and identify costs, institutional considerations, and sustainability considerations including financial, environmental and social responsibility considerations associated with the alternative

1) General Description

Afforestation is the process of converting idle pasture or crop land to forest land by planting and actively managing the land to grow mature trees. The goal of afforestation projects is to enhance carbon sequestration by allocating lands away from cropland and pasture that may have lower carbon storage capacity to forest cover that may have higher carbon storage potential. Research in the carbon storage capacity of different types of land uses is ongoing. However, afforestation is an accepted carbon offset strategy in carbon trading institutions such as the Chicago Climate Exchange (CCX), Clean Development Mechanism under the Kyoto Protocol and the Regional Greenhouse Gas Initiative (RGGI).

As a carbon sequestration activity, afforestation primarily affects atmospheric CO₂. Carbon is fixed from the atmosphere in photosynthesis and is sequestered in a tree's biomass above and below ground. In addition, carbon is transferred to the soil by the roots and by decomposition of forest debris/leaf litter. The rate of carbon accumulation for afforestation varies and depends on the newly planted tree species, climate, soil type, management, and other site-specific characteristics.

Apart from the carbon captured and sequestered, other beneficial uses of afforested lands may include wildlife habitat development/land conservation, recreational usage, and production of timber, pulp wood or other forest products.

2) Cornell Afforestation Project Opportunity

One or more afforestation projects are possible on Cornell University owned lands. There are over 14,000 acres of land owned and managed by Cornell's College of Agriculture and Life Sciences in the Ithaca area. Over 2,500 to 5,000 acres of this land could potentially be targeted for afforestation for purposes of carbon capture and sequestration. The areas proposed for afforestation are forest areas not managed by Cornell Plantations and include Cornell properties located on Mt. Pleasant, near the Tompkins County Airport, and near and Harford Animal Science Teaching and Research Center (Weinstein).

a) Scope of Afforestation Project

For purposes of this memo, it is assumed that 100 acres will be afforested each year for 10 years, resulting in a total of 1,000 acres of afforested lands.

Published studies on afforestation projects in the United States suggest a wide range for the potential carbon capture and sequestration rates. A 2005 EPA report on agriculture and forest offsets indicates that accumulation rates range between 2.2 to 9.5 tons CO₂ per acre per year (Murray, 2005). While, the annual carbon accumulation rate in the CCX tables for forest types in the Northeast ranges from 1.4 to 3.9 tons CO₂/acre/year (Chicago Climate Exchange, 2009).

Sequestration potential on Cornell lands was estimated using the US Forest Service's Carbon Online Estimator or COLE. COLE calculated that the average annual rate of sequestration for forests in Tompkins County for a 50 year period, assuming no additional thinning management is employed, would be 5.1 MtCO₂e/acre. To obtain the net sequestration for offset purposes, the amount of natural sequestration expected from conversion of idle fields to forest would have to be subtracted from this value (approximately 25% or 1.27 MtCO₂e/acre), yielding a net of 3.8 MtCO₂e/acre or an average of 3.8 tons CO₂e/acre/year (Cornell University Department of Natural Resources 2009).

b) Timeframe of Project

An afforestation project on 1,000 acres of Cornell University lands could begin at any time during the period covered by the Climate Action Plan and is assumed to take approximately 10 years to prepare the lands and replant trees.

Published studies on afforestation demonstrate quantifiable carbon sequestration immediately after planting. The rate of carbon sequestration varies by tree species and

with time, but is generally high initially after planting and becomes asymptotic after a certain time period, typically 50-60 years.

c) Project costs

i) Capital

Capital costs for an afforestation project would include labor, materials and equipment incurred during initial planting and would depend upon the acreage to be planted. An estimated unit cost of \$400/acre was used based upon real-world costs for the CU Department of Natural Resources to reforest 5 acres in Freeville, NY (Cornell University Department of Natural Resources 2009). This unit cost includes the following:

- Seedlings at \$300/acre
- Planting labor and equipment (using a tractor-pulled drill) at \$100/acre

Other potential capital costs may include construction of infrastructure such as roads, bridges, parking, storage shelters, etc. for future operations, management, monitoring and maintenance of forest lands. These costs are project specific and cannot be estimated at this time.

ii) Fixed administrative costs

Administration of forest lands is dependent upon the degree of forest management performed. It is assumed that a minimum amount of administration and management would likely be required.

iii) Variable program costs

Forest lands would require some degree of management, monitoring and maintenance. However, forest lands may not need to be significantly managed, depending upon the degree of usage. Optional uses such as recreational trails or collection of maple sap are described further below and may require additional maintenance. In addition, natural or weather-related incidents may require unscheduled maintenance and/or tree replacement. Examples of variable program costs may include:

- Erosion control projects
- Replanting
- Road clearing and maintenance
- Other infrastructure maintenance
- Fertilizers and/or pesticides

Many of these costs cannot be estimated at this time. For purposes of this memo, the following annual operations and maintenance costs were assumed (Cornell University Department of Natural Resources, 2009):

- Forest inventories - \$10/acre for 100 acres/year (10-year rotation)
- Pesticide applications - \$100/acre for 10 acres/year (100-year rotation)

d) Transaction Costs

Transaction costs are associated with activities that include feasibility studies, establishing and verifying baselines, negotiations, regulatory compliance costs, and on-going monitoring and verification costs. For example EPA assumes a transaction cost of \$.33 per ton CO₂e when modeling offsets as part of its economic analysis of cap and trade legislation. This assumption is a weighted average figure for known, past offset projects.

i) Inventory baseline for project

Under the CCX program, a one-time baseline inventory prior to afforestation would be required to document and quantify the existing conditions and future carbon sequestration and offsets. This could be done using existing Cornell resources or an outside contractor. The level of effort and costs associated with a baseline inventory are project specific and are related to the size and condition of the land to be afforested. A baseline inventory over the entire 1,000 acres of proposed lands is assumed to cost approximately \$10,000 assuming a unit cost of \$10/acre.

ii) Monitoring and verification of GHG emissions reductions

Because the carbon capture and sequestration from forests varies with stand age, a routine forest inventory may be required to document the calculated or assumed carbon capture and sequestration quantities. This could be done using existing Cornell resources or an outside contractor. The level of effort and costs associated with a baseline inventory are project specific and are related to the size and condition of the land to be afforested. Forest inventory unit costs are provided above.

Additional studies or testing may voluntarily be conducted by faculty and/or students as part of related research efforts. The results of the studies or testing may serve to further verify the calculated or assumed carbon capture and sequestration quantities.

iii) Registration of Offsets

In addition, registration of offsets with some high quality registries requires a registration fee and a fee to retire or transfer offsets between accounts. For example the Gold Standard levies an Annual Account Subscription Fee of \$500, a Credit Certification/Issuance Fee of \$.15 per offset registered and a Secondary Credit Transfer Fee of \$.01 per offset. It is expected that registration with most registries in the future will require similar fees.

3) Institutional Considerations

a) Mission

i) Aligned with mission of institution

Afforestation is aligned with the mission of Cornell University, particularly the Cornell Agricultural Experiment Station, the Cornell Cooperative Extension service, and its ForestConnect program. However, the scale of the project must be consistent with the other goals and missions of the University. Afforestation projects can not remove lands from other potential future uses that would jeopardize the University's standing as a world-class teaching and research institution.

ii) Education and research opportunities

The education and research opportunities are numerous, including the baseline inventory and routine monitoring. In addition, there are many potential public education/outreach opportunities.

b) Recognition and Acceptance of Afforestation Offsets

Afforestation is a recognized and accepted source of offsets. This type of project is eligible under the RGGI and is expected to be eligible to generate compliance offsets under a federal cap and trade policy.

4) Environmental Sustainability

a) GHG emission reductions/timeframe

The quantity of carbon capture and sequestration in afforestation projects is dependent upon several variables, including

- Species type and quantity/proportion
- Soil types
- Climate
- Health and age of forest stand

b) Biodiversity benefits

Afforestation projects develop idle farm land into forest stands. The afforested land has the potential to support diverse tree species which in turn could create diverse habitat for numerous types of native wildlife species. Preferably a mixture of species would be planted since biodiversity creates for habitat opportunities for other species and add a degree of stability to the ecosystem. Further, these forests should be managed to eventually diversify the age structure, for similar reasons.

c) Additional environmental co-benefits

i) Air quality

There are no industrial processes, discharges or other air quality impacts associated with afforestation projects.

ii) Waste

Wastes associated with afforestation projects are minimal. Forest wastes will be generated if and when the forest is harvested. However, these may be left on the forest floor for decomposition or converted to syn-gas and biochar in a pyrolysis process (see Offset Wedge Tech Memo #2). Additional wastes may require management if other optional forest uses such as recreation are included as part of the afforestation project.

iii) Land conservation

Large-scale afforestation must conserve the land to a relatively undeveloped state in order to maximize the carbon capture and sequestration potential from the land.

iv) Water supply and quality

Afforested land will have no significant impacts on water supply and quality. Rather, it has the potential to protect surface water quality. Forested land or other undeveloped land is many times more effective at preventing erosion and protecting the quality of surface waters than developed land. Best management practices to prevent erosion would be required if the land is ever harvested. Newly planted seedlings would likely require watering during drier summer months to prevent die-off.

5) Social Responsibility

a) Local community benefits

An afforestation project could have potential indirect benefits to the local community in several ways, as discussed above, including:

- Improved air and water quality
- Recreational opportunities
- Land and wildlife habitat conservation
- Local availability of forest products
- Classes, demonstrations, tours and workshops

b) Contribution to improved quality of life for stakeholder groups

Many community members and local land planners support maintenance of forests on Cornell lands.

c) Consistent with values and standards of students, faculty and community

There are no significant impacts associated with afforestation. Some may support reduced forest management to promote greater species biodiversity. In addition, use of pesticides and/or herbicides as part of forest management could have negative effects.

d) Transparent transaction, accounting and reporting

Carbon offset credits developed from afforestation projects on Cornell lands may or may not be actually traded or sold. It is suggested that offset projects should follow established protocols such as those developed by CCX or other carbon trading programs like the European Trading Scheme (ETS) or RGGI for documenting and tracking emission offsets regardless of whether credits are actually sold or traded. Third party verification may be required if credits are traded or may be implemented as a best practice if they are not traded.

e) Strengthens stakeholder and institutional relations

Cornell may strengthen its community relations by implementing afforestation projects for the benefits discussed above in section 5a. Investing in carbon offset projects such as this would demonstrate leadership in combating climate change. Afforestation projects would have no significant impacts on the public.

References

Chicago Climate Exchange, “Annex 1 CCX Carbon Accumulation Tables for Afforestation Offset Projects, <http://carboncredit.ndfu.org/pdfs/Forestry/ForestryTables.pdf>, accessed January 28, 2009.

Cornell University Department of Natural Resources, April 21, 2009, personal communication, David Weinstein telephone conversation with Andrew Murphy, CU Environmental Compliance and Sustainability

Murray, B. et al. November 2005. *Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture*. Page 2-3; Table 2-1, “Representative Carbon Sequestration Rates and Saturation Periods for Key Agriculture, Land-Use Change, and Forestry Practices”, EPA Report 430-R-05-006.

Background

This memo is one of six (6) technical background memos that present information for the six carbon offset actionable alternatives which have been retained for Stage 2 analysis in developing the Cornell University Climate Action Plan (CAP). The six carbon offset alternatives included in this series of technical memos include:

1. Afforestation
2. Forest Management
3. Biochar
4. Soils/tillage practices
5. Agricultural methane
6. Market Purchases of Offsets

The purpose of this memo is to summarize the offset actionable alternative and identify costs, institutional considerations, and sustainability considerations including financial, environmental and social responsibility considerations associated with the alternative

1) General Description

Methane is produced by livestock manure on farms and other organic waste streams. Methane is a powerful greenhouse gas (GHG) that is approximately 23 times more powerful per unit at trapping heat than carbon dioxide (CO₂) (Chicago Climate Exchange 2007). Agricultural methane offset projects are designed to capture agricultural methane for combustion and/or use in generating heat, hot water and/or electricity.

Anaerobic digestion technology is widely used in the wastewater industry. Agricultural digesters are widespread in Europe. Examples of operational anaerobic digesters in agricultural applications are in existence in the United States, so the technology is proven and economically competitive with other manure management systems. The United States Environmental Protection Agency (USEPA), United States Department of Energy (USDOE) and the United States Department of Agriculture (USDA) have jointly developed the AgSTAR program to encourage development of agricultural methane recovery systems. Over 120 systems have been constructed with AgSTAR assistance since 1994 (source: USEPA, <http://www.epa.gov/agstar/accomplish.html>).

a) **Cornell Agricultural Methane Offset Project Opportunity**

An existing pilot project, “Cow Power”, led by Dr. Norman Scott of the Department of Biological and Environmental Engineering, has been ongoing since 2000 in cooperation with the New York State Energy Research and Development Authority (NYSERDA) and New York State Electric and Gas (NYSEG). The project involves use of an anaerobic

digester to convert manure to methane.. Studies have focused on process optimization and regional development using GIS tools. The “Cow Power” project was conducted on a working dairy farm in Candor, NY.

A similar or expanded methane collection system with anaerobic digester or other manure management system could also potentially be constructed on agricultural lands owned or managed by Cornell, particularly the Harford Animal Science Teaching and Research Center or other lands operated by the College of Agriculture and Life Sciences.

The Cornell University Renewable Bioenergy Initiative (CURBI) led by the Cornell University Agricultural Experiment Station (CUAES) in Ithaca, NY is conducting a feasibility study to assess several technologies, including anaerobic digestion. CURBI may or may not incorporate anaerobic digestion depending upon the results of the feasibility study. It is unclear whether Cornell generates enough waste to sustain a digester or whether feedstock such as alfalfa or other energy crops would have to be grown or imported. Importing waste to Cornell could carry potential risk and liability issues and would require evaluation.

For purposes of this technical brief we have identified the Harford T&R facility as a potential site for an anaerobic digestion project. Using methods prescribed in the Regional Greenhouse Gas Initiative (RGGI) Model Rule and assumptions about the volume of manure generated at Harford we have estimated the potential annual offsets that could be generated by an anaerobic digestion/energy project.

These calculations demonstrated a potential annual offset of as much as 1,100 metric tons of CO₂e. In addition, it has been estimated that approximately 475 metric tons of CO₂e could be avoided by using the captured methane in a digester gas fired turbine (compared to New York State grid electricity).

b) Timeframe in which Offset Project is Implemented

The duration for planning, design, construction and commissioning of a digester would depend upon financing as well as the plant size. However, it may be feasible to have a fully commissioned digester for offset purposes in less than 5 years. It is assumed the digester would be coupled with a power plant and operate for 30 years.

c) Project Costs

i) Capital

Capital costs for construction of an anaerobic digestion project would include costs associated with planning, design, permitting and construction of the digestion unit and an appropriately sized module to generate electricity from the biogas. These costs

are project specific. However, several unit cost ranges per animal unit¹ have been published for construction estimates based upon actual projects. For purposes of this memo, an average of these published ranges (\$630/AU) was used with an estimated 1790 AUs at the Harford T&R Center. Cost estimates include an electric generator and an additional 25% was added for project planning, design, permitting and contingency for a total of approximately \$1.5 million. It should be noted that conventional manure management systems such as open lagoons do not allow for methane and energy recovery, which does not allow for payback, resulting in a sunk cost to a farm operation.

Grants and loans for rural energy projects are available from the USDA.

ii) Fixed administrative costs

Fixed administration of a methane collection/anaerobic digester operation would include labor for:

- Operations
- Management
- Invoicing/accounting for carbon offsets
- Record-keeping
- Environmental permitting and compliance

iii) Variable program costs

Variable program costs would be incurred on the operations and maintenance of the manure collection, digester systems, and energy generator. These costs are project specific. For this brief an annual operations and maintenance budget of \$150,000 has been assumed. This has further been adjusted to account for \$130,000 savings associated with the electricity generated from the project that Cornell is no longer required to purchase from NYSEG. Accordingly, net operational cost of the system is assumed to be \$20,000.

Anaerobic digestion of livestock manure would generate carbon offsets as a potential source of income. The offsets could be sold on a trading market such as the CCX. The value of CO₂ has recently fluctuated between \$1-4/metric ton at the CCX.

d) Transaction Costs

Transaction costs are associated with activities that include feasibility studies establishing baselines, negotiations, regulatory, monitoring, and verification costs. For example EPA

¹ AU which equates to 1,000 pounds live animal weight or the approximate weight of one beef cow.

assumes a transaction cost of \$.33 per ton CO₂e, which represents a weighted average of past offset projects.

i) Inventory baseline for project

A baseline inventory must be conducted to document pre-existing conditions and methane emissions under management practices without an approved offset project.

ii) Monitoring and verification of GHG emissions reductions

iii) Registration Fees

In addition, registration of offsets with some high quality registries requires a registration fee and a fee to retire or transfer offsets between accounts. For example the Gold Standard levies an Annual Account Subscription Fee of \$500, a Credit Certification/Issuance Fee of \$.15 per offset registered and a Secondary Credit Transfer Fee of \$.01 per offset. It is expected that registration with most registries in the future will require similar fees

2) Institutional Considerations

a) Mission

i) Aligned with mission of institution

An agricultural methane digestion project and related research are aligned with the mission of Cornell University, particularly the Cornell Waste Management Institute and the Cornell Cooperative Extension.

ii) Education and research opportunities

The education and research opportunities are numerous, including the existing research being conducted by Dr. Norman Scott and Dr. Lars Angenent of the Department of Biological and Environmental Engineering. In addition, there are many potential public education/outreach opportunities.

b) Recognition and Acceptance of Agricultural Methane Offsets

Agricultural animal waste management offset projects that capture and destroy methane are recognized and accepted by existing and proposed GHG compliance regimes, including the Regional Greenhouse Gas Initiative and all major federal climate policy proposals over the last 2 years.² It is expected that offsets from this activity will be eligible to meet Cornell's voluntary "climate neutrality" commitment to the ACUPCC and any ghg emissions reduction compliance obligations under future federal climate change policy.

² Lieberman-Warner, S. 3036, America's Climate Security Act of 2007, and; the 2008 Dingell-Boucher draft climate change legislation (House Energy and Commerce Committee).

3) Environmental Sustainability

a) GHG emission reductions/timeframe

GHG emission reductions generated by a methane capture/anaerobic digestion process are possible by converting agricultural CH_4 to CO_2 and use of biogas rather than fossil fuels for generation of electricity and/or heat.

Using data from 116 AgSTAR projects suggests an average annual reduction in CO_2 equivalents of 2.3 tons/animal. The animals at these farms included dairy cows, swine and others.

b) Biodiversity benefits

An anaerobic digester or other methane capture project may not be responsible for any tangible beneficial impacts to biodiversity in the region.

c) Additional environmental co-benefits

i) Air quality

Anaerobic digesters can be very effective at helping to control odors from animal wastes, which can help farmers' relations with residential neighbors.

Combustion of biogas produces CO_2 and other constituents. However, CO_2 emissions in this case are preferable to fugitive methane emissions because methane is a much more powerful GHG than CO_2 .

Emissions from any resultant combustion process would likely require an air permit and associated monitoring.

ii) Waste

Anaerobic digestion is essentially a closed loop, zero waste process. Byproducts of the process include biogas, which can be used for combustion or electrical generation, and solid digestate which contains residual moisture, Nitrogen and Phosphorus and can be applied as liquid fertilizer or dried and reused as bedding material. The potential reduction in quantity of waste and its disposal would have direct economic benefits to farmers.

iii) Land conservation

An anaerobic digestion system can help farmers become more self-sufficient, more efficient and more competitive, which could support farmers' efforts toward land conservation and mitigation of urban sprawl.

iv) Water supply and quality

The potential for land conservation mentioned above is directly attributable to improved surface water quality. Undeveloped land is many times more effective than developed land at preventing erosion and protecting the quality of surface water. The anaerobic digestion process may or may not use process water to transfer manure to digesters, depending upon the final design.

4) Social Responsibility

a) Local community benefits

It is estimated that there are over 7,000 dairy farms in New York State, in addition to farms with other types of livestock (USDA 2004). Each of these livestock farms have to manage manure. So, there are many other opportunities for partnerships with existing dairy farms in New York. An anaerobic digester or other agricultural methane capture project could have potential indirect benefits to the local community in several ways, as discussed above, including:

- Improved air and water quality
- Land conservation
- Classes, demonstrations, tours and workshops

b) Contribution to improved quality of life for stakeholder groups

Construction of anaerobic digesters at individual farms and/or availability of a central anaerobic digester unit at Cornell or elsewhere within central New York may serve to improve the operations, effectiveness and cost efficiency for farmers and other land owners in the area.

c) Consistent with values and standards of students, faculty and community

Many community members and local land planners would likely support conservation tillage practices on Cornell lands.

d) Transparent transaction, accounting and reporting

Carbon offset credits developed from agricultural methane projects on Cornell lands may or may not be actually traded or sold. It is suggested that offset projects should follow established protocols such as those developed by CCX or other carbon trading programs like the European Trading Scheme (ETS) or the Regional Greenhouse Gas Initiative (RGGI) for documenting and tracking emission offsets regardless of whether credits are actually sold or traded. Third party verification may be required if credits are traded or may be implemented as a best practice if they are not traded.

e) Strengthens stakeholder and institutional relations

Cornell may strengthen its community relations by implementing agricultural methane projects for the benefits discussed above in section 5a. Investing in carbon offset projects such as this would demonstrate Cornell's leadership in combating climate change.

An agricultural methane project could expand upon current research and promote further interaction between faculty and students at several different colleges. Several government agencies (local, state and federal) may also be served by such a project.

References

Chicago Climate Exchange, 2007, "Overview and Frequently Asked Questions, Agricultural Methane Offsets in Chicago Climate Exchange",
http://www.chicagoclimatex.com/docs/offsets/Agricultural_Methane_Offsets_faq.pdf,
accessed January 28, 2009.

Cornell University Cow Power project website, <http://www.cowpower.cornell.edu/>, accessed January 28, 2009.

RGGI, Inc., December 31, 2008, Regional Greenhouse Gas Initiative Model Rule,
<<http://www.rggi.org/docs/Model%20Rule%20Revised%2012.31.08.pdf>>
accessed April 23, 2009.

United States Department of Agriculture, 2004, 2002 Census of Agriculture, New York State and County Data,
http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_1_State_Level/New_York/NYVolume104 , accessed January 28, 2009.

United States Environmental Protection Agency, 2002, "Managing Manure with Biogas Recovery Systems, Improved Performance at Competitive Costs", USEPA publication EPA-430-F-02-004,
<http://www.epa.gov/agstar/pdf/manage.pdf>, accessed January 28, 2009.

Background

This memo is one of six (6) technical background memos that present information for the six carbon offset actionable alternatives which have been retained for Stage 2 analysis in developing the Cornell University Climate Action Plan (CAP). The six carbon offset alternatives included in this series of technical memos include:

1. Afforestation
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The purpose of this memo is to summarize the offset actionable alternative and identify costs, institutional considerations, and sustainability considerations including financial, environmental and social responsibility considerations associated with the alternative

General Description

Biochar is charcoal produced from the slow pyrolysis of organic biomass such as wastes from agriculture, forestry, industries (e.g., lumber, pulp, and veneer production) and residential yard wastes. Pyrolysis is a thermo-chemical reaction where biomass is heated in the absence of oxygen. The pyrolysis process that creates biochar also creates gaseous byproducts, commonly referred to as syngas, which both has useful properties as a fuel source for the generation of heat or electricity. Pyrolysis plant operating conditions can be adjusted to produce different levels of competing outputs (i.e., char, syngas, or heat).

The production of biochar has been proposed as an effective method for long-term capture and sequestration of carbon in the earth. The entire biochar process is considered a carbon “sink”, as it returns carbon captured during the photosynthesis of biomass growth to the soil for long term sequestration in the form of biochar. The process of creating biochar is an alternative to extracting all of the useable energy from the feedstock through complete combustion.

Consequently, by making biochar, less energy is being derived in exchange for lower carbon emissions and the ability to sequester carbon for long time periods. Biomass feedstock materials should be relatively free of moisture. More liquefied wastes such as dairy manure would be more amenable to anaerobic digestion or require blending with drier feedstock.

Cornell Biochar Project Offset Opportunity

A feasibility study is underway to assess a 1 to 2-ton/hour continuous capacity slow pyrolysis plant as part of the Cornell University Renewable Bioenergy Initiative (CURBI). A pilot scale

or full scale pyrolysis process could be located on lands owned and managed by Cornell near the Ithaca campus.

Project Scale (calculations from Roberts et al, in preparation, 2009)

This memo will focus on biochar production from a large scale pyrolysis unit that could operate for up to 7000 hours per year, processing 1 – 2 dry tons per hour. This analysis will use this level of operation to estimate the amount of biochar that could be produced and the amount of acres that would be needed to spread this biochar.

A large scale pyrolysis unit could potentially use approximately 8,000 - 15,000 tons of dry biomass feedstock per year (or 16,000 – 30,000 tons of wet biomass, assuming an average moisture content of 50%, which would require drying prior to pyrolysis). This unit could potentially produce 2,400 to 4,500 tons of biochar per year, which would contain 1300 - 2400 tons of C (4,700 – 8,900 tons of CO₂e), depending upon the feedstock biomass used and the amount of syngas produced. The resulting carbon in the form of biochar would be expected to exhibit long-term stability after being applied to the soil.

The following existing waste sources may be available for use as pyrolysis feedstock:

- Yard waste biomass,
- Pre-ground pallet waste,
- Wastes currently being composted (e.g., food waste),
- Animal bedding from the polo barns, and
- Wastes from the vet school and greenhouses.

Cornell forests could be used to produce biomass feedstock that could be sustainably harvested, chipped and delivered to the pyrolysis facility. Additional feedstock may be available from afforestation projects and/or if crop biofuel plantations were established.

Biochar produced from a pyrolysis unit could potentially be applied to any cultivated or forested lands owned or managed by Cornell. At a typical annual application rate 5 Mg C per hectare (which is equivalent to 3.3 tons of biochar per acre with an average biochar C content of 68 wt. %), the larger pyrolysis unit would require 700 – 1400 acres to spread 2,400 – 4,500 tons of biochar each year. However, the biochar could be spread much more densely than this, with annual applications of 20 tons of biochar per acre with subsequent positive crop responses, and even applications of biochar up to 140 Mg C/ha (92 tons biochar/acre) can produce increased crop yields (Lehman et al, 2006).

However, it is unlikely that all of Cornell's lands could accept a high rate of biochar application because of the variation in soils and other conditions. Realistically, relatively little of Cornell's forest land is suited to easy application of biochar because of the lack of roads and hilly terrain.

Perhaps 100 to 200 forested acres could be used to sequester 5000 to 10000 tons C at an application rate of up to 50 tons C/acre. Assuming that the maximum biochar yield from the proposed full-scale pyrolysis plant is 4,500 tons/year, the resulting application rate is well below this maximum application rate.

Given that there are no functioning large scale biochar-pyrolysis facilities in the US, these quantities of sequestration remain longer term objectives rather than operational guidelines. However, given the large amounts of carbon that could be sequestered and the added potential for bio-energy generation from pyrolysis co-products, testing of the viability of producing and applying large quantities of biochar to soils, should be given priority.

Project Timeframe

Offsets could be delivered upon the start of full-scale operations. Full-scale biomass pyrolysis plants are relatively new. The duration for planning, design, construction and commissioning of such a plant would depend upon financing as well as the plant size. However, it may be feasible to have a fully commissioned plant accepting biomass within 5 years.

Project Costs

Capital

The budget for the proposed 1 to 2-ton/hour continuous capacity slow pyrolysis plant for CURBI is approximately \$3.5 million while the whole CURBI project may be closer to \$15 million (CUAES, 2009).

The feasibility of pyrolysis is largely dependent upon the value of carbon. At lower values of carbon (<\$5/ton), pyrolysis may not be feasible. While at higher costs, pyrolysis becomes more attractive (see discussion below under "Variable Program Costs").

Fixed administrative costs

Fixed administration of a biomass pyrolysis operation would include labor for:

- Operations
- Management
- Invoicing/accounting for services and carbon offsets
- Record-keeping
- Environmental permitting and compliance

These costs have not been estimated at this time.

Variable program costs

Variable program costs would likely be incurred on the operations and maintenance of the pyrolysis plant.

The costs of producing biochar for carbon sequestration depend on the feedstock source being used. Roberts estimates the cost of collection and transport (15 km) of potential feedstocks in the range of \$35 to \$45/ton with a resulting cost of \$240 to \$310 per ton CO₂e sequestered in biochar (Roberts 2009).

However, the resulting syngas and biochar have value that could reduce these production costs. The generation rates of syngas and biochar depends upon pyrolysis processing conditions and the type of feedstock. The syngas can be sold as fuel, while the biochar itself has a potential value, depending on how carbon is valued. Furthermore, the biochar has value as a soil amendment, providing carbon, phosphorus and potassium to soils and reducing the need for fertilizer. An application rate of 5 tons C per hectare has been shown to decrease fertilizer needs by 7% because of increased nutrient availability following application (Steiner et al 2008).

The total cost of biochar production, assuming a low value for carbon of \$3.38/ton CO₂e (current Regional Greenhouse Gas Initiative (RGGI) price) and a conservative estimate on the electricity produced from the syngas, would range from approximately \$100 to \$230 per ton CO₂e sequestered, depending upon the feedstock used. However, if carbon is valued at a higher rate (\$80/ton CO₂e), biochar has a production cost of \$40 to \$150 per ton CO₂e sequestered, depending upon the feedstock used.

Assuming a conservative average net production cost of \$165/ton CO₂e and an average annual biochar production of 3450 ton/year (8600 tons of CO₂e sequestered), the resulting annual operating budget would be approximately \$1.4 million. This cost could be reduced with higher values of carbon and electricity/heat. It is further assumed that operational cost efficiencies would be realized with time. These operational costs will be further evaluated and refined in the CURBI feasibility study in progress.

Offset Transaction Costs

Transaction costs are associated with activities that include feasibility studies, establishing and verifying baselines, negotiations, regulatory compliance costs, and on-going monitoring and verification costs. For example EPA assumes a transaction cost of \$.33 per ton CO₂e in its cap and trade economic modeling assumptions and represents a weighted average of past offset projects.

Inventory baseline for project

Under a carbon offset program such as RGGI or CCX, a one-time baseline inventory may be required to document and quantify the existing conditions and future carbon sequestration and offsets. This could be done using existing Cornell resources or an outside contractor. The level of effort and costs associated with a baseline inventory are project specific.

Monitoring and verification of GHG emissions reductions

A routine review/inventory of biochar produced may be required to document the calculated or assumed carbon capture and sequestration quantities. This could be done using existing Cornell resources or an outside contractor. The level of effort and costs associated with a baseline inventory are project specific and have not been estimated for this memo.

Additional studies or testing may voluntarily be conducted by faculty and/or students as part of related research efforts. The results of the studies or testing may serve to further verify the calculated or assumed carbon capture and sequestration quantities.

Registration of Offsets

In addition, registration of offsets with some high quality registries requires a registration fee and a fee to retire or transfer offsets between accounts. For example the Gold Standard levies an Annual Account Subscription Fee of \$500, a Credit Certification/Issuance Fee of \$.15 per offset registered and a Secondary Credit Transfer Fee of \$.01 per offset. It is expected that registration with most registries in the future will require similar fees.

Institutional Considerations**Mission****Aligned with mission of institution**

Biomass pyrolysis, biochar production and related research have the potential to have a significant impact upon efforts to reduce atmospheric greenhouse gases and combat climate change. Accordingly, this project is aligned with the mission of Cornell University.

Education and research opportunities

The education and research opportunities are numerous. Biochar research is currently being conducted within the Department of Crop and Soil Sciences, the Department of Natural Resources and the Department of Horticulture. In addition, there is a biochar

group which meets monthly and the Cornell Center for Sustainable Future (CCSF) awarded an Academic Venture Fund (AVF) grant to further biochar research. This research will involve several departments from three colleges as well as Cornell Plantations (Cornell CSS, 2009). There are also many potential public education/outreach opportunities.

Recognition and Acceptance of Biochar Offsets

As an emerging technology, biochar is a promising source of offsets but will need additional research to demonstrate its duration in soil before it is likely to be considered as an eligible compliance offset. For purposes of Cornell University's voluntary, "climate neutrality" commitment, the university has a good deal of freedom and can count CO₂e sequestered from a pilot project using this process towards its ACUPCC commitment. However, it is recommended that a protocol be established up front for measuring and quantifying whatever offset credit the University wishes to take.

Environmental Sustainability

GHG emission reductions/timeframe

GHG emission reductions as well as capture and sequestration are possible with biomass pyrolysis and biochar production.

Biodiversity benefits

If a biomass pyrolysis plant obtains most of the feedstock from farm crops, it may not be responsible for any tangible beneficial impacts to biodiversity in the region. Further, since the areas of forest that are amenable to application are limited, no regional affects of biodiversity would be anticipated. Biodiversity of soil fauna and flora could be significantly altered in those areas where biochar was applied.

Additional environmental co-benefits

Air quality

The pyrolysis process requires heat, which would likely be obtained from the syngas produced during pyrolysis. A small amount of fossil fuel such as natural gas is needed for the process start up, which is less than 1% of the energy of the biomass feedstock. The pyrolysis process produces syngas and tarry oils, which can easily be converted to clean syngas using existing technologies such as thermal cracking, gas filters and scrubbers. Complete combustion of the syngas would have primarily CO₂ and H₂O as emission species, and other emissions in smaller amounts such as CO, NO_x and SO_x would likely require an air permit and associated monitoring.

Waste

Biomass pyrolysis is essentially a zero waste process. Byproducts of the process include syngas which can be recycled and combusted to fuel the pyrolysis process; bio-oils which can be converted to syngas with tar cracking, used for direct combustion, or further refined to biodiesel; and biochar, which is useful as a soil amendment for further biomass growth, food production and long-term carbon sequestration.

Land conservation

A biomass pyrolysis system at Cornell would require the development of land for the process itself. The footprint of a pyrolysis plant would depend upon the size and design throughput of the system.

However, the biomass feedstock for pyrolysis would most likely come from agricultural and/or forestry operations. This feedstock may provide income for farmers and land owners which could support efforts toward land conservation and mitigation of urban sprawl.

Water supply and quality

The potential for land conservation mentioned above is directly attributable to improved surface water quality. Undeveloped land is many times more effective than developed land at preventing erosion and protecting the quality of surface water

The pyrolysis process does not use significant amounts of process water for heating or cooling and would not affect local water supplies.

Social Responsibility

Local community benefits

A biomass pyrolysis project could have potential indirect benefits to the local community in several ways, as discussed above, including:

- Improved air and water quality
- Land and wildlife habitat conservation
- Local availability of biochar and syngas products
- Classes, demonstrations, tours and workshops

Contribution to improved quality of life for stakeholder groups

Availability of a pyrolysis unit at Cornell or elsewhere within central New York may serve to improve the operations, effectiveness and cost efficiency for farmers and other land owners in the area.

Consistent with values and standards of students, faculty and community

An effective pyrolysis unit would be largely consistent with values held by the Cornell community. Future life cycle analyses of a pyrolysis unit may lend further credence to those with doubts.

Potential negative effects may occur if feedstock suppliers develop practices or alter existing practices to support monoculture crops.

Transparent transaction, accounting and reporting

Carbon offset credits developed from pyrolysis/biochar projects on Cornell lands may or may not be actually traded or sold. It is suggested that offset projects should follow established protocols such as those developed by CCX or other carbon trading programs like the European Trading Scheme (ETS) or the Regional Greenhouse Gas Initiative (RGGI) for documenting and tracking emission offsets regardless of whether credits are actually sold or traded. Third party verification may be required if credits are traded or may be implemented as a best practice if they are not traded.

Strengthens stakeholder and institutional relations

Cornell may strengthen its community relations by implementing projects for the benefits discussed above in section 5a. A pyrolysis/biochar project could involve research and interaction between faculty and students at several different colleges. Several government agencies (local, state and federal) may also be served by such a project.

References

Cornell University Agricultural Experiment Station (CUAES), February 5, 2009, personal communication, Lewis, Andrew, Director of Operations, telephone conversation with Andrew Murphy, Cornell University Environmental Compliance and Sustainability, Ithaca, NY.

Lehman, J., Gaunt, J., and Rondon, M., 2006, "Bio-Char Sequestration in Terrestrial Ecosystems – A Review", <http://www.css.cornell.edu/faculty/lehmann/publ/MitAdaptStratGlobChange%2011,%20403-427,%20Lehmann,%202006.pdf>, accessed January 28, 2009.

Roberts, K. G.; Joseph, J.; Gloy, B.; Lehmann, J., Life cycle assessment of biochar production: Estimating the energetic, economic, and climate change potential. *In preparation* **2009**.

Steiner, C.; Glaser, B.; Teixeira, W. G.; Lehmann, J.; Blum, W. E. H.; Wolfgang Zech, Nitrogen retention and plant uptake on a highly weathered central Amazonian Ferralsol amended with compost and charcoal. *Journal of Plant Nutrition and Soil Science* **2008**, 171, (6), 893-899.

Background

This memo is one of six (6) technical background memos that present information for the six carbon offset actionable alternatives which have been retained for Stage 2 analysis in developing the Cornell University Climate Action Plan (CAP). The six carbon offset alternatives included in this series of technical memos include:

1. Afforestation
2. Forest Management
3. Biochar
4. Soils/tillage practices
5. Agricultural methane
6. Market Purchases of Offsets

The purpose of this memo is to summarize the offset actionable alternative and identify costs, institutional considerations, and sustainability considerations including financial, environmental and social responsibility considerations associated with the alternative.

1) General description

Forest Management approach to creating offsets is accomplished by managing forest growth to enhance carbon sequestration via silviculture practices or conservation of standing forest stocks to ensure higher sequestration potential. This can be accomplished by planting moderately fast-growing species to accumulate timber (and carbon) faster or can be achieved through practices such as fertilization, controlled burning, and thinning to increase forest and carbon productivity.

Additional beneficial uses of intensive forestry lands may include wildlife habitat development/land conservation, recreational usage, production of timber, pulp wood or other forest products and carbon capture and sequestration. Carbon is fixed from the atmosphere in photosynthesis and is sequestered in a tree's biomass above and below ground. In addition, carbon is transferred to the soil by the roots and by decomposition of forest debris/leaf litter.

a) Cornell Forestry Management Offset Opportunity

Intensive forest management may be possible on all 6,636 acres of Cornell University owned forest lands. The areas proposed for intensive forest management are forest areas not managed by Cornell Plantations and include Cornell properties located at Arnot forest, on Mt. Pleasant, near the Tompkins County Airport, and near and Harford Animal Science Teaching and Research Center. Harvested biomass from this program could also be co-fired with coal to replace up to 10% by weight or (4.5% by BTUs) of the coal

burned by Cornell after completion of the Cornell Combined Heat and Power Project. To replace this with wood would require approximately 2,500 dry tons, depending on the BTU content of the wood, which would probably be average because of the mixture of dense hardwoods (high btu content) and conifers (low). The Fuels Mix and Renewable Energy Wedge Group will be evaluating this option for the Climate Action Plan.

b) Project Scale

Recent modeling of forests in Tompkins County using the US Forest Service NED2 model (Twery et al, 2005) estimates the carbon sequestration rate of the existing conditions in the 6,636 acres of Cornell forest lands to be 7,770 tons CO₂e/yr, while the average sequestration rate of the same acreage while intensively managed over the next 50 years (2009 – 2058) could sequester 30% more for a net potential additional sequestration of 2,330 tons CO₂e /year. This net sequestration potential is after the annual harvesting of 2,500 tons of biomass each year for use at the Cornell central heating plant (Cornell University Department of Natural Resources, 2009).

c) Project Timeframe

Published studies on intensive forest management demonstrate quantifiable carbon sequestration immediately after a cutting regime is implemented. The rate of carbon sequestration varies by tree species and with time, but is generally high initially and becomes asymptotic after a certain time period, depending on the type of management used.

d) Management approach

An example of a possible intensive forest management strategy is listed in the table below.

Thinning from below in 2009	Cutting small trees to 60ft ² /ac
Thinning from above in 2019	Cutting largest trees to 60ft ² /ac
Seed cut in 2039	Cutting small trees to 40ft ² /ac
Shelter-wood top cut in 2058	Cutting all trees >3in dbh to 10ft ² /ac

However, the specific strategies to be used would be determined by the Cornell's forest management experts.

e) Project costs

i) Capital

There are no capital costs for this project. No new equipment will be required, as timber harvesting will be contracted to outside sources. It is further assumed that because the harvested timber will be used by the

However, annual operations and maintenance costs for an intensive forest management project are required, which would include contracted labor, materials and equipment costs incurred for annual pesticide applications, boundary markings and forest inventories. It is assumed that forest operations will occur to a portion of the forested lands each year on a rotating inventory (Cornell University Department of Natural Resources, 2009), as described below:

- Inventory 600 acres/yr at \$10/acre
- Apply pesticides on 60 acres/yr at \$100/acre
- Perform boundary markings on 100 acres/yr at \$10/acre

An annual operations budget of \$13,000 has been estimated for these forested lands. This budget does not include the forest harvest/thinning operations, which would cost approximately \$50/acre. For purposes of this memo, these costs are assumed to be attributed to the biomass portion of the Fuels Mix and Renewable Energy Wedge of the CAP.

ii) Fixed administrative costs

Administration of forest lands is dependent upon the degree of forest management performed. It is assumed that a minimum amount of administration and management would likely be required. However, additional administrative costs may be involved to document eligibility standards and obtain independent verification, etc.

iii) Variable program costs

Forest lands would require some degree of management, monitoring and maintenance. However, forest lands may not need to be significantly managed, depending upon the degree of usage. Optional uses such as recreational trails or collection of maple sap are described further below and may require additional maintenance. In addition, natural or weather-related incidents may require unscheduled maintenance and/or tree replacement. Examples of variable program costs may include:

- Erosion control projects
- Replanting
- Road clearing and maintenance
- Other infrastructure maintenance
- Pesticides

These costs have not been estimated and are not included in any costs given in this memo.

f) Transaction Costs

Transaction costs are associated with activities that include feasibility studies, establishing and verifying baselines, negotiations, regulatory compliance costs, and on-going monitoring and verification costs. For example EPA assumes a transaction cost of \$.33 per ton CO₂e in its cap and trade economic modeling assumptions and represents a weighted average of past offset projects.

i) Inventory baseline for project

A baseline inventory prior to intensive forest management operations would be required to document and quantify the existing conditions and future carbon sequestration and offsets. This could be done using existing Cornell resources or an outside contractor. A baseline inventory over the entire 6,636 acres of forest lands is assumed to cost approximately \$67,000 assuming a unit cost of \$10/acre.

ii) Monitoring and verification of GHG emissions reductions

Because the carbon capture and sequestration from forests varies with stand age, a routine forest inventory would be required to document the calculated or assumed carbon capture and sequestration quantities. This could be done using existing Cornell resources or an outside contractor. It is assumed that the forest lands will be inventoried on a 10-year rotating basis. Similar to the baseline inventory above, a unit cost of \$10/acre would result in an annual inventory cost of approximately \$6,000 - \$7,000.

Additional studies or testing may voluntarily be conducted by faculty and/or students as part of related research efforts. The results of the studies or testing may serve to further verify the calculated or assumed carbon capture and sequestration quantities. A source for third part certification and official registration, if desired, would need to be investigated.

iii) Registration fees

In addition, registration of offsets with some recognized or high quality registries requires a registration fee and a fee to retire or transfer offsets between accounts. For example the Gold Standard levies an Annual Account Subscription Fee of \$500, a Credit Certification/Issuance Fee of \$.15 per offset registered and a Secondary Credit Transfer Fee of \$.01 per offset, adding about \$.26 per MtCO₂e to a 5,000 MtCO₂e offset project. It is expected that registration with most registries in the future will require similar fees

2) Institutional Considerations

a) Mission

i) Aligned with mission of institution

Intensive forest management is aligned with the mission of Cornell University, particularly the Cornell Agricultural Experiment Station, the Cornell Cooperative Extension service, and its Forest Connect program.

ii) Education and research opportunities

The education and research opportunities are numerous, including the baseline inventory and routine monitoring. In addition, there are many potential public education/outreach opportunities.

b) Recognition and Acceptance of Forest Management Offsets

Forest management practices are a demonstrated and recognized source of CO₂e offsets. While not accepted by the Regional Greenhouse Gas Initiative, offsets created by more intensive forest management practices are proposed by the two major federal climate policy proposals introduced during the last two years and the Western Climate Initiative.¹ It is expected that offsets from this activity will be eligible to meet Cornell's voluntary "climate neutrality" commitment to the ACUPCC and any greenhouse gas emissions reduction compliance obligations under future federal climate change policy.

3) Environmental Sustainability

a) GHG emission reductions/timeframe

The quantity of carbon capture and sequestration in intensive forest management projects is dependent upon several variables, including

- Species type and quantity/proportion
- Soil types
- Climate
- Health and age of forest stand

Published studies suggest that intensive forest management projects in the United States have the potential to capture and sequester an average of 2 tons of carbon (7.2 tons carbon dioxide) per acre per year. Modeling conducted with the NED2 model, as described above, was conducted for purposes of this memo. The results of the modeling indicate that the total average sequestration potential for the forest lands is approximately 1.5 tons/acre/year or a net sequestration above baseline conditions of approximately 0.3 tons/acre/year for the next 50 years (Cornell University Department of Natural Resources, 2009).

¹ Lieberman-Warner, S. 3036, America's Climate Security Act of 2007, and; the 2008 Dingell-Boucher draft climate change legislation (House Energy and Commerce Committee).

b) Biodiversity benefits

Intensive forest management projects have the potential to support diverse tree species which in turn could create diverse habitat for numerous types of native wildlife species. Preferably a mixture of species would be maintained since biodiversity creates for habitat opportunities for other species and add a degree of stability to the ecosystem. Further, these forests should be managed to eventually diversify the age structure, for similar reasons.

c) Additional environmental co-benefits

i) Air quality

There are no industrial processes, discharges or other air quality impacts associated with intensive forest management projects.

ii) Waste

Wastes associated with intensive forest management projects are minimal. Forest wastes will generally be left on the forest floor to enhance habitat. Material not needed for this will be useable for fuel feedstock. Additional wastes may require management if other optional forest uses such as recreation are included as part of the intensive forest management project.

iii) Land conservation

Large-scale intensive forest management must conserve the land to a relatively undeveloped state in order to maximize the carbon capture and sequestration potential from the land.

iv) Water supply and quality

Intensive forest management land will have no significant impacts on water supply and quality. Rather, it has the potential to protect surface water quality. Forested land or other undeveloped land is many times more effective at preventing erosion and protecting the quality of surface waters than developed land. Best management practices to prevent erosion.

4) Social Responsibility

a) Local community benefits

An intensive forest management project could have potential indirect benefits to the local community in several ways, as discussed above, including:

- Improved air and water quality
- Recreational opportunities
- Land and wildlife habitat conservation

- Local availability of forest products
 - Classes, demonstrations, tours and workshops
- b) Contribution to improved quality of life for stakeholder groups
Many community members and local land planners support maintenance of forests on Cornell lands.
- c) Consistent with values and standards of students, faculty and community
There are no significant impacts associated with intensive forest management. Some may support reduced forest management to promote greater species biodiversity. In addition, use of pesticides and/or herbicides as part of forest management could have negative effects.
- d) Transparent transaction, accounting and reporting
Carbon offset credits developed from intensive forest management projects on Cornell lands may or may not be actually traded or sold. It is suggested that offset projects should follow established protocols such as those developed by CCX or other carbon trading programs like the European Trading Scheme (ETS) or the Regional Greenhouse Gas Initiative (RGGI) for documenting and tracking emission offsets regardless of whether credits are actually sold or traded. Third party verification may be required if credits are traded or may be implemented as a best practice if they are not traded.
- e) Strengthens stakeholder and institutional relations
Cornell may strengthen its community relations by implementing intensive forest management projects for the benefits discussed above. Investing in carbon offset projects such as this would demonstrate leadership in combating climate change. Intensive forest management projects would have no significant impacts on the public if the elements outlined above to maintain habitat diversity are implemented.

References

Cornell University Department of Natural Resources, April 21, 2009, personal communication, David Weinstein telephone conversation with Andrew Murphy, CU Environmental Compliance and Sustainability

Twery, Mark J.; Knopp, Peter D.; Thomasma, Scott A.; Rauscher, H. Michael; Nute, Donald E.; Potter, Walter D.; Maier, Frederick; Wang, Jin; Dass, Mayukh; Uchiyama, Hajime; Glende, Astrid; Hoffman, Robin E. 2005. NED-2: a decision support system for integrated forest ecosystem management.

Background

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1. Afforestation
2. Forest Management
3. Biochar
4. Soils/tillage practices
5. Agricultural methane
6. Market Purchases of Offsets

The purpose of this memo is to summarize the offset actionable alternative and identify costs, institutional considerations, and sustainability considerations including financial, environmental and social responsibility considerations associated with the alternative

1) General Description

Agricultural soils can sequester additional carbon under a number of different tillage and soil management practices. Conservation tillage is an agricultural practice that reduces on crop lands leaves crop residue in place to cover at least 30% of the soil surface after planting. Similarly, no tillage practices leave soil undisturbed from harvest to planting (Baker et al, 2006). Under both scenarios reduce soil disturbance reduces the release of CO₂e to the atmosphere via decomposition of organic carbon in the soil. Conversion of cropland to pasture land would accomplish the same result.

It is believed that plowing or tillage of soil has historically contributed to depletion of soil organic carbon (SOC) reservoirs in croplands. It has been estimated that croplands have lost an average of 36 tons carbon per hectare and that conservation tillage practices have the potential to sequester 24-40Mt C/year (Baker et al, 2006).

Conservation tillage as a carbon offset strategy is promoted by the Kyoto Protocol and accepted by the Chicago Climate Exchange (CCX). Agricultural soil management has further been recognized as an eligible offset category under S 3036, Lieberman-Warner (as amended), Western Climate Initiative, and perhaps provisions of the Dingell Boucher discussion bill.

Other research differs and has suggested that “Though there are other good reasons to use conservation tillage, evidence that it promotes CO₂e sequestration is not compelling” and

instead offers that historic SOC loss may instead be due to annual cropping systems and draining of historic wetlands (Baker et al, 2006).

a) Cornell Agricultural Soil Tillage Offset Project Opportunity

Conservation and no tillage practices are already conducted on many acres by Cornell Farm Services and at the Musgrave Research Farms (~1,000 acres). Conservation tillage projects could be conducted on additional lands owned and managed by Cornell. For purposes of this memo, it is assumed that conservation tillage/no tillage practices could be instituted at the Harford Animal Science Teaching and Research Center on up to 1,000 acres.

b) Project Scale

Studies suggest that no-till practices can sequester an average of 0.6 tons C/ha/year (0.24 tons C/acre/year or 0.9 tons CO₂/acre/year) (Baker et al, 2006). CCX allows for annual offsets of 0.2 to 0.6 metric tons CO₂ per acre per year, depending upon the region, the soils and the particular practices being undertaken (Chicago Climate Exchange 2008). For purposes of this offset brief it is assumed that CO₂e sequestration rate for a Cornell-sourced soil tillage project is .4/tons CO₂e/acre/yr.

c) Project Timeframe

Carbon offsets would be delivered immediately upon implementation and documentation of conservation tillage practices.

d) Project costs

i.) Capital

Cornell University College of Agriculture and Life Sciences owns sufficient farm equipment. For purposes of this memo, it is assumed that no capital costs are required because conservation tillage is already conducted on a large amount of acreage. Future conservation tillage or no tillage operations may require purchase of additional alternative planting equipment or modifications to this existing equipment.

ii.) Fixed administrative costs

Fixed administration of conservation tillage or no tillage operations would include labor for:

- Operations
- Management
- Invoicing/accounting for services and carbon offsets
- Record-keeping

iii.) Variable program costs

Variable program costs may be incurred on the operations and maintenance of the plant, including replacement and emergency repairs of specialty planting equipment, although this is not expected to exceed current expenses.

It should also be noted that conservation or no tillage practices can save operations costs by reducing the need for fuel consumption and water. It also saves labor, so additional operations and management expenses are mostly associated with start-up and learning curves.

e) Transaction Costs

Transaction costs are associated with activities that include feasibility studies, establishing and verifying baselines, negotiations, regulatory compliance costs, and on-going monitoring and verification costs. For example EPA assumes a transaction cost of \$.33 per ton CO₂e in its cap and trade economic modeling assumptions, which represents a weighted average of past offset projects.

i.) Inventory baseline for project

Under the CCX program, a one-time baseline inventory prior to implementation may be required to document and quantify the existing conditions and future carbon sequestration and offsets. This could be done using existing Cornell resources or an outside consultant/contractor. The level of effort and costs associated with a baseline inventory are project specific and are related to the size and condition of the land.

ii.) Monitoring and verification of GHG emissions reductions

A regular review may be required to document the calculated or assumed carbon capture and sequestration quantities. This could be done using existing Cornell resources or an outside contractor. The level of effort and costs associated with a baseline inventory are project specific and are related to the size and condition of the land.

Additional studies or testing may voluntarily be conducted by faculty and/or students as part of related research efforts. The results of the studies or testing may serve to further verify the calculated or assumed carbon capture and sequestration quantities.

iii.) Registration Fees

In addition, registration of offsets with some high quality registries requires a registration fee and a fee to retire or transfer offsets between accounts. For example the Gold Standard levies an Annual Account Subscription Fee of \$500, a Credit Certification/Issuance Fee of \$.15 per offset registered and a Secondary Credit Transfer Fee of \$.01 per offset. It is expected that registration with most registries in the future will require similar fees

2) Institutional Considerations

a) Mission

(i) Aligned with mission of institution

Conservation tillage or no tillage operations and related research are aligned with the mission of Cornell University, particularly the Department of Crop and Soil Sciences and the Cornell Cooperative extension.

(ii) Education and research opportunities

The education and research opportunities are numerous. In addition, there are many potential public education/outreach opportunities.

b) Recognition and Acceptance of Soil Tillage Offsets

Conservation soil tillage management practices are recognized by the Chicago Climate Exchange's voluntary offset market. While additionality is a complicating factor in determination of what soil tillage practices result in an eligible offset, both federal climate policy proposals introduced during the last two years contain provisions to allow offsets from this activity.¹ It is expected that offsets created by placing additional crop and pasture lands under conservation tillage will be eligible to meet Cornell's voluntary "climate neutrality" commitment to the ACUPCC. Conservation tillage may also potentially meet Cornell's emissions reduction compliance obligations under future federal climate change policy.

3) Environmental Sustainability

a) GHG emission reductions/timeframe

CCX allows for annual offsets of 0.2 to 0.6 metric tons CO₂ per acre per year, depending upon the region, the soils and the particular practices being undertaken.

b) Biodiversity benefits

Crop residues from conservation tillage and/or no tillage operations increase biodiversity.

c) Additional environmental co-benefits

i.) Air quality

There are no industrial processes, discharges or other air quality impacts associated with conservation tillage or no tillage projects. Rather the locomotive power required for conservation tillage or no tillage practices is typically less than conventional tillage practices, which leads to reduced air emissions from farm equipment. In addition crop residues can reduce airborne soil erosion

¹ Lieberman-Warner, S. 3036, America's Climate Security Act of 2007, and; the 2008 Dingell-Boucher draft climate change legislation (House Energy and Commerce Committee).

ii.) Land conservation

Carbon offset funding from conservation tillage practices may provide income for farmers and land owners which could support efforts toward land conservation and mitigation of urban sprawl.

iii.) Water supply and quality

The potential for land conservation mentioned above is directly attributable to decreased erosion and improved surface water quality. Conservation tillage practices do not use additional water over conventional farming practices and would not affect local water supplies. Rather crop residues have the ability to better retain soil moisture than conventional tillage techniques.

4) Social Responsibility

a) Local community benefits

A conservation tillage project could have potential indirect benefits to the local community in several ways, as discussed above, including:

- Improved air and water quality
- Land conservation
- Cornell sponsored outreach through classes, demonstrations, tours and workshops

b) Contribution to improved quality of life for stakeholder groups

Many community members and local land planners would likely support conservation tillage practices on Cornell lands.

c) Consistent with values and standards of students, faculty and community

There are no significant impacts associated with conservation tillage practices. Greater use of pesticides and/or herbicides resulting from conservation tillage practices in transitional years could have negative effects, but inputs are generally lower in subsequent years.

d) Transparent transaction, accounting and reporting

Carbon offset credits developed from conservation tillage projects on Cornell lands may or may not be actually traded or sold. It is suggested that offset projects should follow established protocols such as those developed by CCX or other carbon trading programs like the European Trading Scheme (ETS) or the Regional Greenhouse Gas Initiative (RGGI) for documenting and tracking emission offsets regardless of whether credits are actually sold or traded. Third party verification may be required if credits are traded or may be implemented as a best practice if they are not traded.

e) Strengthens stakeholder and institutional relations

Cornell may strengthen its community relations by implementing conservation tillage projects for the benefits discussed above in section 5a. Investing in carbon offset projects such as this would demonstrate leadership in combating climate change.

A conservation tillage project could involve research and interaction between faculty and students at several different colleges. Several government agencies (local, state and federal) may also be served by such a project.

References

Baker, J., Ochsner, T., Venterea, R., and Griffis, T., 2006, “Tillage and soil carbon sequestration – What do we really know?”, *Agriculture, Ecosystems and Environment*, Vol. 118, pages 1-5.

Chicago Climate Exchange, 2008, “Soil Carbon management Offsets” brochure, http://www.chicagoclimatex.com/docs/offsets/CCX_Soil_Carbon_Offsets.pdf, accessed January 28, 2009.

Core4 website, <http://www2.ctic.purdue.edu/Core4/CT/CTSurvey/10Benefits.html>, accessed January 28, 2009.

Cornell University Department of Crop and Soil Sciences website, <http://css.cals.cornell.edu/cals/css/about/musgrave-research-farm.cfm>, accessed February 6, 2009.

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1. Afforestation
2. Forest Management
3. Biochar
4. Soils/tillage practices
5. Agricultural methane
6. Market Purchases of Offsets

The purpose of this memo is to summarize offset market purchases as an actionable alternative and identify costs, institutional considerations, and sustainability considerations including financial, environmental and social responsibility considerations associated with the alternative.

1) General Description of Offsets

GHG offsets represent a real reduction, sequestration or destruction of greenhouse gas (GHG) emissions from projects or activities outside the boundary of a regulatory program or an entity's carbon footprint. The concept of carbon dioxide (CO₂e) offsetting stems from the idea that addressing climate change does not hinge on where the CO₂e emissions reductions occur. From a scientific perspective, GHG emissions assimilate and accumulate uniformly across the earth's atmosphere. The geographical location of greenhouse gas emissions -- or a reduction of greenhouse gases -- is immaterial to its impacts on climate change. The net result of reducing, sequestering, destroying or avoiding one metric of CO₂e in Ithaca, New York is equivalent to reducing or sequestering one ton of CO₂e in Ithaca, Georgia. As such purchases of credible and high quality offsets should be regarded as an investment in real and permanent GHG emissions reductions.

Offsets are purchased by companies and institutions to achieve voluntary GHG emissions reductions not immediately possible through direct emissions reductions or avoidance of on-site emissions. Offsets are also a recognized element of mandatory international GHG emissions reduction programs, including the Kyoto Protocol, the European Union Emissions Trading System, Canada's GHG program, and the emerging regulatory regime in Australia. In the United States the Northeast's mandatory Regional Greenhouse Gas Initiative recognizes offsets while several U.S. domestic cap-and-trade programs proposed in the 110th and 111th Congress have included offsets as an important cost containment measure that can substantially reduce the overall cost of achieving emission reduction for regulated entities.

In addition to increasing the cost effectiveness of regulatory programs, offsets can benefit GHG emissions initiatives by encouraging early emission reduction activities, either ahead of or beyond mandatory requirements and stimulating innovation and emissions reduction activities in sectors outside the boundary of a regulatory program or an entity's carbon footprint that provide environmental, social, and economic co-benefits.

Offset Projects Types -- Voluntary and Compliance

	Emissions Reductions	Sequestration	Avoided Emissions
Compliance Offsets	<ol style="list-style-type: none"> 1. Methane capture and destruction <ul style="list-style-type: none"> ✓ Livestock Waste ✓ Muni Waste ✓ Coal mines 2. NG efficiency projects 3. Fertilizer, Nutrient Management 	<ol style="list-style-type: none"> 4. Afforestation 5. Forest management 6. Geologic sequestration 7. Soil Sequestration <ul style="list-style-type: none"> ✓ Agriculture tillage ✓ Rangeland conservation ✓ Bio-char 	<ol style="list-style-type: none"> 8. Avoided Deforestation
Voluntary Offsets Low Probability Offsets will be compliance-eligible but still <u>may</u> be used for voluntary program purposes.	<ol style="list-style-type: none"> 1. Transportation end use efficiency 2. Fuel Switching 3. Distributed renewable 4. Industrial fugitive emissions 		<ol style="list-style-type: none"> 5. Fuel Switching 6. Electric energy efficiency 7. RECS 8. Grid-tie renewable energy projects

The ACUPCC acknowledges that in the short run it will be very difficult for institutions to achieve climate neutrality without offsets.¹ Still for purposes of the ACUPCC agreement offsets are regarded as strategy that is complementary to direct on-campus GHG emissions reductions, and not a replacement for those strategies. The ACUPCC guidelines state:

¹ American College and University Presidents Climate Commitment, "Investing in Carbon Offsets: Guidelines for ACUPCC Institutions", November 2008 v1.0, page 10.

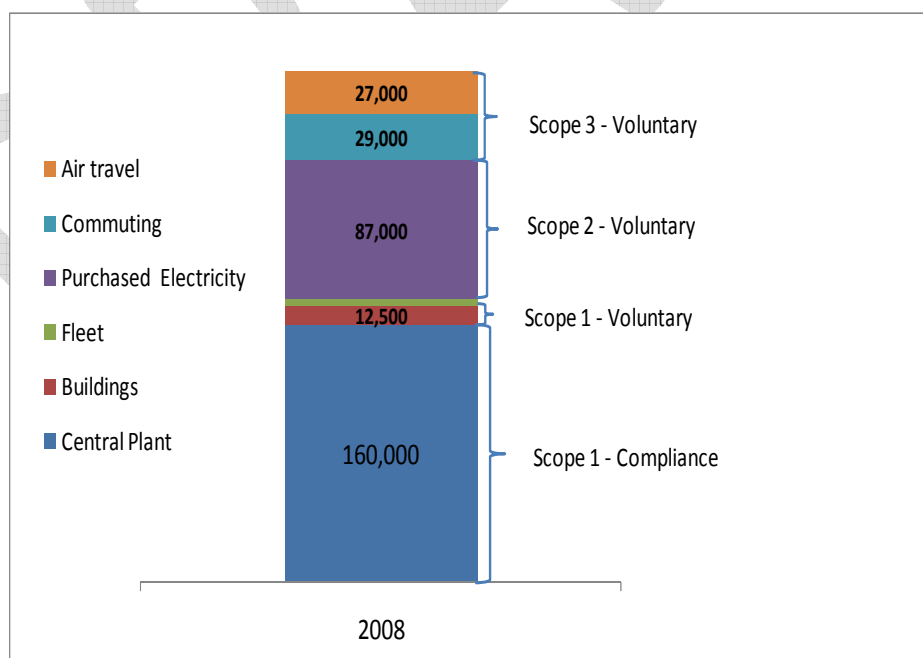
“...the short term use of high quality offsets can be an effective way to drive real reductions in GHG emissions now, and can serve as a useful tool for internalizing the costs of GHG emissions and accelerating innovation on campuses to reduce GHG emissions more quickly. As such the ACUPCC supports smart investment in offsets as an effective way to help create a GHG-free future.”²

Cornell will likely be considering purchase offsets as part of its voluntary “climate neutrality” commitment to the ACUPCC at some point in its CAP. There is also a high probability it will need to employ offsets as a strategy to achieve and compliance with potential future mandatory GHG regulations that may cover the university’s central plant.

2) Scope of Cornell’s Market Purchases of Offsets

Depending on the greenhouse gas emissions reductions achieved through the other wedge strategies, and the target date for achieving climate neutrality Cornell’s demand for offsets could be substantial. Under the ACUPCC agreement all of Cornell’s GHG emissions (Figure 1) must be neutralized. At one extreme if Cornell were to have implemented the agreement in 2008, the University would face having to acquire offsets to compensate for 319,000 metric tons of CO₂e based on its 2008 GHG emissions inventory.

Figure 1 Cornell 2008 GHG Inventory



² Ibid, page 10

The principle factors that will determine Cornell's volume of offset purchases will be the volume of Cornell-sourced offsets the university develops on Cornell owned lands or in surrounding community; the extent to which Cornell achieves direct emissions reductions of Scope 1-3 sources; and the time line and milestones it sets for achieving climate neutrality.

Over time aggressive investment in actions to reduce on-campus GHG emissions will require fewer offsets than an approach where actions are minimal. Conversely, if Cornell sets a target date for climate neutrality early on and before campus emissions reductions have been achieved then more offsets will be required over time.

It is important that Cornell's strategy for purchasing and acquiring offsets recognize the difference between offsets needed for its voluntary climate neutrality commitment and an emissions reduction obligation it would face under a mandatory federal cap and trade program. Cornell, like many other universities who operate large central utility plants could be regulated under a federal cap and trade program. While the voluntary commitment to the ACUPCC suggests that acquiring offsets be considered a secondary strategy to be employed only after the university has minimized direct emissions as much as possible, a mandatory federal requirement could necessitate Cornell accelerate its plans to purchase offsets as a least cost containment strategy as part of its compliance obligation.

3) Market Purchases of Offsets/Allowances

There are several ways Cornell could approach acquiring and purchasing of offsets through the market place. The two most common approaches for buying offsets in volume are through a request-for-proposal (RFP) and spot market over-the-counter purchases through third party brokers. Either approach can be used to purchase offsets for voluntary and compliance purposes. Under an RFP Cornell would specify the volume, minimum quality standards, offset types and timelines they would be willing to accept.

The principle means of acquiring offsets for voluntary purposes is through voluntary over-the-counter (OTC) carbon markets or the Chicago Climate Exchange (CCX). These markets are relatively new but are growing rapidly. Both have transacted sales for a growing volume of offsets from projects and activities that include afforestation, avoided deforestation, methane capture from animal waste, coal mines and landfills; agricultural and range soil sequestration; energy efficiency; and renewable energy credits (RECs). Purchasing voluntary offsets from the pool of carbon financial instruments created by the CCX would require Cornell to join the CCX.

A third strategy is for Cornell to buy offsets with the procurement of goods and services. One option currently available is the simultaneous purchase of offset when university related

air travel is purchased to compensate for GHG emissions associated with the travel. Airlines and third parties affiliated with internet based travel providers currently provide this service.

An important consideration for Cornell in entering the voluntary market for offsets is the institution's reputation and the importance of avoiding offsets with questionable impact on greenhouse gas emissions. While federal offset guidelines will determine which types of offsets are eligible for meeting federal compliance obligations, the credibility of Cornell's voluntary commitment can be protected by ensuring that any purchased offsets meet strict credibility criteria and standards and follow recognized protocols.

A number of standards exist for the voluntary market. The best standards require offsets be derived from projects that can demonstrate they are additional, real, permanent, measurable, verified, have clear ownership of title, and take place during a period of time that is aligned with the emissions they are intended to offset. Increasingly offset transactions are being verified to a specific third party standard. The Voluntary Carbon Standard, CDM, CCX, VER+ and Gold Standard are growing in recognition and in 2007 were cited by Ecosystem Marketplace as the most frequently used standards by the voluntary offset market.³

Another option to ensure high quality purchase of GHG emissions reductions is for Cornell to just focus on voluntarily purchases of emissions allowances from a mandatory U.S. or international GHG emissions reduction programs. As long as these programs are enforced, allowances from these sources would be very credible.

a) Timeframe in which Market Purchases of Offsets is Implemented

Timing of market purchases will depend on the milestones established to achieve "climate neutrality" and the timing scope of federal climate change policy. The ACUPCC commitment provides some leeway as to when climate neutrality will be achieved. One important timing issue is whether Cornell should purchase offsets along with other campus emissions reductions strategies to achieve climate neutrality as soon as possible. An alternative strategy would be to postpone its climate neutrality target date until other measures are implemented and only then invest in market purchases of offsets to make up the difference.

b) Project Costs

- i) Capital – Not Applicable
- ii) Fixed administrative costs

³ Ecosystem Marketplace and New Carbon Finance. May 2008. *State of the Voluntary Carbon Markets 2008*, Page 53.

Depending on the volume and timing of offsets purchased Cornell might want to consider whether to hire a full time employee to manage its offset portfolio. Administrative responsibilities would include issuing RFPs or engage in over the counter market purchases, accounting of and record keeping of volumes and transactions and managing offset portfolio

iii) Annual Incremental Costs of Market Purchased Offsets and Allowances

Costs of purchasing offsets and allowances from the market will vary depending on the volume of offsets required to meet either Cornell's voluntary goals or compliance obligations under a federal cap and trade program. The quality and type of offsets demanded by Cornell will influence the costs as well. For example in a 2007 survey conducted by Ecosystems Marketplace, prices for voluntary over the counter offsets showed a wide range of variation. Prices ranged between \$1.80/metric ton of CO₂e to as high as \$300/metric ton CO₂e. Prices also reflected demand for a type of offset with some of the most highly valued offsets coming from Forestry projects, averaging \$6.8 to \$8.2/metric ton CO₂e. Methane-based projects including livestock waste, land-fill and coal mine projects were also highly sought after and commanded an average price of \$6.00 per metric ton CO₂e.⁴

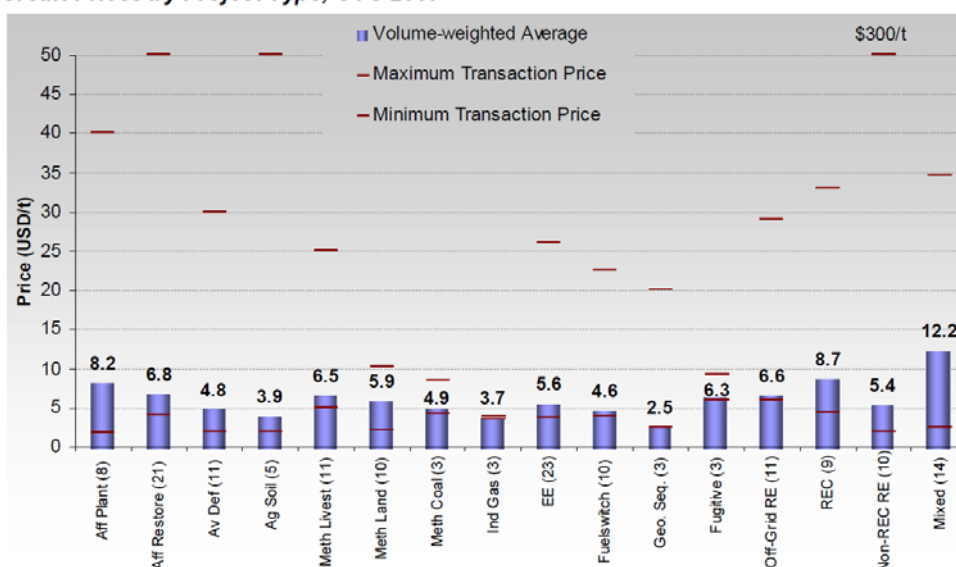
In contrast, allowances purchased for compliance purposes in mandatory regulated markets averaged \$22.82 per metric ton CO₂e, considerably higher than average offset prices in the voluntary market. What this price does not take into consideration are the auctions of allowances conducted by the Regional Greenhouse Gas Initiative in 2008. Prices for those allowances were relatively low today compared to the European Union Trading System, ranging from \$3.00-\$3.50 per metric ton.

c) Transaction Costs

Transaction costs are likely to be embedded in the purchase of offsets. However, if Cornell chooses to register offsets with a high quality registry there will be additional costs associated with registration and transfer fees.

⁴ Ecosystem Marketplace and New Carbon Finance, "State of the Voluntary Carbon Markets 2008, Page 8, May 2008.

Credit Prices by Project Type, OTC 2007



Source: Ecosystem Marketplace, New Carbon Finance. Note: Numbers in parentheses indicate number of data points. The weighted average prices in this chart are not directly comparable with the price chart in last year's report. This chart shows the weighted average prices across the value chain, whereas last year's chart showed only prices from retailers, which are higher than the value chain average.

i) Registration Fees

Registration of offsets with some high quality registries requires a registration fee and a fee to retire or transfer offsets between accounts. For example the Gold Standard levies an Annual Account Subscription Fee of \$500, a Credit Certification/Issuance Fee of \$.15 per offset registered and a Secondary Credit Transfer Fee of \$.01 per offset. It is expected that registration with most registries in the future will require similar fees

4) Institutional Considerations

a) Mission

i) Aligned with mission of institution

Both ACUPCC publications, *Investing in Carbon Offsets: Guidelines for ACUPCC Institutions* and the *ACUPCC Voluntary Carbon Offsets Protocol*, recognize that offsets projects and purchases can be designed in a way that add value and are aligned with the education, research and service mission of institutions of higher education. Cornell University's market purchases of offsets can be structured in a way that places a high priority on offsets from projects with demonstrated educational, environmental and social co-benefits and support more sustainable communities.

ii) Education and research opportunities

Cornell's expertise in environmental science, natural resources, agriculture, business and law could be used to contribute to the development of protocols, practices,

hedging strategies and other business models related to the market purchases and banking of voluntary offsets and allowances..

b) Recognition and Acceptance of Market Purchases of Offsets

Cornell's commitment to climate neutrality under the ACUPCC and any emissions reduction obligations it will face under a mandatory federal climate program represent two distinct requirements. Still, the objectives of both initiatives overlap, i.e. measurable and permanent reduction and sequestration of GHG emissions. It is certain that some types of offsets will be recognized as an option for meeting emission reduction obligations under a federal compliance program. It is also clear that some emissions reductions currently sold as offsets in the voluntary market will not be eligible as offsets under a cap and trade program. Key to Cornell's interim strategy for purchasing offsets in the voluntary market in the absence of a federal program is to target purchase of high quality offsets that are additional, real, permanent, measurable, verifiable, and have clear ownership of title. That way even if an offset ends up not qualifying against the university's compliance obligation it could still be counted as a credible contribution towards Cornell's climate neutrality goal.

5) Environmental Sustainability

a) GHG emission reductions/timeframe

The geographical location of greenhouse gas emissions – or a reduction of greenhouse gases -- is immaterial to its impacts on climate change. Therefore market purchases of high quality offsets provide the same climate change benefit as direct emissions reductions on the Cornell campus. Market purchases of offsets also offer Cornell the flexibility to structure delivery of offsets to coincide with climate neutrality milestones or compliance goals.

b) Additional environmental co-benefits

Market purchases of offsets can be structured to acquire only offsets from projects that provide environmental co-benefits beyond the beneficial impacts the offsets have on climate change. There are any number of credible offset projects that would meet this standard including afforestation, forest management, soil conservation tillage, agricultural waste to methane projects, renewable energy and energy efficiency projects. To varying degrees these projects contribute to land conservation, bio-diversity, improved air quality, water quality and waste management.

6) Social Responsibility

One of the attractive features of market purchases of offsets is the flexibility to design acquisition strategies that are aligned with the mission and goals of Cornell and strengthen local stakeholder and institutional relationships. Community-based offsets

may be an economically viable option for the university that would provide co-benefits to the local community. In recognition of the unique relationship between the university and the surrounding community, Cornell could issue an RFP specifically requesting offsets generated from projects identified aligned with the Energy and Climate Change Elements of the Tompkins County Comprehensive Plan.

References

American Colleges and University Presidents Climate Commitment, “Investing in Carbon Offsets: Guidelines for ACUPCC Institutions, November 2008 v1.0

American Colleges and University Presidents Climate Commitment, “Voluntary Carbon Offset Protocol”.

Ecosystem Marketplace, “Offsetting Emissions: A Business Brief on the Voluntary Carbon Market”, Second Edition, February 2008.

Electric Power Research Institute, “Description of Key Issues in the Design of GHg Emissions Offset Programs”, December 2008.

Ecosystem Marketplace and New Carbon Finance, “State of Voluntary Carbon Markets 2008”, May 2008.

Chicago Climate Exchange, 2007, “Overview and Frequently Asked Questions, Project-based Credits – “Offsets” – in Chicago Climate.

Pew Center on Global Climate Change, Greenhouse Gas Offsets in a Domestic Cap and Trade Program, Fall 2008.”

United States General Accounting Office, “Carbon Offsets: The U.S. Voluntary Market Is Growing, but Quality Assurance Poses Challenges for Market Participants”, August 2008, GAO-08-1048.

Lighting: Finish Campus-wide Retrofits

Description

During the next 10 years, lighting retrofits will be completed on the remaining two-thirds of campus buildings at a rate of \$1 million annually.

Time Frame

Years 1-10

Assumptions

- The lighting retrofit will cost \$1 per square foot, yield a 7-year payback, and reduce annual lighting electrical consumption by 25%.

Costs & Benefits

Capital Cost: \$10,000,000 (\$1,000,000/year over 10 years)
Operating Cost: \$0 (already included in base case)
Operating Savings: \$1,500,000 (\$150,000/year over 10 years)

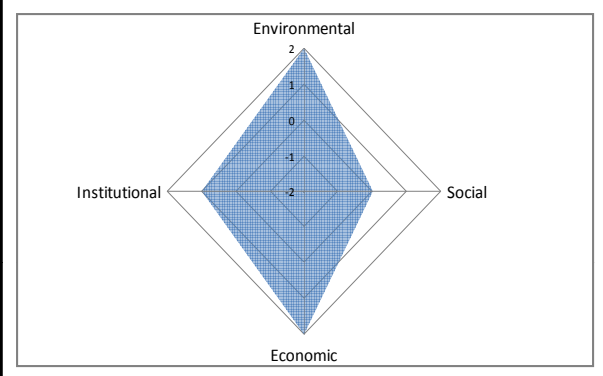
5,630 avg annual

225,187 Total

Value in Tons of
CO₂e through 2050

\$170 / ton

19% IRR



Next Steps

- Continuation of existing practices

Issues & Opportunities

- Disposal will require careful management
- Retrofit process will involve building occupants in order to achieve acceptable fixture choices and lighting levels
- Good near-term economics

Lighting: 2nd Generation Retrofits

Description

During years 16-40, all campus buildings will be retrofit with the next generation of lighting technology at a cost of \$1.50/square foot (1.5 times the cost of our existing retrofit projects) and be completed at a rate of \$800,000 annually.

Time Frame

Years 16-40

Assumptions

- Retrofitting the next generation of lighting technology across all campus buildings during years 16-40 will cost \$1.50 per square foot, yield a 50% reduction in lighting energy consumption, and reduce typical peak from about 1 watt/square foot to 0.5 watt/square foot, yielding a 20-year payback.

Costs & Benefits

Capital Cost: \$20,000,000 (\$800,000/year over 25 years)
Operating Cost: \$0 (project management costs already in base case)
Operating Savings: \$1,500,000 after year 25

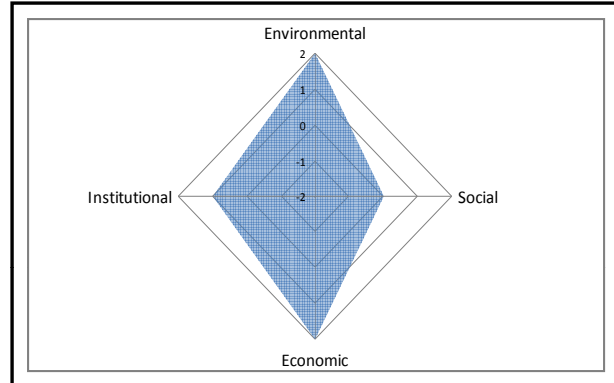
2,300 avg
annual

56,000 Total

Value in Tons of
CO₂e through 2050

(\$95) / ton

3% IRR



Next Steps

- Assess next generation of lighting technologies

Issues & Opportunities

- Disposal will require careful management
- Retrofit process will involve building occupants in order to achieve acceptable fixture choices and lighting levels
- Long payback period

Lighting: Greenhouse Lighting

Description

The existing high-intensity, warehouse-type lighting at Guterman and Ken Post Labs will be replaced with low-intensity, high-efficiency lighting fixtures, along with a greenhouse-specific lighting control system. Greenhouse lighting fixture and control upgrades will create lighting that is more efficient, more uniform, and dims in response to increased daylight.

Time Frame

Years 1-5

Assumptions

- These lighting upgrades will yield a simple payback of less than 5 years.
- During years 6-15, improvements will be undertaken at the balance of Cornell's 200,000 NSF of greenhouse space at Ithaca, and will be replicated at Geneva and Long Island at a cost of \$3,000,000 (... though these latter two sites are outside the footprint of the present Cornell GHG Inventory, and are not included in the costs/benefits for this analysis).

Costs & Benefits

Capital Cost: \$4,000,000

Operating Cost: \$0

Operating Savings: \$ 900,000

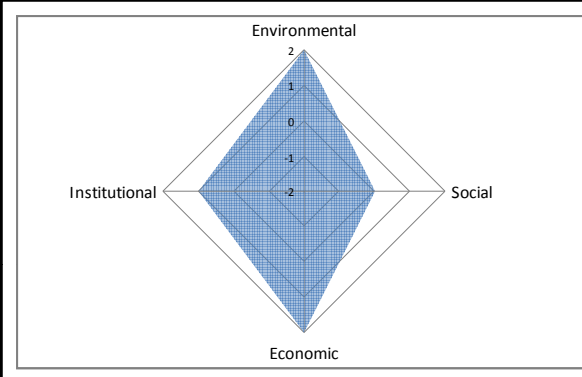
3,800 avg annual

145,000 Total

Value in Tons of
CO₂e through 2050

\$197 / ton

30% IRR



Next Steps

- Collaborate with researchers to develop design solutions that address their research requirements
- Verify that pilot installations meet design specifications

Issues & Opportunities

- Disposal will require careful management
- The project team will need to engage researchers in the proposed changes and selection of preferred alternatives
- Good near-term economics

Stationary Equipment: Fume Hoods

Description

Fume hoods use 10% of Cornell's total cost of energy, or \$7,500,000 annually. Unused fume hoods will be deactivated until it must be re-activated to enable active research in that lab. Project Design and Construction (PDC) Shops would then re-activate the fume hood, rebalance the supply and exhaust air in the lab, and have EHS verify that the fume hood operation is acceptable.

Time Frame

Years 1-5

Assumptions

- There are over 1,500 fume hoods on campus, each using \$5,000 of energy per year. If 25% of the 500+ fume hoods in the 250+ multi-fume hood labs were deactivated, Cornell would save \$625,000 annually. The total cost to de-activate and re-activate a fume hood is \$500 - \$2,000.
- As part of this program, chemicals stored in fume hoods would be relocated to storage cabinets.

Costs & Benefits

Capital Cost: \$250,000 (\$50,000/year for 5 years)
Operating Cost: \$170,000 annually (\$120,000 EH&S + \$50,000 U&EM= \$170,000 annual cost across yrs 1-5 only)
Operating Savings: \$625,000 annually by Year 5 calculated at current billed rate

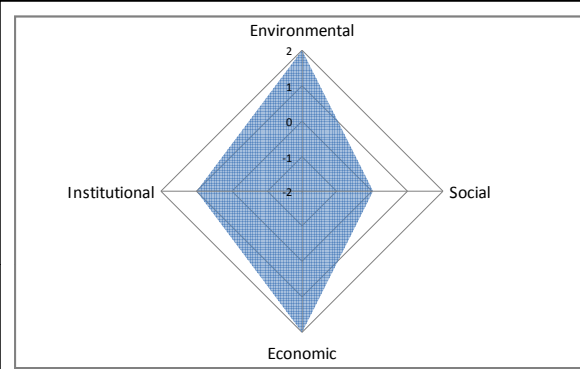
1,200 ^{avg}
annual

48,000 ^{Total}

Value in Tons of
CO₂e through 2050

\$153 / ton

29% IRR



Next Steps

- Fund new EH&S lab banding program
- Institute program

Issues & Opportunities

- Great economic benefits
- Active hood management shows institutional leadership
- The project team will need to engage researchers in the proposed changes and implement a pilot program to develop the process and prove implementation effectiveness

Stationary Equipment: Growth Chambers

Description

Growth chambers use refrigeration, heating and lighting to simulate growing environments for research. Collectively, they use 10% of Cornell's electric energy. This program would retrofit lighting and controls in 500 growth chambers (100 per year) during years 1-5.

Time Frame

Years 1-5

Assumptions

- There are 500 walk-in growth chambers on campus, each consuming \$6,000 in annual billed energy. Pilot projects have demonstrated that lighting and controls retrofits can reduce energy use by 75% or more.
- The cost to retrofit growth chambers is \$7,000/unit, with an annual savings of \$4,500/unit. Beginning in year 2, savings would accumulate at a rate of \$450,000 each year.

Costs & Benefits

Capital Cost: \$3,500,000 (\$700,000 annually over 5 years)

Operating Cost: \$0

Operating Savings: \$2,250,000 annually by Year 5 based on current billed rates

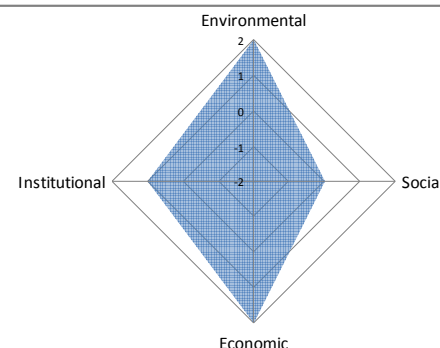
9,000 ^{avg}
annual

360,000^{Total}

Value in Tons of
CO₂e through 2050

\$234 / ton

144% IRR



Next Steps

- Develop retrofit package & procedures

Issues & Opportunities

- Great economic benefits
- Active management of research assets shows institutional leadership
- The project team will need to continue to engage researchers in the proposed changes as the work progresses across campus

HVAC: Energy Conservation Initiative Phase I

Description

The Energy Conservation Initiative (ECI) will be continued and expanded to cover all Ithaca Campus facilities, significantly increasing maintenance and doubling capital conservation projects. Conservation focused maintenance will be expanded to include space controls conservation and focused preventive maintenance (PM) for Contract College Facilities (CCF). A new conservation-focused PM program will be added for Campus Life and the professional schools.

Time Frame

Years 1-5

Assumptions

- We can achieve a 20% reduction in each building after PM and capital conservation projects are completed. Campus-wide energy use will be reduced by 5% as a result of this effort. We will be engaging in improvements at a rate of \$5,000,000 per year over the five years of Phase I.
- Additional staff costs are as follows:
 - \$400,000 for new PM staff in CCF
 - \$300,000 for new PM staff in Campus Life
 - \$50,000 for new PM staff in Professional Schools

Costs & Benefits

Capital Cost: \$25,000,000

Operating Cost: \$750,000

Operating Savings: \$1,500,000 annually by Year 5 based on current billed rates

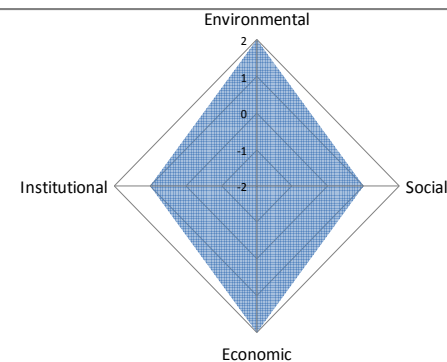
13,500 ^{avg}
annual

540,000^{Total}

Value in Tons of
CO₂e through 2050

\$114 / ton

14% IRR



Next Steps

- Fund new PM staff
- Create a capital and PM funding model

Issues & Opportunities

- Program is minimally disruptive to building occupants
- Good payback
- Create more reliable, more comfortable spaces

HVAC: Energy Conservation Initiative Phase II

Description

A second round of Energy Conservation Initiative (ECI) improvements – along with continued preventive maintenance (PM) – will be done on all campus buildings. This program will include the retrofit of heat recovery devices, along with replacement of pneumatic space controls with digital equipment. The ECI program will be expanded to include off-central-campus facilities in this time period.

Time Frame

Years 6-15

Assumptions

- Since lower-cost, quicker-payback measures were completed during ECI Phase I, this round of work will cost twice as much to yield approximately 10% total campus savings. Funds will be disbursed at a rate of \$10,000,000 per year over 10 years.

Costs & Benefits

Capital Cost: \$100,000,000

Operating Cost: \$150,000 annually (for Project Management)

Operating Savings: \$10,000,000 annually at end of 10-year effort based on current billed rates

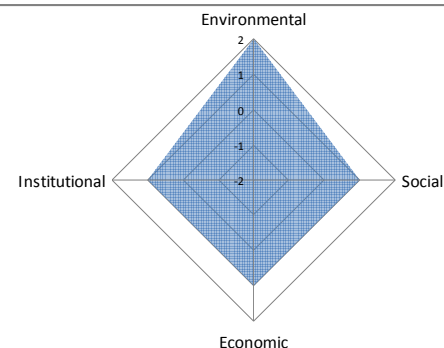
22,000 avg annual

735,000 Total

Value in Tons of
CO₂e through 2050

\$25 / ton

7% IRR



Next Steps

- Develop & evaluate packages of measures for ECI Phase II
- Create a capital funding model

Issues & Opportunities

- Implementation activities are potentially disruptive to building occupants and will need to be carefully managed; pilots may be necessary
- Creates more reliable, more comfortable spaces

HVAC/Envelope: Major System Upgrades

Description

In the long-term, major building systems will need to be replaced. These extend beyond mechanical systems to include the potential for new fenestration and other major upgrades of the building envelope. These upgrades will yield substantial improvements in occupant comfort and reduce maintenance costs.

Time Frame

Years 16-40

Assumptions

- No one can be certain of the technologies that will be available. We assume a one billion-dollar program at an estimated cost of \$300 per square foot. This cost is based on the Olin Hall and Vet Research Tower mechanical/electrical upgrade projects underway in 2009, both of which include envelope upgrades and innovative HVAC systems. Costs are assumed to be *in addition to* typical building renovation costs, replacing major systems *before* the end of their service life.
- This effort would yield a 30% reduction in billed energy use for one quarter of our present campus buildings, implying that a major upgrade of all campus buildings will be *a century-long effort* costing \$4 billion. Funds will be disbursed at a rate of \$40,000,000 per year over 25 years.

Costs & Benefits

Capital Cost: \$1,000,000,000

Operating Cost: \$450,000 annually (for Project Management)

Operating Savings: \$7,500,000 annually at end of 25-year effort based on CAP model

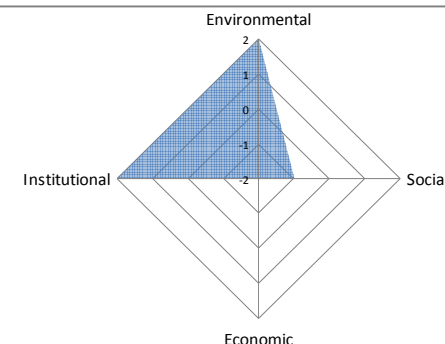
5,000 avg annual

123,000^{Total}

Value in Tons of
CO₂e through 2050

(\$7,340)/ ton

no IRR



Next Steps

- Further evaluate packaging & cost-effectiveness of major system upgrades

Issues & Opportunities

- Implementation activities are projected to be very disruptive to building occupants and will need to be carefully managed; pilots will be necessary
- Creates numerous jobs
- Large first cost with poor payback
- Creates more comfortable & reliable spaces

Building Envelope: Weatherization

Description

Windows and doors will be caulked and weather-stripped to reduce outside air infiltration. Windows required for ventilation would remain operable. The first year's pilot effort will focus on the 10 worst buildings from the older areas of campus, identifying the most effective package of measures and means to deliver them. That package will then be used to improve 30 buildings the following year.

Time Frame

Years 1-2

Assumptions

- Based on a fixed budget of \$10,000 per building, infiltration work will be driven by blower-door pressurization that will help locate areas to be sealed. Once the maximum permitted leakage rate is attained, infiltration-reduction work will be terminated.
- Annual savings will be \$2,000 per building (20% electric, 40% heating, 40% cooling), yielding a five-year simple payback.

Costs & Benefits

Capital Cost: \$400,000 (\$100,000 in Year 1, \$300,000 in Year 2)

Operating Cost: \$0

Operating Savings: \$80,000 annually by Year 5 based on current billed rates

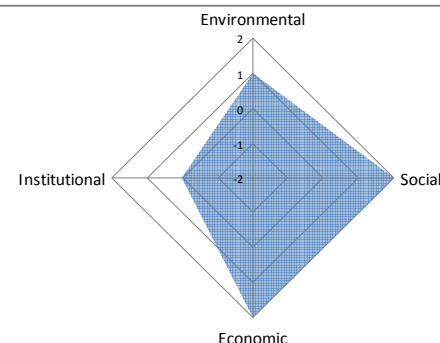
170 avg
annual

6,900 Total

Value in Tons of
CO₂e through 2050

\$83 / ton

10% IRR



Next Steps

- Develop methodology for infiltration-reduction work
- Test methods on 10 pilot buildings
- Refine methodology for 30 remaining buildings

Issues & Opportunities

- Improved thermal comfort in drafty spaces
- Quick paybacks
- Create modest-skilled union jobs

Whole Bldg: Lab Ventilation Effectiveness

Description

There is professional consensus that a higher *quality* air flow, properly controlled, creates a safer work space with lower *quantities* of air. Lab air flows will be modified, and the resulting energy cost savings will be used for monitoring and testing to verify that lab environments will indeed be safer. Staff necessary to effect this initiative will be paid for with a portion of the savings that will be realized before the end of the pilot period.

Time Frame

Years 1-5

Assumptions

- Higher-quality air flows will allow us to safely reduce ventilation rates from 8/4 air changes per hour (occupied/unoccupied) to 6/3. 200 labs will be re-commissioned each year over five years.
- Annual energy costs savings will be \$1 per square foot for 1-million square feet of Cornell's lab space and associated support spaces ventilated with 100% outside air. The first 5 years of this program will **re-commission half of that space**.

Costs & Benefits

Capital Cost: \$1,250,000 (\$250,000/year for 5 years)

Operating Cost: \$120,000 annually

Operating Savings: \$1,000,000 annually by Year 5 based on current billed rates

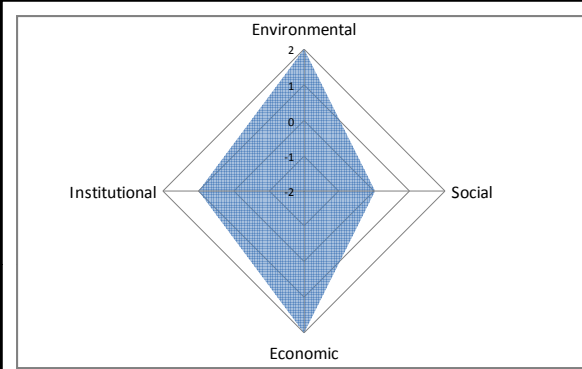
1,900 avg
annual

76,000 Total

Value in Tons of
CO₂e through 2050

\$108 / ton

23% IRR



Next Steps

- Develop program guidelines
- Identify labs for pilot effort
- Re-commission pilot labs & measure efficacy of modifications
- Revise program guidelines as necessary

Issues & Opportunities

- Program will require an education/training component that reinforces the importance of source control in lab environments
- The project team will need to engage researchers in order to ensure that research is not constrained

Whole Bldg: Continuous Commissioning

Description

Building Automation and Control Systems develop tremendous volumes of data. Most is lost because we fail to archive it and don't have the capacity to analyze the data to inform operational and design decisions. We will create an interval data database with analysis software and provide staff support to operate and maintain it. Analysis tools will direct conservation-focused maintenance efforts. Data and analysis tools will be widely available to PDC Control and Refrigeration Shop staff, building management, energy engineers, and design engineers.

Time Frame

Years 1-5

Assumptions

- We anticipate being able to reduce building energy use 2-5%. Since each 1% of building energy use costs \$700,000, annual return on this investment would range from \$1,400,000 - \$3,500,000.

Costs & Benefits

Capital Cost: \$0

Operating Cost: \$300,000 (for Data Steward, Energy Analyst, software, and annual software license)

Operating Savings: 2% annual savings by Year 5

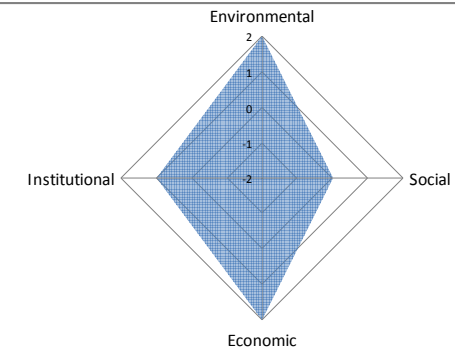
3,000 avg
annual

120,000 Total

Value in Tons of
CO₂e through 2050

\$107 / ton

52% IRR



Next Steps

- Identify & acquire software
- Retain staff
- Set up hardware
- Upload top 50 buildings' (defined by energy use) data over two years
- All 150 major buildings uploaded within four years

Issues & Opportunities

- Greater campus wide access to building data

User Behavior: Conservation Outreach

Description

Student and staff representatives will advise, encourage, and conduct periodic checks to ascertain whether Best Practices are being followed. They will be supervised by a Building Manager/Coordinator (for academic buildings) or a House Dean/Resident Manager (for campus housing). Technical support will be provided by U&EM staff, while programmatic support will be provided by Cornell's Sustainability Coordinator in ECOS.

Time Frame

Pilot program in Year 1, with expansion to campus-wide effort by Year 15

Assumptions

- Approximately 10% of university-wide electrical load is within the control of individuals. We assume that improved user behaviors will reduce that by 15%, yielding a net reduction in electrical load of a modest 1.5% of annual electrical costs, or \$400,000 annually (based on 2008/09 billed rates).
- As part of this initiative, we will evaluate and implement strategies to give users local control of equipment.

Costs & Benefits

Capital Cost: \$90,000 (web development)

Operating Cost: \$150,000 for U&EM/ECOS staff support & Eco-Reps

Operating Savings: \$400,000 annually by Year 5 based on current billed rates

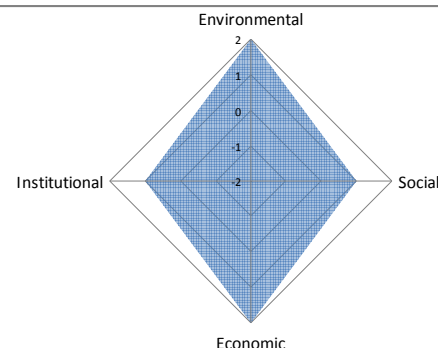
1,600 avg
annual

64,000 Total

Value in Tons of
CO₂e through 2050

\$155 / ton

60% IRR



Next Steps

- Develop program guidelines for student, building staff & academic staff models
- Develop lists of Best Practices
- Run AY09-10 pilot programs in Campus Life, Colleges of Engineering & Agriculture and Life Sciences
- Rework program based on pilots
- Begin expanding program in AY10-11

Issues & Opportunities

- Cultivates a conservation ethic in the next generation of leaders

Plug Load: Convection Heaters

Description

Students, faculty and staff frequently use personal convection heaters beneath their desks. The financial return on a radiant heater would justify giving away more efficient and comfortable radiant units via an exchange program. Prior to the exchange, Facilities staff will assess whether modest envelope or HVAC improvements may help avoid the need for a personal heater. This work would be done as part of the Conservation-Focused Maintenance already funded by Cornell.

Time Frame

Years 1-5

Assumptions

- The typical convection heater consumes 1,000 watts. If operated during daily work hours, it would have an operating cost of \$200 per year. A \$100 radiant panel uses 1/10th of the electricity, saving \$180 per year.
- If 10% of Cornell's 14,000 staff and grad students use personal convection heaters and would replace them, we'd need 1400 units at a cost of \$140,000.
- This would yield over \$450,000 in savings over five years. Thus, this program would pay for itself even if people are now using their personal heaters only 1/3 of their daily working hours.

Costs & Benefits

Capital Cost: \$0

Operating Cost: \$20,000 in Year 1, then \$30,000 annually in Years 2-5

Operating Savings: \$250,000 annually by Year 5 based on current billed rates

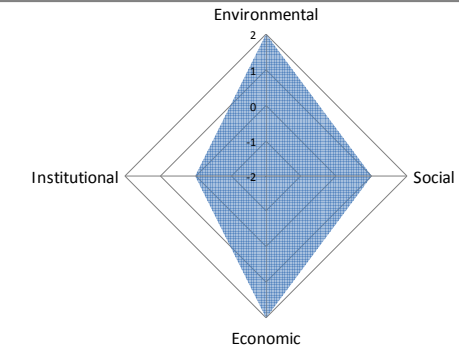
1,000 avg
annual

40,000 Total

Value in Tons of
CO₂e through 2050

\$247 / ton

no IRR



Next Steps

- Survey to characterize & confirm space heater usage patterns
- Identify/specify replacement heater
- Develop program guidelines
- Commence Year 1 pilot program

Issues & Opportunities

- People may change behavior at home and work

Space Planning and Management Program - Moderate

Description

More effective use of existing space holds the potential to reduce the material, energy and land resources consumed by new buildings and slow overall campus growth in building square foot terms. The intent here is to increase building space efficiency (i.e., people per gross square foot); utilization rates; and to build/renovate to consistent standards and to evaluated needs.

Time Frame

Years 1-5 for primary effort; Years 6-10 for consideration of space charge system

Assumptions

- In new construction projects: 10% increase in space efficiency
- In renovation or utilization Projects: 5% increase in space efficiency
- Requires creation of a program, including development and implementation of space standards, creation of a space advisory council (or similar oversight body), improved inventory and utilization data and reporting, and a monitor & control process for space use, renovations & new construction, amongst other elements.
- Focuses on “defrag” of existing space and use of standards / control process for development of new buildings/renovations
- Percentage reductions apply to the Base Case scenario

Costs & Benefits

Capital Cost: \$2 Million (50/50 split between Facility Inventory Management System (FIMS) (software/hardware) and an initial space utilization project)

Operating Cost: \$200,000 (software/hardware/IT support)

Operating Savings: \$300,000 (Avoided; reduction of required staff time) + up to \$3.6 Million by 2050 (O&M savings)

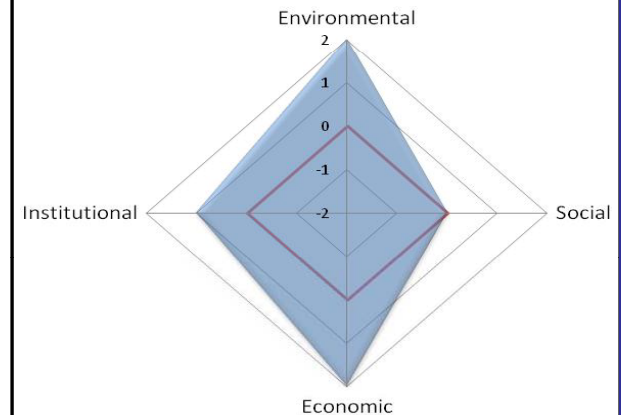
2,500 avg
annual

94,000 Total
Value in Tons of CO₂e
Through 2050

Levelized Savings (Cost)

\$3,244

184% IRR



Next Steps

- RFP and then PAR for FIMS
- Identify priorities for utilization studies

Issues & Opportunities

- Requires development of a comprehensive program
- Potential to involve Design and Environmental Analysis students in standard development, and efficiency and utilization studies on campus

Space Planning and Management Program - Aggressive

Description

More effective use of existing space holds the potential to reduce the material, energy and land resources consumed by new buildings and slow overall campus growth in building square foot terms. The intent here is to increase building space efficiency (i.e., people per gross square foot); utilization rates; and to build/renovate to consistent standards and to evaluated needs.

Time Frame

Years 1-5 for primary effort; Years 6-10 for consideration of space charge system

Assumptions

- In new construction projects: 15% increase in space efficiency
- In renovation or utilization projects: 10% increase in space efficiency
- Requires creation of a program, including development and implementation of space standards, creation of a space advisory council (or similar oversight body), improved inventory and utilization data and reporting, and a monitor & control process for space use, renovations & new construction, amongst other elements.
- Focuses on “defrag” of existing space and use of standards / control process for development of new buildings/renovations
- Percentage reductions apply to the Base Case scenario

Costs & Benefits

Capital Cost: \$2 Million (50/50 split between Facility Inventory Management System (FIMS) (software/hardware) and an initial space utilization project)

Operating Cost: \$200,000 (software/hardware/IT support)

Operating Savings: \$300,000 (Avoided; reduction of required staff time) + up to 5.4 Million by 2050(O&M savings)

4,000 ^{avg}
annual

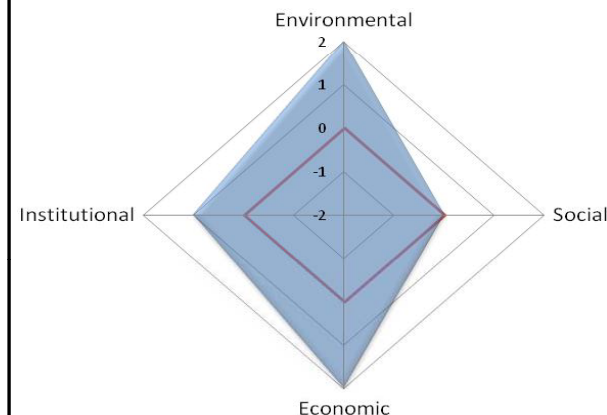
150,000 ^{Total}

Value in Tons of CO₂e
Through 2050

Levelized Savings (Cost)

\$3,287

292% IRR



Next Steps

- RFP and then PAR for FIMS
- Identify priorities for utilization studies

Issues & Opportunities

- Requires development of a comprehensive program
- Potential to involve Design and Environmental Analysis students in standard development, and efficiency and utilization studies on campus

Space Mitigation through Alternative Work Strategies - Moderate

Description

Cornell will integrate alternative work strategies (AWS), such as telecommuting (work from home or satellite location), flexible work hours, and job sharing, into more common practice. While the primary intent is focused on employee recruitment and retention, a secondary benefit can be predicted to accrue in space savings.

Time Frame

Year 11+ for impact of alternative work strategies

Assumptions

- A **3%** reduction in growth associated with workforce adoption of AWS
- Employees and supervisors embrace AWS
- The space “freed up” by employee use of AWS can be meaningfully aggregated and managed for higher efficiency per person served, resulting in lower demand for new/more space and thus, slower/lower growth

Costs & Benefits

Capital Cost: 0
Operating Cost:
Operating Savings:

500 avg
annual

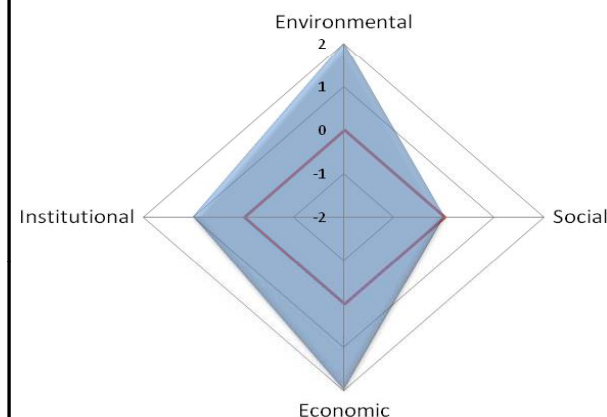
16,000 Total

Value in Tons of CO₂e
Through 2050

Levelized Savings (Cost)

\$2,650

No IRR



Next Steps

- AWS pilots already underway, leadership by HR
- Identify and implement pilots that more directly relate AWS to space

Issues & Opportunities

- The success of AWS is strongly correlated with commitment to success by supervisory staff

Space Mitigation through Alternative Work Strategies - Aggressive

Description

Cornell will integrate alternative work strategies (AWS), such as telecommuting (work from home or satellite location), flexible work hours, and job sharing, into more common practice. While the primary intent is focused on employee recruitment and retention, a secondary benefit can be predicted to accrue in space savings.

Time Frame

Year 11+ for impact of alternative work strategies

Assumptions

- A **5%** reduction in growth associated with workforce adoption of AWS
- Employees and supervisors embrace AWS
- The space “freed up” by employee use of AWS can be meaningfully aggregated and managed for higher efficiency per person served, resulting in lower demand for new/more space and thus, slower/lower growth

Costs & Benefits

Capital Cost: 0
Operating Cost:
Operating Savings:

900 avg
annual

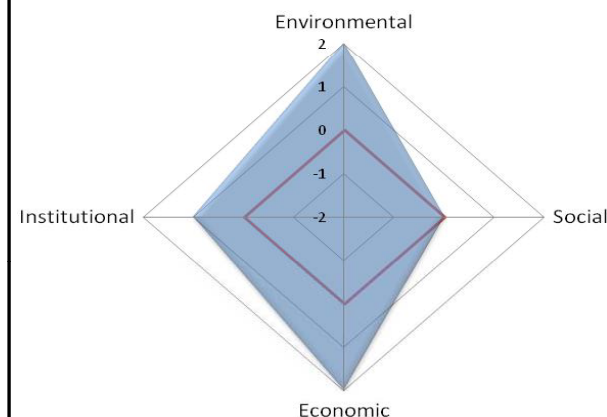
26,000 Total

Value in Tons of CO₂e
Through 2050

Levelized Savings (Cost)

\$2,650

No IRR



Next Steps

- AWS pilots already underway, leadership by HR
- Identify and implement pilots that more directly relate AWS to space

Issues & Opportunities

- The success of AWS is strongly correlated with commitment to success by supervisory staff

Green Infrastructure – Open Lands Management

Description

Convert open and under-utilized Cornell land into natural landscape such as hardwood trees and “no-mow” meadow to increase the carbon capture potential of Cornell properties.

Time Frame

Years 1-5 years: 50 N + 100 R acres; Years 6-10: 50 N acres; Years 10+: 20 C acres

Assumptions

- Compact development facilitates preservation of existing open space
- Naturalize (N) (convert lawn to forest) 100 acres of “open space” at average rate of 10 acres / year (probable limit of available space on main campus)
- Convert (C) 20 acres of rural land from pavement to hardwood trees
- Reforest (R) 100 acres of under-utilized rural lands (not on main campus, could include bio-fuel plots or other sustainable forestry management uses)
- Carbon sequestration estimated only for trees for 2010 – 2050 (ref. USDOE, 1998)

Costs & Benefits

Capital Cost: Planting \$7,570/ acre x 220 acres = \$1,665,400
Demolition: \$10,000/ac x 20 acres = \$200,000

Operating Cost: \$350/acre x 220 acres = \$77,000/year for first 5 years;
\$7,000/year for remaining years

Operating Savings: Mowing cost (100 ac) + Brush hog cost (100 ac) + plowing cost (20 ac)

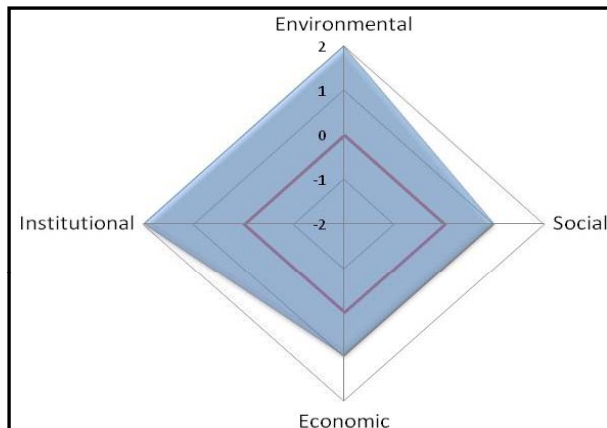
130 avg
annual

6,077 Total

Value in Tons of CO₂e
Through 2050

\$ / ton

IRR



Next Steps

- Prioritize sites to naturalize and/or reforest
- Develop appropriate plant species lists
- Expand trial plots to test alternative techniques

Issues & Opportunities

- Additional environmental benefits include habitat creation, water and air quality improvements, stormwater reduction
- Additional carbon sequestration would be performed by understory vegetation, but was not calculated

Green Infrastructure - Conversion

Description

Convert portions of paved Cornell land into natural landscape such as hardwood trees and “no-mow” meadow to increase the carbon capture potential of Cornell properties. Convert surface parking lots to structured parking and provide natural landscape in recovered land.

Time Frame

Years 1-5: 3 acres; Years 6-10: 10 acres; Years 10+: 17 acres

Assumptions

- Convert and eliminate existing surface lots as land needed for academic uses; assume academic uses built over structured parking
- 30 acres (3000 stalls total) eliminated through TDM and /or conversion to structured parking (2000 stalls) from surface lots. Resultant land planted to 10 acres trees + 20 acres lawn
- Greening surface parking through median and perimeter planting (500 trees or 10 acres)

Costs & Benefits

Capital Cost: Structured parking cost per stall: \$72K x 2000 = \$144,000,000

Demolition: \$10,000/ac x 30 acres = \$300,000

Planting \$10,000/ acre x 20 acres = \$200,000 trees;

\$5,000/ace x 20 acres = \$100,000 lawn

Operating Cost: Landscape: \$350/acre x 30 acres = \$10,500/year for first 5 years; \$1,000/year for remaining years. Operation of garage not included.

Operating Savings: Surface Lots: annual plowing , annual patching, complete rebuild after 20 years. Carbon cost: 600 gal diesel + 611gal gasoline / year plowing = 25,380 lbs CO₂-e/year

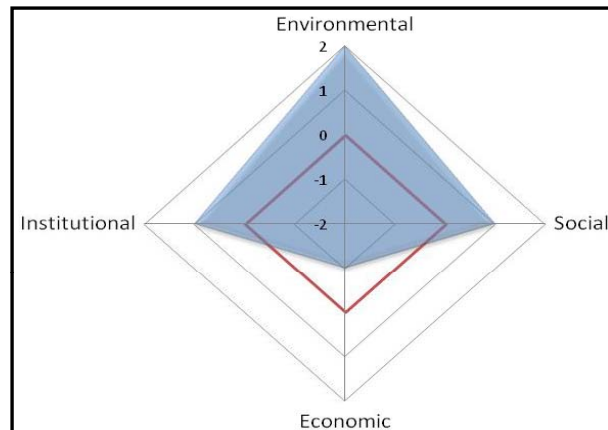
25 avg
annual

1002 Total

Value in Tons of CO₂e
Through 2050

\$ / ton

IRR



Next Steps

- Prioritize perimeter and median areas of parking lots for planting
- Develop appropriate plant list
- Develop model design for “green surface-parking lot” (pilot project)

Issues & Opportunities

- Additional environmental benefits include habitat creation, water and air quality improvements, stormwater reduction.
- Locating structured parking at periphery of core campus as per CMP reduces VMTs & enhances pedestrian- and transit-friendly environment

Compact Mixed Use Development - Moderate

Description

Growth in a compact mixed land use pattern within the existing development footprint increases density through campus redevelopment, reduces the number and length of trips by single occupancy vehicles due to close-in housing and enhanced transit; and conserves existing open lands for carbon sequestration. The amount of built acreage to total acreage for the town campus is increased (from 0.46 to 0.61) with no new land consumed, resulting in minimal extension of new roads and utilities, creating significant savings in both capital and operating costs.

Time Frame

Years 1 - 40 years

Assumptions

- Increase the number of graduate and professional students living on campus to the CMP goal of 25% (from current level of 15%); 132 days per year for commute trips (fall and winter semester, excluding holidays and weekends); results in 2,217,600 VMT reduced.
- Increase number of faculty/staff who live on campus to CMP goal of 5% (from current level of 1%); 260 days per year of commute trips (excluding holidays and weekends); results in 3,7455,600 VMT reduced.
- Actual CO₂e reductions from compact mixed use development will be greater than indicated here due to a lack of detailed data for analysis.
- Requires creation of affordable housing in compact mixed-use transit accessible area of campus
- No net addition of new paved areas and minimal utility lines to serve redeveloped areas.

Costs & Benefits

Capital Cost: Investment in “affordable” on campus housing. Can be offset significantly by supporting community nodal development and affordable housing on transit routes. Compact development also saves on road and utility capital costs and CO₂e.

Operating Cost: NA

Operating Savings:

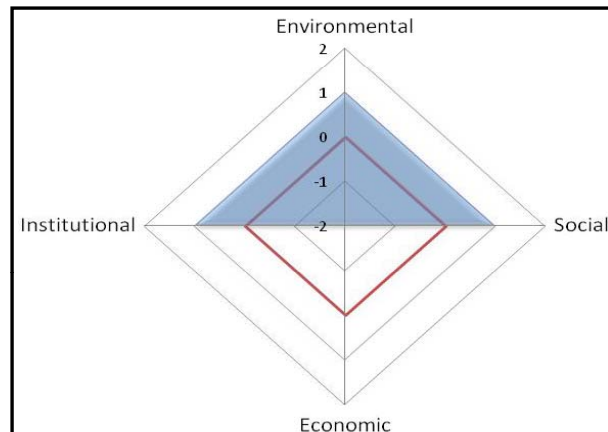
XX,XX^{avg}
annual

XXX,XX^{Total}

Value in Tons of CO₂e
Through 2050

\$ / ton

IRR



Next Steps

- Proceed with CMP implementation steps related to proximate housing and transit

Issues & Opportunities

- On-campus housing needs to be balanced with off campus housing proximate to campus or in nodes well served by transit routes to reduce campus spending and support sustainable community development
- Due to a lack of base data, the current calculations do not include VMT reductions from reduced intra-campus travel due to the compact mixed use development pattern and increased walking, bike and transit use

Compact Mixed Use Development - Aggressive

Description

Growth in a compact mixed land use pattern within the existing development footprint increases density through campus redevelopment, reduces the number and length of trips by single occupancy vehicles due to close-in housing and enhanced transit; and conserves existing open lands for carbon sequestration. The amount of built acreage to total acreage for the town campus is increased (from 0.46 to 0.61) with no new land consumed, resulting in minimal extension of new roads and utilities, creating significant savings in both capital and operating costs.

Time Frame

Years 1- 40

Assumptions

- Increase the number of graduate and professional students living on campus to goal of 30% (from current level of 15%); assumed 132 days per year for commute trips (fall and winter semester, excluding holidays and weekends); resulted in 3,326,400 VMT reduced.
- Increase number of faculty/staff who live on campus to goal of 10% (from current level of 1%); assumed 260 days per year of commute trips (excluding holidays and weekends); resulted in 84,273,275 VMT reduced.
- Actual CO₂e reductions from compact mixed use development will be greater than indicated here due to a lack of detailed data for analysis.
- Requires creation of affordable housing in compact mixed-use transit accessible area of campus
- No net addition of new paved areas and minimal utility lines to serve redeveloped areas.

Costs & Benefits

Capital Cost: Investment in “affordable” on campus housing; can be offset significantly by supporting community nodal development and affordable housing on transit routes; compact development also saves on road and utility capital costs and CO₂e

Operating Cost: NA

Operating Savings:

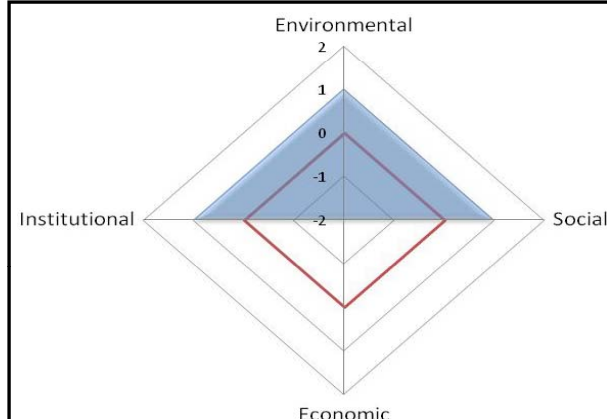
XX,XXX^{avg}_{annual}

XXX,XXX^{Total}

Value in Tons of CO₂e
Through 2050

\$ / ton

IRR



Next Steps

- Proceed with CMP implementation steps related to proximate housing and transit

Issues & Opportunities

- On-campus housing needs to be balanced with off campus housing proximate to campus or in nodes well served by transit routes to reduce campus spending and support sustainable community development
- Due to a lack of base data, the current calculations do not include VMT reductions from reduced intra-campus travel due to the compact mixed use development pattern and increased walking, bike and transit use

Laboratory Energy Use Intensity - Aggressive

Description

Utilize state-of-the-art technologies in concert with emerging design best practices to drastically reduce net energy consumption of laboratory buildings. Combine technologies, policies, and practices to achieve laboratory energy use intensity (EUI) for new and renovated building space of no greater than **140 KBTU/GSF/YR.**

Time Frame

Year 1, permanent

Assumptions

- Corresponds to approximately 50% improvement over ASHRAE 90.1-2007 and over Cornell "Best in Class" laboratory buildings (Duffield Hall, Boyce Thompson Institute, Biotechnology Building, Olin Hall, and Phillips Hall)
- EUI target is used as a prerequisite for approval of new projects
- All technology or policies employed will be compliant with Cornell Environmental Health and Safety (EH&S)
- O&M costs will not increase over the reference case

Costs & Benefits

Capital Cost: \$17/SF premium cost (4%) to current average lab cost of \$450/SF

Operating Cost:

Operating Savings: \$20.2 MM energy costs, \$3.2MM carbon cost

5,600 avg annual

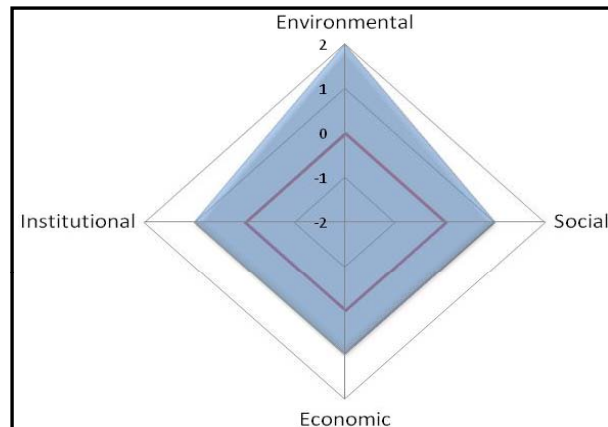
210,000 Total

Value in Tons of CO₂e
Through 2050

Levelized Savings (Cost)

\$106/ ton

12% IRR



Next Steps

- Modify LEED/30 Guidelines to be consistent with new Laboratory EUI requirements.

Issues & Opportunities

- Achievement will rely on collaboration with EH&S
- Project team will need to engage researchers to ensure that strategies are identified to meet efficiency goals without compromising research

Office/Classroom Energy Use Intensity - Aggressive

Description

Utilize currently available technologies and current higher education design best practices to significantly improve energy efficiency of office/classroom buildings. Combine technologies, policies, and practices to achieve energy use intensity (EUI) for new and renovated building space of no greater than **42 KBTU/GSF/YR.**

Time Frame

Year 1, permanent

Assumptions

- 50% reduction in energy consumption (per square foot) compared to Cornell "Best in Class" office/classroom buildings (Rhodes Hall, Space Sciences, Sage Hall, Tjaden Hall, White Hall; Hollister Hall, Kennedy Roberts, Goldwin Smith Hall, Warren Hall, Rockefeller Hall)
- EUI target is used as a prerequisite for approval of new projects

Costs & Benefits

Capital Cost: \$5/SF premium cost to current average cost of \$350/SF

Operating Cost:

Operating Savings: \$15 MM energy costs, \$2.5 MM carbon cost

4,400 ^{avg}
annual

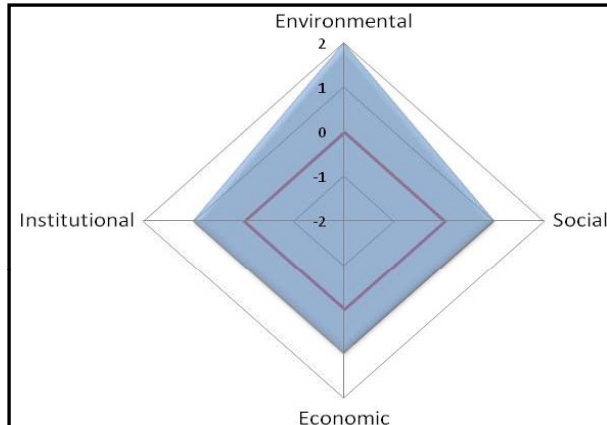
162,000 ^{Total}

Value in Tons of CO₂e
Through 2050

Levelized Savings (Cost)

\$118

15% IRR



Next Steps

- Modify LEED/30 Guidelines to be consistent with new Office/Classroom EUI requirements

Issues & Opportunities

Fleet Services Vehicle Improvements

Description

Establish an higher fleet fuel efficiency standard, reducing fuel consumption by university-owned vehicles. This includes a right-sizing of the fleet, seeking smaller and/or hybrid vehicles as appropriate. As technology develops and becomes standardized, pursue alternative fuel vehicles (AFV). Advocate for production and availability of lower-carbon vehicles (e.g. state vehicle purchase contract, lobbying).

Time Frame

Years 1-5 for primary effort; Years 6-15 for consideration of AFVs

Assumptions

- In the contract colleges' fleet, an increase in efficiency of 50-85%. Coupled with potential reductions in vehicle miles traveled would result in 35-50% reduction in fuel consumption.
- Requires establishment of centralized purchasing standards.
- More fuel efficient vehicles would have an average additional first cost of \$2,000. Will taper to \$1000 by 2020

Costs & Benefits

Capital Cost: \$2000->\$1000 (marginal vehicle cost) (\$300k/yr -> \$75k/yr)

Operating Cost: ~ 0

Operating Savings: up to \$1M /yr : reduced fuel costs

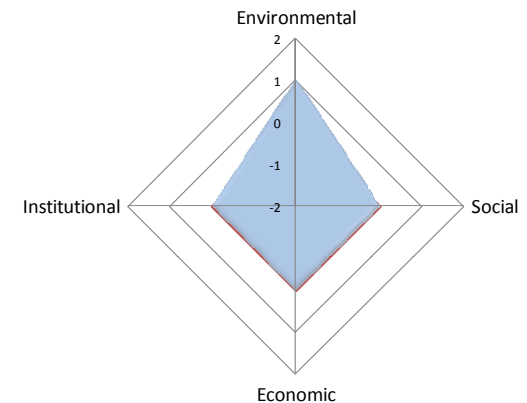
1,050 ^{avg}
annual

42,600 ^{Total}

Value in Tons of CO₂e
Through 2050

\$219 / ton

19% IRR



Next Steps

- Establish mileage standards and other vehicle standards.

Issues & Opportunities

- Raises public awareness of fuel efficient and AFVs
- New vehicle types, such as hybrids, may require specialized training for mechanics

Business Travel

Description

Establish a system to promote the use of less carbon-intensive modes for business travel. Education and awareness are central components. Under higher-reduction goals, would also include a portal to assist in finding/booking lower carbon travel. A strong component would be increased use and availability of teleconferencing tools and facilities.

Time Frame

Years 1-2 for initial implementation; primary reductions achieved in years 15-20

Assumptions

- Benefits assume immediate implementation (during current fiscal environment).
- Education and awareness (without other incentives/mandates) will increase utilization of existing (and new) teleconferencing facilities.
- Much of travel is critical to the institutional mission therefore there is a limit to the potential reduction
- Intra-campus business travel is not included in the inventory and thus not addressed.
- A travel carbon budget and/or other central standards may be required to achieve these reductions, but are not assumed.
- Benefits assumed to be less if implementation is delayed.

Costs & Benefits

Capital Cost: Average of \$50k-180k/yr: tele-conference facilities & decision tool (NPV of \$1M-3.2M)

Operating Cost: \$500-1.6M/yr in 2050 : supporting FTE

Operating Savings: \$1.5M-3.5M/yr in 2050 : avoided travel costs

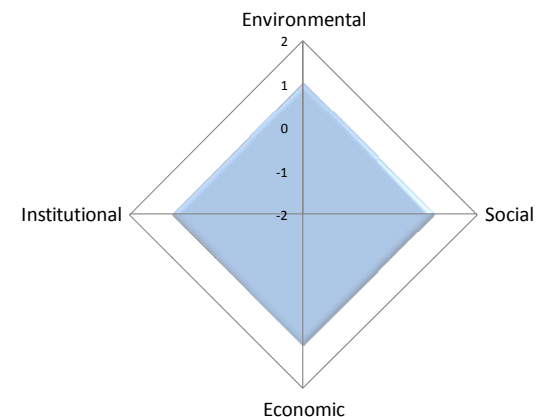
5,100 ^{avg}
annual

205,000 ^{Total}

Value in Tons of CO₂e
Through 2050

\$24 / ton

13% IRR



Next Steps

- Establish targets and related implementation programs

Issues & Opportunities

- Raise public awareness of travel decisions (at university and beyond)
- Despite potential initial perception of reduced communication (specifically in-person), the overall communication may increase using video & web-based tools
- Potential negative impact on Ithaca Tompkins Regional Airport

Commuter Travel

Description

Additional enhancements to commuter options through improvements to programs and infrastructure, on- and off-campus. Includes expansion to both incentives and program flexibility, including flex-time & flex-place. Advocate within the community and beyond for improvements that will reduce carbon impact of commuter travel.

Time Frame

Years 1-2 for initial implementation; reductions achieved over 15 years

Assumptions

- Cornell continues with population and land use changes on campus as per CMP
- Express park & ride is successfully implemented in the community within 2-3 yrs
- Tying funding for these programs to parking permit revenue is not sustainable in the long term
- Institutional commitment to program from the highest levels of the university.
- Cornell would assist with critical community transportation infrastructure (on and off campus) beyond the \$10 million initiative.
- Avoided costs assume that parking replacement would occur 5 years after shift occurs to alternate mode (and parking demand has decreased) and the space would otherwise need to be replaced. Cost per space is assumed \$50k (2008\$).
- Incentives may need to be coupled with pricing strategies (i.e. disincentives) to be successful

Costs & Benefits

Capital Cost: Avoided capital cost of replacement parking of up to \$100 Million

Operating Cost: Between \$750,000 and \$1.5 million per year depending upon targets; includes capital expenditures

Operating Savings: N/A (avoided parking O&M not modeled)

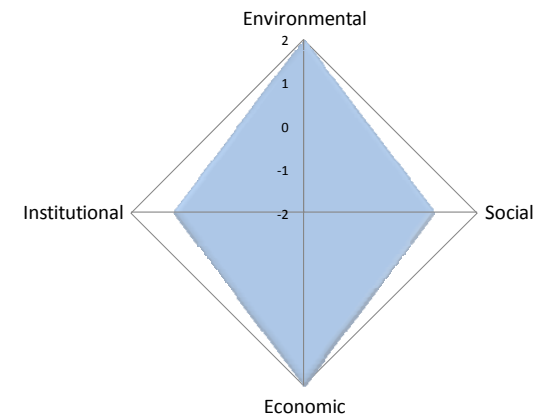
1,900 ^{avg}
annual

75,000 ^{Total}

Value in Tons of CO₂e
Through 2050

\$109 / ton

21% IRR



Next Steps

- Establish modal targets and identify short term program and capital requirements

Issues & Opportunities

- Substantial reductions in fuel use & emissions
- Supports more compact land use
- Substantial cost savings (Cornell and individuals) and community economic development
- Improved community services
- Improved institutional goodwill as a result

Hydroelectric Plant – Reline Penstock

Description

Cornell's hydroelectric plant on Fall Creek was built in 1904 and currently includes two Ossberger cross-flow turbines with a total rated capacity of 1,950 kW. Water is supplied from Beebe Lake through a 1,670 foot penstock providing about 140 feet of head to the turbines. The existing penstock has not been significantly updated since it was originally constructed in 1904.

Time Frame

Years 1-5

Assumptions

- It is estimated that 20 feet of head is currently lost through the penstock at a flow rate of 10 feet per second.
- Options for relining the oldest sections of pipe to reduce friction losses were estimated at \$750,000 to \$1.6 million.
- Assumed relining the existing penstock with HDPE would reduce head loss due to friction by 5 feet at an estimated cost of \$1 million.
- A 5 foot reduction in head loss would provide a 4.2 percent increase in output equivalent to 250 MWh per year.

Costs & Benefits

Capital Cost: \$1,000,000

Annual Incremental Operating Cost: No change

100 avg
annual

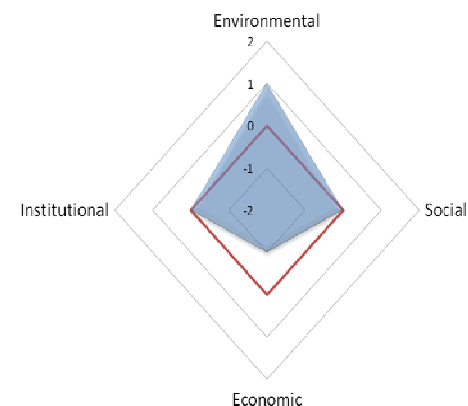
4,100 Total

Value in Tons of CO₂e
Through 2050

(\$276) / MT

Levelized Savings (Cost)

2% IRR



Next Steps

- Evaluate need for penstock repair versus options for further improvement in system efficiency/output

Issues & Opportunities

- Some sections of the penstock may require repair or replacement anyway to avoid damage to turbines

Hydroelectric Plant – Turbine Rebuild

Description

Cornell's hydroelectric plant consists of two Ossberger cross-flow turbines with a total rated capacity of 1,950 kW. The plant currently operates 20 to 30 percent below its maximum capacity with the current penstock. It is estimated that the condition of turbines contributes a large portion of this deficiency that could be alleviated by rebuilding them.

Time Frame

Years 1-5

Assumptions

- Turbines currently operate at 65% efficiency – down from 80% efficiency when new
- Current annual average output from the plant is 6,000 MWh per year (after controls upgrade in summer 2008)
- Assume turbine rebuild could return them to like-new efficiency
- Increased efficiency would increase average annual output by 900 MWh
- Replacing 900 MWh of purchased electricity with carbon-free hydro power would reduce Cornell's GHG emissions by about 370 MTCO₂e per year.
- Assume turbines will require rebuilding again in 20 years (2030).

Costs & Benefits

Capital Cost: \$150,000 (for both turbines)

Avoided Capital: \$25,000 (replacing main bearings and vane bearings)
\$15,000 (repairing cavitation damage)

Annual Incremental Operating Cost: No change

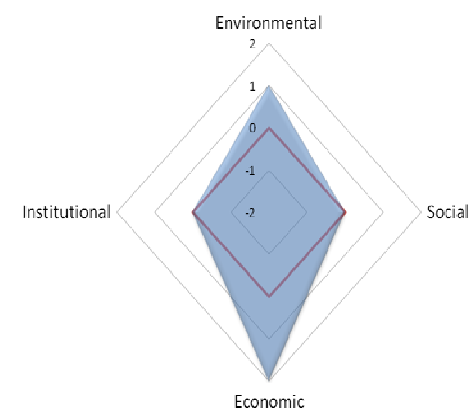
370 avg annual

14,800 Total
Value in Tons of CO₂e
Through 2050

\$228 / MT

Levelized Savings (Cost)

77% IRR



Next Steps

- Project has a relatively low cost and high payback – include in capital budget request

Issues & Opportunities

- The turbines are showing signs of wear and some degree of maintenance or rebuilding may be required anyway (see **Avoided Capital**)

Hydroelectric Plant – Restructure Intake

Description

Cornell's hydroelectric plant consists of two Ossberger cross-flow turbines with a total rated capacity of 1,950 kW. The plant currently operates 20 to 30 percent below its maximum capacity with the current penstock. A portion of this reduction in capacity is due to head loss at the intake and downtime due to ice buildup on the trashrack in the winter.

Time Frame

Years 1-5

Assumptions

- It is estimated that 20 feet of head is currently lost through the penstock at a flow rate of 10 feet per second.
- 5 feet of head loss is estimated through the intake structure.
- Replacing the trashracks and flapper gate plus reshaping the bellmouth within the existing intake structure would reduce head loss by 3 feet, but at a significantly lower cost than rebuilding the entire intake structure.
- This 3-foot improvement in head loss would equate to a 2.5% improvement in output or about 150 additional MWh per year, reducing GHG emissions by 60 MTCO₂e per year.
- Avoided downtime due to plugging/icing will also raise output by an additional 150 MWh per year.

Costs & Benefits

Capital Cost: \$200,000 to replace the trashracks, flapper gate, and reshape the bellmouth within the existing intake structure

Annual Incremental Operating Cost: Reduces labor by \$10,000 per year

120 avg
annual

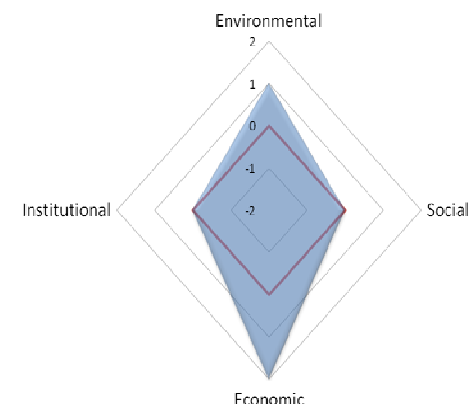
4,900 Total

Value in Tons of CO₂e
Through 2050

\$244 / MT

Levelized Savings (Cost)

21% IRR



Next Steps

- Redesign intake within existing structure and submit for bid

Issues & Opportunities

- A redesigned intake structure would reduce labor required for operating and maintaining the system

Hydroelectric Plant – Draft Tubes

Description

Cornell's hydroelectric plant on Fall Creek was built in 1904 and currently includes two Ossberger cross-flow turbines with a total rated capacity of 1,950 kW. Water is supplied from Beebe Lake through a 1,670 foot penstock providing about 140 feet of head to the turbines. An additional 7-10 feet of effective head could be achieved by adding draft tubes to the backend of the turbines and extending them down below the tailwater surface.

Time Frame

Years 1-5

Assumptions

- Assuming an additional 7 feet of head could be achieved by implementing draft tubes, output from the plant could increase by as much as 6 percent (350 MWh per year).

Costs & Benefits

Capital Cost: \$100,000

Annual Incremental Operating Cost: No change

140 avg
annual

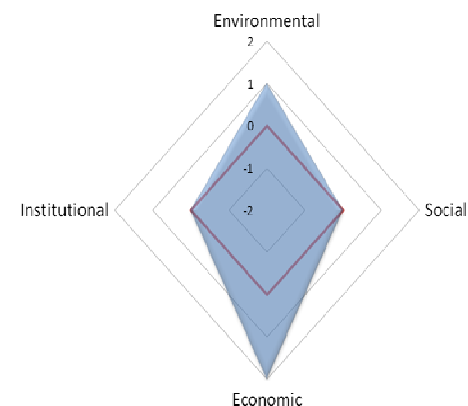
5,700 Total

Value in Tons of CO₂e
Through 2050

\$214 / MT

Levelized Savings (Cost)

34% IRR



Next Steps

- Evaluate potential limitations to project feasibility:
 - Performance curves of the existing turbines should be checked to ensure they are not at or near their calibration limits
 - Cavitation is also a concern
 - Physical restrictions under the powerhouse could require structural modifications

Issues & Opportunities

- Consider linking this project with the turbine rebuild to ensure the turbines are adequately calibrated to utilize the additional head provided by draft tubes

Replace Turbine Generator #1

Description

Replace steam backpressure turbine generator #1 (TG-1) in the CHP with a newer multi-stage model could increase cogeneration capacity from the central plant boilers.

Time Frame

Years 1-5

Assumptions

- It is estimated that the power output could be increased by approximately 550 kW at peak load conditions with a more efficient turbine generator (existing turbine is rated at 1,810 kW & a newer multi-stage turbine can achieve 2,360 kW)
- We have assumed the generator will operate 3,500 hours per year based on current use of TG-1. 75% of those hours will be in the summer and 25% in winter.
- This results in additional generation of approximately 1,900 MWh per year.
- Assuming that increased capacity would offset electricity purchased from NYSEG (with a GHG emission factor of 0.4 MTCO₂e per MWh), the reduction in Cornell's GHG footprint would be about 790 MTCO₂e per year.
- Assume some additional fuel input required during winter operation (25% of 3,500 hours) to account for degraded steam quality = ~2,000 mmBtu/year.

Costs & Benefits

Capital Cost: \$1,500,000 for new turbine and generator (upgraded switchgear is not included in this total)

Annual Incremental Operating Cost: Cost of additional fuel required to produce steam during winter operation of TG-1 = 2,000 mmBtu per year. This additional fuel is assumed to be coal until 2030 and natural gas after 2030.

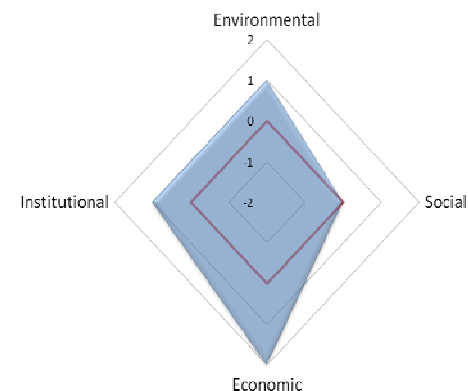
650 avg
annual

25,000 Total
Value in Tons of CO₂e
Through 2050

\$161 / MT

Levelized Savings (Cost)

13% IRR



Next Steps

- Further evaluate this option once funding is identified

Issues & Opportunities

- May wish to change the operational sequencing with TG-2 to take advantage of the higher efficiency
- Additional analysis is necessary to determine the exact amount additional fuel might be required to account for degraded steam quality through TG-1 due to additional electrical production

Co-Fire Wood (up to 10% by weight)

Description

Cornell estimates that up to 10 percent (by weight) of the coal burned in boilers #1 and #8 could be replaced with wood without major modifications to the boilers. Some modifications would be required, however, primarily with regard to additional or upgraded solid fuel handling and storage.

Time Frame

Years 1-5

Assumptions

- Upgrades to fuel handling and storage systems would be required
- No major modifications to the boilers themselves
- Boilers are currently permitted to co-fire up to 10% wood (Btu basis)
- Propose co-firing 10% wood on a weight basis (~2,000 tons wood/year based on Cornell's anticipated post-CCHPP coal consumption)
- 10% by weight equates to 4.5% on a Btu basis assuming 12,000 Btu/lb coal and 5,400 Btu/lb wood
- Additionally, the moisture contained in the wood requires additional energy to heat and boil, thus effectively lowering the energy content by another 1,100 Btu/lb to about 4,300 Btu/lb.
- Assume cost of \$53.50 per ton of wood or \$6.22 per mmBtu

Costs & Benefits

Capital Cost: \$300,000 for upgrades to fuel handling and storage
Annual Incremental Operating Cost: Additional 0.5 FTE (\$35,000) per year for labor.

900 avg
annual

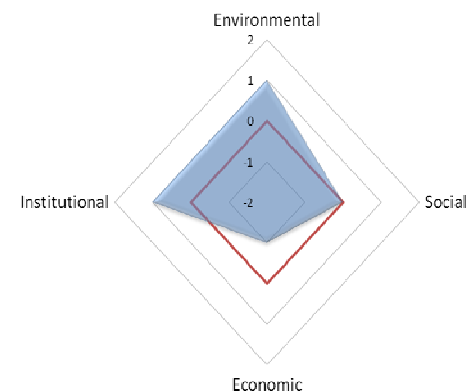
17,000 Total

Value in Tons of CO₂e
Through 2050

(\$122) /MT

Levelized Savings (Cost)

No IRR



Next Steps

- Perform more detailed analysis of capital cost requirements and fuel availability

Issues & Opportunities

- This project is only valid as long as coal is burned at Cornell (projected through 2030)
- The projected value of wood is a conservative estimate that includes the cost of wood, transportation, and sustainable forestry practices required to produce a consistent supply of woody biomass from Cornell lands

Landfill Gas Energy (Geneva Campus)

Description

Cornell's College of Agriculture and Life Sciences New York State Agricultural Experiment Station is located in Geneva, NY, approximately 40 miles northwest of Ithaca at the northern end of Seneca Lake. According to USEPA's Landfill Methane Outreach Program (LMOP), there are two landfills within 10 miles of the Geneva campus with landfill gas available for beneficial use. Both landfills are already collecting their gas and using it to produce electricity onsite.

Time Frame

Years 1-5

Assumptions

- Ontario County Sanitary Landfill is located 4 miles west of Geneva in Stanley, NY and currently produces 5.6 MW of electricity in addition to some heat in an onsite boiler. The landfill plans to expand its generating capacity to 12 MW.
- Ontario County Landfill is expected to stop accepting waste in 2030 so landfill gas production will continue to increase for at least 20 more years.
- The Geneva campus uses an average of about 1 MW of electricity and has an annual heating load of about 90,000 mmBtu.
- This analysis assumes a direct use project in which gas is piped from the landfill to the Experiment Station for use in the boiler that current exists on campus.
- Methane destruction credits are not available since the landfill is required to collect its gas under New Source Performance Standards (NSPS).

Costs & Benefits

Capital Cost: \$500,000 (for modification to existing boiler & gas service to bldg.) Assume capital cost for gas cleanup, compression, and pipeline will be paid for by an outside entity and added to the price Cornell pays for the gas.

Incremental Operating Cost: Landfill gas is expected to cost 90% of natural gas cost plus the cost of capital projects required to bring LFG to Geneva minus \$3 per mmBtu for NYSEG LDC cost.

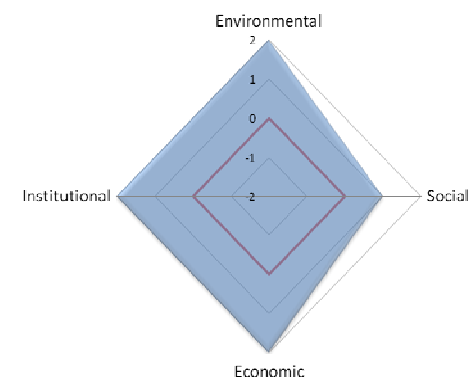
4,800 ^{avg}
annual

182,000 ^{Total}
Value in Tons of CO₂e
Through 2050

\$39 / MT

Levelized Savings (Cost)

45% IRR



Next Steps

- Continue discussions with landfill gas owner, with the intent to develop a pipeline and long-term agreement

Issues & Opportunities

- The Geneva campus is not currently included in Cornell's GHG inventory and therefore this project will not impact the inventory until satellite campuses are included in a statewide inventory
- Potential future upgrade to CHP system at the Geneva campus to provide both heating and electricity
- Might also consider siting a generator at the landfill and purchasing power for additional savings
- Seneca Meadows landfill, 9 miles northeast of Geneva, also has gas available

Large Scale Wind Energy

Description

This project is the installation of large wind turbines connected to the Cornell campus. The available resource appears to be in the 12 mw range.

Time Frame

Years 1-5 construction begins

Assumptions

- Assume a capacity factor of 29%=average annual output of about 30,500 MWh
- Since the majority of the production will occur during “wind season” (October - April), Cornell will not be able to use most of that power. For the purposes of this analysis, we have assumed all electricity will be sold at the wholesale rate (\$0.015 per kWh below retail).

Costs & Benefits

Capital Cost: \$35,000,000

Annual Incremental Operating Cost: \$70/kW installed = \$840,000 per year

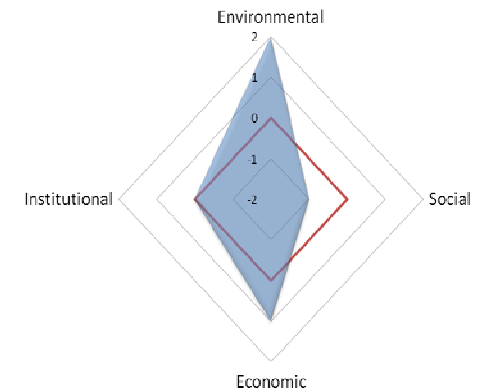
11,500 ^{avg}
annual

439,000 ^{Total}
Value in Tons of CO₂e
Through 2050

(\$1) / MT

Levelized Savings (Cost)

6% IRR



Next Steps

- Determine best approach to reintroduce the project to the local community

Issues & Opportunities

- Cornell began a feasibility study for generating large quantities of electricity using wind energy on nearby university property; community opposition and technical challenges stopped this project; such a project, however, may have renewed life as part of the CAP
- Verify ability to claim carbon reductions

Cornell University Renewable Bioenergy Initiative (CURBI)

Description

The Cornell University Renewable Bioenergy Initiative (CURBI) is in the initial stages of a feasibility study that will determine how best to use 57 campus waste streams and other university-owned biomass resources to generate renewable energy for the university. The feasibility study is considering several options, including direct combustion, anaerobic digestion, and pyrolysis.

Time Frame

Years 6-15

Assumptions

- Cornell currently produces (or, in the case of a biomass crop, has the ability to produce) woody waste, compost, and biomass crops from university operations and university-owned lands.
- The total amount of energy available from these biomass sources is estimated at about 300,000 mmBtu per year:
 - Woody biomass = 6,000 dry tons/yr @ 9,000 Btu/lb = 108,000 mmBtu/yr
 - Compost = 6,000 tons/yr @ 5,000 Btu/lb = 60,000 mmBtu/yr
 - Biomass crop = 8,000 dry ton/yr @ 8,000 mmBtu/yr = 128,000 mmBtu/yr
- Although the exact energy conversion technologies have yet to be determined, we have assumed a conservative estimate of 50% efficiency resulting in 150,000 mmBtu of energy production used to replace current natural gas combustion.
- We have also assumed the majority of capital costs for these projects would be funded by research dollars. Only the cost of connecting the systems to the existing distribution system has been included here.

Costs & Benefits

Capital Cost: \$5,000,000 (connection to existing central heating system)

Incremental Operating Cost: No change (incremental cost paid by research)

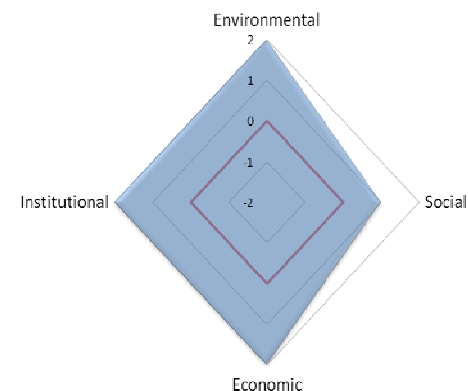
8,700 ^{avg}
annual

305,000 ^{Total}
Value in Tons of CO₂e
Through 2050

\$88 / MT

Levelized Savings (Cost)

18% IRR



Next Steps

- Next Step: Complete CURBI feasibility study

Issues & Opportunities

- Details of this project will be determined by the feasibility study currently underway
- The type of connection to campus (e.g., electricity, biogas, other) and the distance is also TBD; these details will impact the cost impact

Co-Fire Wood-Based Product (up to 20%)

Description

Cornell estimates that up to 20 percent (by Btu) of the coal burned in boilers #1 and #8 could be replaced with a wood-based product (e.g., E-coal, torrefied wood) without major modifications to the boilers. Some modifications would be required, primarily with regard to additional or upgraded solid fuel handling and storage. The capital cost required for these upgrades are incremental to any upgrades associated with handling wood as part of the short-term co-firing alternative.

Time Frame

Years 6-15

Assumptions

- Upgrades to fuel handling and storage systems would be required.
- No major modifications to the boilers themselves.
- Propose co-firing 20% wood-based product (e.g., E-coal, torrefied wood) on a Btu basis (~24% on a weight basis)
- Assume 12,000 Btu/lb coal and 10,000 Btu/lb torrefied wood
- Capital cost assumes co-firing wood was implemented in the short term and the capital required for that project was spent. Otherwise, total capital for this project is \$1.4 million.

Costs & Benefits

Capital Cost: \$1,100,000 (\$1 million incremental cost for upgrades associated with co-firing straight wood in the short term + \$100,000 in permitting costs)

Annual Incremental Operating Cost: 15% additional fuel cost compared to coal; 1 additional FTE @ \$70,000 per year

5,000 avg
annual

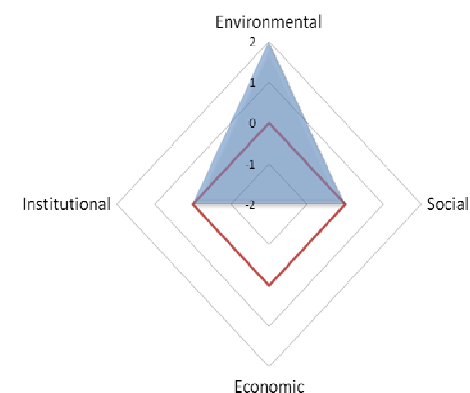
70,000 Total

Value in Tons of CO₂e
Through 2050

(\$77) / MT

Levelized Savings (Cost)

No IRR



Next Steps

- Although the project cost is high relative to payback, the impact of this alternative on carbon reduction is significant; Cornell may wish to pursue this project further by performing a more detailed analysis of the fuel, equipment and capital required to co-fire a wood-based product – especially if the base case assumption of coal boiler retirement in 2030 changes

Issues & Opportunities

- This project is only valid as long as coal is burned at Cornell (projected through 2030)

Reduce Steam Losses – Guterman Loop

Description

There are no direct measurements of steam distribution system losses, but rough estimates show that losses range from 8 to 12 percent throughout the system are possible. Newer installations at Cornell are very energy efficient and well insulated, so losses are fairly low. However, there is a significant amount of older piping in place – particularly on the eastern side of the campus - that likely has fairly high heat loss and should be a candidate for repair/upgrade.

Time Frame

Years 1-5, project start; implement over a 4-year period

Assumptions

- Cornell estimates 8 to 12 percent losses in the steam distribution system as a whole and reports that the steam line out to the east (towards Guterman and the College of Veterinary Medicine) may be in most need of repair/replacement.
- Assume 8,000 feet of 12" pipe with a current R-value of R-2 will be replaced with R-16. The difference in heat flow for these two R-values on a 12" pipe is about 340 Btu/hr per linear foot. This equates to about 24,000 mmBtu per year for the entire 8,000 foot run.

Costs & Benefits

Capital Cost: \$12,000,000 (8,000 feet X \$1,500 per foot)

Annual Incremental Operating Cost: Reduced fuel consumption by 24,000 mmBtu per year (coal until 2030, natural gas after 2030)

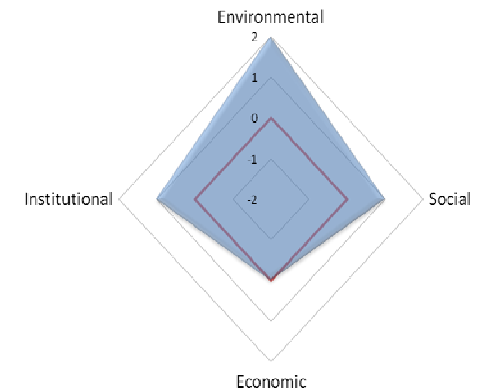
3,500 ^{avg}
annual

138,000 ^{Total}
Value in Tons of CO₂e
Through 2050

\$126 / MT

Levelized Savings (Cost)

10% IRR



Next Steps

- Perform monitoring to determine more precise estimate of heat loss and potential savings

Issues & Opportunities

- Heat loss assumptions are based on estimates of existing insulation versus performance of new pipe insulated to R-16

Early Conversion to Natural Gas

Description

With the addition of CCHPP, there will be enough steam production capacity using natural gas to satisfy the needs of the university year round. Conversion of Cornell's steam production is already planned (in the base case) for 2030 when the coal boilers will be retired. This alternative would accelerate that schedule. In order to eliminate coal, Cornell must convert or add boilers with oil-fired steam production to allow for adequate capacity during a natural gas outage.

Time Frame

Years 6-15 (target 2020 conversion – 10 years prior to base case assumption)

Assumptions

- In the event of a natural gas outage, there is not currently enough steam production capacity using oil to handle peak loads in the winter.
- Therefore, coal is still required under existing conditions and due to the operational constraints of coal combustion (e.g., long startup times), coal is burned to produce steam throughout the winter months.
- Oil-fired boilers, unlike coal, can be started up quicker in the event of an outage to serve as backup to the existing natural gas systems.
- Boiler #5 is currently capable to burn oil, but is not currently permitted to do so.
- The base case assumes 2 dual fuel package boilers will be installed in 2030
- Cornell's existing 700,000 oil tank provides about 9 days of steam production capacity at 400 kpph so no additional oil storage capacity would be required for backup use.

Costs & Benefits

Capital Cost: Assume accelerated implementation of \$40 million for additional dual fuel (natural gas/oil) package boilers currently in the base case for 2030

Operating Cost: Difference in coal and natural gas costs between 2020 and 2030

22,000 ^{avg}
annual

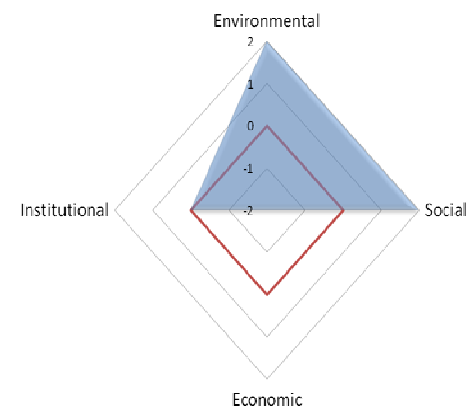
245,000 ^{Total}

Value in Tons of CO₂e
Through 2050

(\$174) / ton

Levelized Savings (Cost)

No IRR



Next Steps

- This alternative is already part of the base case in 2030 and will have a significant impact on GHG emissions regardless of when it is implemented; although economics do not look good, Cornell could consider early conversion to achieve a more immediate reduction in GHG emissions

Issues & Opportunities

- Actual cost could be as low as \$5 million per boiler

Engineered Geothermal Systems (EGS) – Demonstration

Description

At sufficient depths (6-10 kilometers) below ground surface, the earth contains a substantial amount of heat energy, even in our geological region. Engineered Geothermal Systems (EGS) involve drilling deep wells, creating a fractured zone, and circulating water through the rock to “mine” this heat. The potential to use this energy is documented in a DOE report completed by MIT in 2008. The USDOE is considering support for such research at a large (demonstration) scale.

Time Frame

Years 1-5: initial research/exploration; Years 10+: demonstration & use of energy

Assumptions

- The recommended EGS action is a demonstration-scale research project and will be designed to support large-scale research/demonstration, which will include campus use of extracted heat energy.
- The initial research and exploration stage will be used to refine estimates of renewable energy value; initial data suggests about 600,000 mmBtu of thermal energy might be available from a two-well system drilled to 6.5 km
- Thermal resource is likely insufficient to provide steam or efficient electricity production. Assume the eastern part of campus (Guterman/Vet School area) will be converted to hot water heat for most efficient use of available heat.
- 2 MW of electricity will be produced using an organic rankine cycle power generator during summer months when the campus heat demand is low.
- Project assumed to last indefinitely due to limited use of the thermal resource. Assume no redrilling required.

Costs & Benefits

Capital Cost: DOE grant application indicates 20% cost share by Cornell; assume \$20 million drilling costs, \$5 million heat exchange plant, \$25 million hot water conversion for Guterman/Vet school area loop; \$50 million X 20% = \$10 million
Additionally, assume 10% cost share for Cornell on a \$7 million organic rankine cycle power generator (\$7 million X 10% = \$700,000)

Annual Incremental Operating Cost: \$100,000 per year for thermal hydraulic and seismic monitoring

12,500 ^{avg}
annual

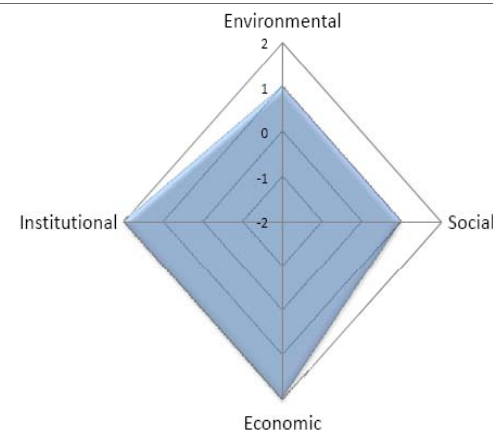
490,000 ^{Total}

Value in Tons of CO₂e
Through 2050

\$85 / MT

Levelized Savings (Cost)

15% IRR



Next Steps

- Develop DOE grant application

Issues & Opportunities

- This project is subject to grant funding and is not recommended as a primarily facilities project
- Professor Jeff Tester will lead effort
- The success of this technology could have significant impacts nationally and lead to new research opportunities in multiple departments
- The practical use of low-grade thermal energy could require significant changes to our infrastructure & systems to use this renewable energy effectively – both a challenge & an opportunity
- There is significant uncertainty about the level of thermal resource available

Expanded Engineered Geothermal with Biomass Peaking

Description

Engineered Geothermal Systems (EGS) involve drilling deep wells, creating a fractured zone, and circulating water through the rock to “mine” this heat. The potential to use this energy is well documented in a DOE report completed by MIT in 2008. Pending demonstration of the research-scale project this expanded project has the potential to satisfy nearly all of Cornell’s heating needs, but only as hot water. Cornell’s heat distribution system will have to be converted to hot water to take full advantage. Biomass gasification is assumed to handle peak loads.

Time Frame

Pending success of research scale EGS; begin construction 2020, startup 2030

Assumptions

- If the research scale project proves feasibility of EGS at Cornell, assume 2 additional well pairs and an upgraded heating plant would be necessary to provide 90% of annual heating (all but the winter peak)
- Cornell would have to convert its heat distribution system to hot water.
- Assume expanded EGS would provide heat only – most electrical requirements would be purchased from NYSEG or generated from renewable sources.
- Redrilling required every 10 years at 50% of original drilling cost.
- Biomass gasification sized to satisfy peak load. Assuming 180 kpph of heat from 3 well pairs, the biomass plant would provide up to 220 kpph at a cost of \$240,000 per kpph. This plant could provide cogeneration in summer months.

Costs & Benefits

Capital Cost: \$50 million for wells and heating plant; \$225 million for converting heating system to hot water (incremental to Guterman loop already converted); \$50 million for biomass gasification (syngas to be used in existing boilers).

Operating Cost: Assume no substantial change in labor from existing central plant operations; \$200,000 per year for monitoring; redrilling cost every 10 years at 50% of original cost (\$5 million per well X 6 wells = \$30 million in 2040)

50,000 ^{avg}
annual

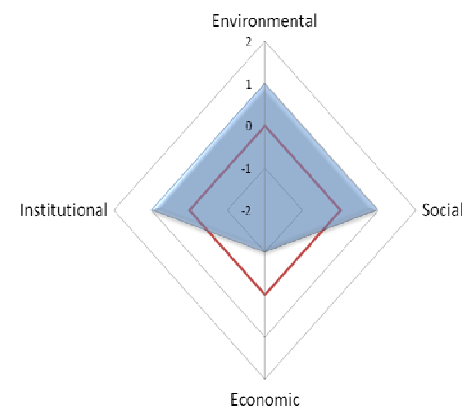
1,230,000 ^{Total}

Value in Tons of CO₂e
Through 2050

\$3 / ton

Levelized Savings (Cost)

7% IRR



Next Steps

- Await results of demonstration scale EGS project

Issues & Opportunities

- Majority of potential capital costs are in conversion to hot water systems.
- Increases need for electricity from other sources
- This alternative is one of two long-term scenarios that removes fossil fuels from Cornell’s central plant (the other is large-scale biomass gasification); one of these two alternatives will be chosen based on the results of the Demonstration Scale EGS project

Large-Scale Biomass Gasification

Description

As larger and more efficient energy conversion technologies for biomass continue to develop, a large scale biomass plant could a viable alternative for Cornell in the future. There are numerous potential biomass energy production possibilities, but biomass gasification has been used as the basis of this analysis.

Time Frame

Pending results of demonstration-scale EGS; Implement in 2030 to coincide with retirement of coal boilers

Assumptions

- Cornell's peak steam demand is expected to remain level at about 400,000 pounds per hour after implementation of demand-side reduction alternatives.
- Although not proven at this size, today's cost for cogenerating biomass gasification plants is about \$240,000 per kpph of capacity, not including any new boilers. That equates to about \$100 million for a 400 kpph gasification plant.
- Assume the two package boilers included in the base case for 2030 will remain and be used to fire the syngas produced by the gasification plant.
- Biomass availability study by David Weinstein indicates substantial amounts of land available for sustainable biomass production from a combination of woody biomass & biocrops within 25 miles of Ithaca. The estimated sustainable harvest was well over 300,000 tons per year, about 3x the amount needed for this action
- Some cogeneration may be possible during summer months (assume 8 months per year).

Costs & Benefits

Capital Cost: \$100,000,000 for a 400 kpph biomass gasification plant based on today's prices

Operating Cost: \$35/ton for wood (2009)

60,000 ^{avg}
annual

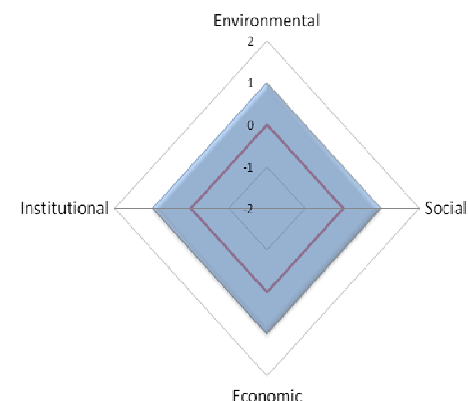
1,500,000 ^{Total}

Value in Tons of CO₂e
Through 2050

\$35 / ton

Levelized Savings (Cost)

11% IRR



Next Steps

- Await results of Demonstration Scale EGS to determine path forward

Issues & Opportunities

- This alternative is one of two long-term scenarios that removes fossil fuels from Cornell's central plant (the other is the expanded EGS w/ biomass peaking alternative); one of these two alternatives will be chosen based on the results of the Demonstration Scale EGS project

Carbon Capture and Sequestration (CCS)

Description

Effective use of carbon capture and sequestration (CCS) technologies would allow Cornell to continue burning fossil fuels with existing infrastructure. However, the technologies used to capture and sequester carbon are evolving and do not appear to be viable yet. A study by Professor Andrew Hunter from Cornell's Chemical Engineering Department analyzed the possibility of employing CCS technology on the CCHPP. That study is the basis of this analysis.

Time Frame

Years 16+

Assumptions

- The study modeled the capture of 90 percent of the CO₂ from the CCHPP (56,200 lb CO₂/hr) using an amine process and then piping it 40 miles north of Ithaca to some gas fields southwest of Syracuse.
- The estimated capital cost for the capture and sequestration was between \$50 million and \$80 million.
- Additionally, the regeneration process for the chemicals used to capture the CO₂ required 6 MW of electricity – 20 percent of the output from the CCHPP.

Costs & Benefits

Capital Cost: \$80 as modeled (achieves 90% capture of CCHPP emissions)
Operating Cost: \$7 million per year for chemical costs; 6 MW of continuous power to the system

29,000 ^{avg}
annual

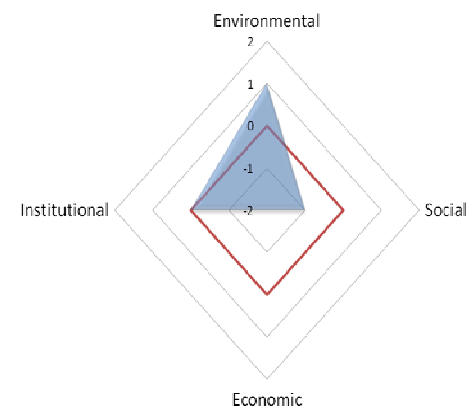
726,000 ^{Total}

Value in Tons of CO₂e
Through 2050

(\$489) / ton

Levelized Savings (Cost)

No IRR



Next Steps

- CCS alternative sent to bike rack; reevaluate in the future as technical feasibility increases and prices decreases

Issues & Opportunities

- Unproven
- Too expensive

Offsets - Afforestation

Description

Afforestation is the conversion of idle crop or pasture land to mature growth forest lands. Afforestation provides long term sequestration of atmospheric CO₂ in the trees' biomass and soils surrounding the root system of trees. Cornell owns several land holdings that are candidates for afforestation projects.

Time Frame

Years 1-5 for planting; 50 years to realize full offset potential of plantings

Assumptions

- One thousand acres of existing pasture/crop lands near Mt. Pleasant, Ithaca Tompkins Regional Airport and the Harford Teaching & Research Center will be planted at a rate of 200 acres/year for 5 years
- Average net sequestration rate = 3.8 tons CO₂/acre/year over a 50 year period
- Annual operating costs assume a rotating inventory of 10% of total afforested area (10-yr cycle) and rotating herbicide application on 100-yr cycle beginning after planting completed
- Assumes project lands are dedicated and no harvesting during 50 year period
- University will follow protocols necessary to create high quality, compliance-eligible afforestation offsets
- Transaction costs to create high quality compliance offsets assumed to be \$.33/ton, which includes feasibility studies, establishing and verifying baselines, negotiations, regulatory compliance costs, and on-going monitoring and verification costs (costs based on 2007 EPA modeling assumptions)

Costs & Benefits

Capital Cost: \$400,000 (5-year budget for labor, materials and equipment for forest planting)

Annual Incremental Operating Cost: \$2,000 plus \$.51/ton CO₂e/yr transaction costs and registration and transfer fees required to create high quality offsets

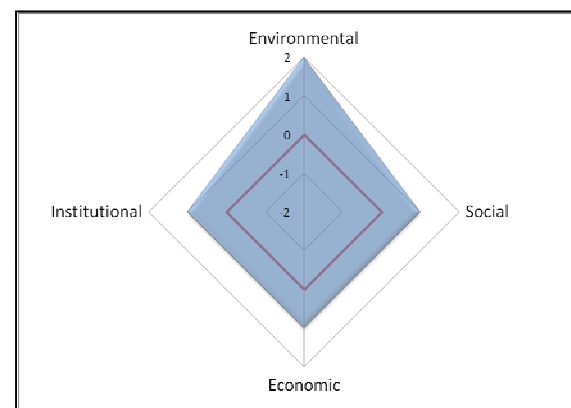
3,600 ^{avg}
annual

136,000 ^{Total}

Value in Tons of CO₂e

(\$6.90)/ ton

18% IRR



Next Steps, Issues & Opportunities

- Identify 1,000 acre tract of pasture/crop to convert to new forest lands; this land could not be used for other purposes
- Assign Department of Natural Resources as the lead responsible entity for afforestation project development
- Afforestation offsets widely recognized by both voluntary and emerging mandatory regulations
- Afforested areas of Cornell lands could come under intensive forest management practices to increase sequestration rates

Offset -- Forest Management

Description

Forest Management approach to creating offsets is accomplished by managing forest growth to enhance carbon sequestration via silviculture practices or conservation of standing forest stocks to ensure higher sequestration potential. This can be accomplished by planting moderately fast-growing species to accumulate timber (and carbon) faster or can be achieved through practices such as fertilization, controlled burning, and thinning to increase forest and carbon productivity.

Time Frame

Years 1-3 to establish baseline and initiate the project; 50 years to fully establish

Assumptions

- Intensive forest management to be performed over 6,636 acres of Cornell lands near Arnot Forest, Mt. Pleasant, Ithaca Tompkins Regional Airport and Harford T & R Center
- The US Forest Service model indicates natural growth rates on 6,636 acres of forest will sequester an average of 7,770 tons CO₂e per year
- Assume more intensive silviculture practices to increase the growth rate of the forest above the natural growth rate to withdraw 2,500 wet tons biomass/yr and increase the net amount of CO₂ sequestered by 30%; this would increase the capacity of the 6636 acres to sequester an additional 2,330 tons CO₂e per acre per year above the natural growth rate
- University will follow protocols necessary to create high quality, compliance-eligible forest management
- Transaction costs to create high quality offsets assumed to be \$.33/ton, which includes feasibility studies, establishing and verifying baselines, negotiations, regulatory compliance costs, and on-going monitoring and verification costs; costs based on 2007 EPA modeling assumptions

Costs & Benefits

Capital Cost: \$0

Operating Cost: \$13,000/yr plus \$.51/ton CO₂e/yr transaction costs and registration and transfer fees required to create high quality offsets

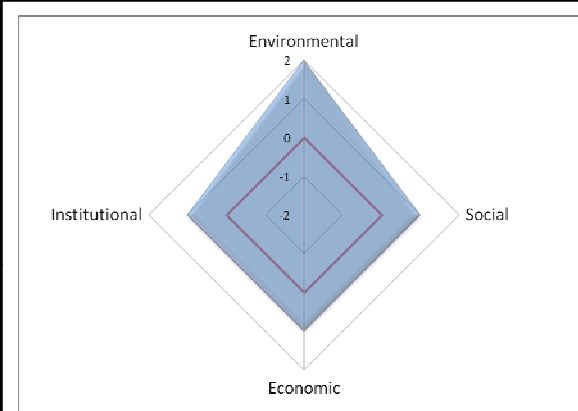
15,000 ^{avg}_{annual}

570,000 ^{Total}

Value in Tons of CO₂e
Through 2050

(\$1.35) / ton

128% IRR



Next Steps, Issues & Opportunities

- Identify the 6,6000 acres of existing forest lands that will come under more intensive management
- Assign Department of Natural Resources as the lead responsible entity for forest management
- Assign Forest and Fields Advisory group to identify synergies between afforestation, forest management and use of Cornell harvested wood for CURBI central plan co-firing project
- Forest management offsets increasingly recognized in voluntary markets and may be included in U.S. regulatory regime

Offsets – Biochar

Description

Biochar is produced by the low-temperature pyrolysis of biomass material that can result in a longer-lived net increase in the removal of CO₂e from the atmosphere compared to standard forest and agricultural sequestration practices. Pyrolysis of biomass results in a two fold increase in the carbon content of the biomass material and locks up rapidly decomposing carbon in plants into a more stable form of carbon. When incorporated into soils biochar and the carbon associated with it can be sequestered for hundreds (or perhaps thousands of years). Greater emissions reductions are possible if pyrolysis gases are captured and used to produce energy.

Time Frame

Years 1-5 years for planning, design and construction; assume 20 year plant design life

Assumptions

- Planned CURBI project will include full-scale pyrolysis unit with a continuous throughput of 1-2 tons/hour (4,000 tons/year)
- Assume approx. 3,500 tons biochar produced/year with average 68% C content
- Assume 8600 tons CO₂e sequestered annually at total unit cost of \$165/ton CO₂e
- CURBI project will be managed, operated and located at CUAES or adjacent lands
- Resultant biochar spread on Cornell crop lands
- Offsets created by Biochar research projects should be considered for use to meet voluntary ACUPCC commitment to offset Scope 3 emissions
- As a CURBI research project the full capital costs of the pyrolysis unit and the incremental operations costs should not be borne by the “offsets” generated from the project; for accounting purposes it is recommended that offsets be considered a no-cost by-product of the CURBI research project

Costs & Benefits

Capital Cost: \$ 0

Annual Incremental Operating Cost: Assumed cost to develop protocols, standards and registration fees at \$.51/ton CO₂e/yr over life of CURBI project

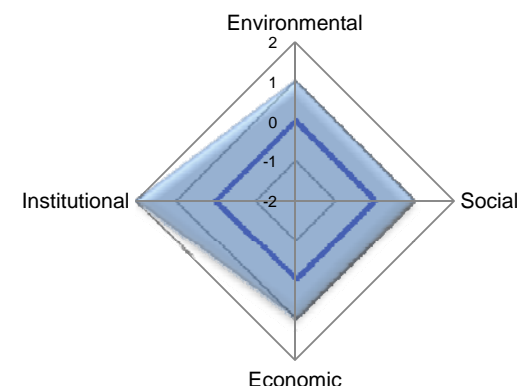
3,800 ^{avg}
annual

140,000 ^{Total}

Value in Tons of CO₂e

(\$0.48) / ton

353% IRR



Next Steps, Issues & Opportunities

- This is potentially game changing technology for climate change and Cornell research and development opportunities should be identified and pursued
- Biochar is a promising technology and approach for creating soil sequestration offsets but requires more research and validation of the duration the CO₂e is sequestered in soil before biochar will be accepted as an offset
- Cornell should establish and document protocols and standards for monitoring and verification of soil sequestration duration and creation of biochar offsets

Offsets –Ag Animal Waste-to-Methane

Description

Methane is a powerful greenhouse gas that is produced by agricultural livestock manure. Agricultural methane offset projects are designed to capture methane created from agricultural animal waste and to flare it or combust it to generate heat, hot water and/or electricity.

Time Frame

Years 1-5 for planning, design and construction; assume 30 year design life

Assumptions

- Project to overhaul/retrofit/replace existing manure collection system(s) at Harford Teaching & Research (T&R) Center to capture and treat 6 months of annual manure production for anaerobic digestion
- Annual digester CH₄ production = approx 1100 metric tons CO₂e
- Approx 475 metric tons CO₂ avoided annually by use of digester gas fired turbine (compared to NYS grid)
- University will follow protocols necessary to create high quality, compliance-eligible offsets if cost effective
- Transaction costs to create high quality offsets assumed to be \$.33/ton; includes feasibility studies, establishing and verifying baselines, negotiations, regulatory compliance costs, and on-going monitoring and verification costs (costs based on 2007 EPA modeling assumptions)

Costs & Benefits

Capital Cost: \$1.5 million (estimated budget for design and construction, assuming a rate of \$630/animal unit and 25% for planning and design). Energy recovery module estimated at 36% of total project costs. **Net Annual Incremental Operating Cost:** \$20,000 (\$150,000 estimated budget minus \$130,000 estimated cost savings from energy recovery. Plus \$.51/ton CO₂e/yr transaction costs and registration and transfer fees required to create high quality offsets.

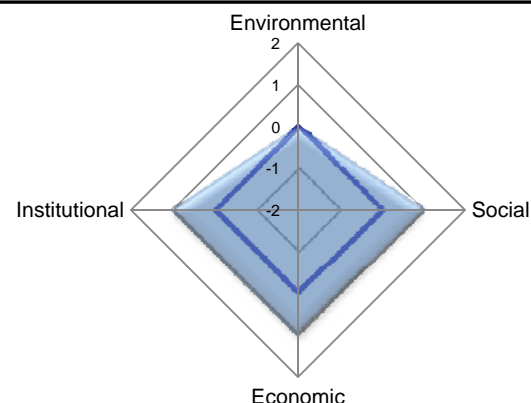
1,500 ^{avg}
annual

47,000 ^{Total}

Value in Tons of CO₂e

(\$75.41) / ton

No IRR



Next Steps, Issues & Opportunities

- Evaluate co-benefits of this offset project as part of a larger manure collection and waste management system at the T&R Center
- The T&R Center needs to be rebuilt; when plans are developed an opportunity exists to incorporate animal manure treatment and energy system into new facility
- Difficult to justify project economics on the basis of offsets alone

Offsets – Soil Tillage

Description

Conservation tillage is an agricultural practice that leaves crop residue in place to cover at least 30% of the soil surface after planting. Similarly, no tillage practices leave soil undisturbed from harvest to planting. Under both scenarios reduced soil disturbance reduces the release of CO₂e to the atmosphere via decomposition of organic carbon in the soil.

Time Frame

Conservation tillage/no tillage is currently practiced on approx. 900 acres by Farm Services and on approx. 100 acres at Musgrave Farms
Years 1-5 for implementation at Animal Science T&R Center in Harford, NY

Assumptions

- Continue conservation tillage/no tillage to be practiced at Farm Services and Musgrave Farms (~1000 acres)
- Institute conservation tillage/no tillage practices and expand to Harford Animal Science T&R Center (200 acres/year, up to 1,000 acres total)
- CO₂ sequestration rate = 0.4 tons/acre/year
- University will follow protocols necessary to create high quality offsets; currently, the only protocols recognized for soils sequestration are those established for the Chicago Climate Exchange (CCX) and used for voluntary compliance purposes; high probability some form of agricultural soil sequestration offsets will be eligible under future federal GHG regulations
- University should identify, authorize and fund a campus entity to administer soil tillage projects as well as other offset projects
- Transaction and registration fees to create high quality offsets assumed to be \$.51/ton/CO₂e
- Soil tillage offsets used for voluntary commitments at least through 2012

Costs & Benefits

Capital Cost: \$0

Annual Incremental Operating Cost: Costs to create high quality offsets assumed to be \$51/ton CO₂e/yr transaction costs and registration and transfer fees required to create high quality offsets.

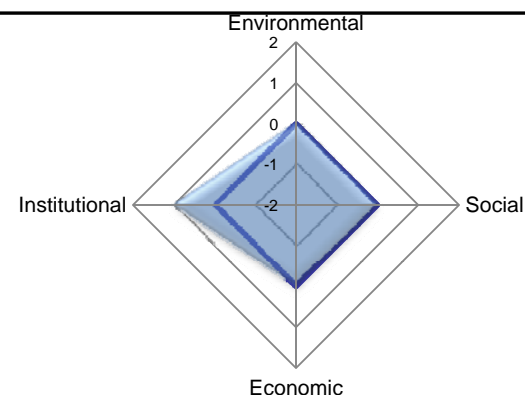
390 avg
annual

15,000 Total

Value in Tons of CO₂e

(\$0.48) ton

274% IRR



Next Steps, Issues & Opportunities

- Identify Cornell lands that are currently under soil conservation tillage practices in order to establish a baseline
- Identify crop lands not currently under soil conservation tillage practices where practice can be applied
- Establish appropriate protocols for monitoring, measuring and verifying amount of CO₂e sequestered through this practice
- Environmental assessment of water quality and herbicide impacts should be conducted

Offsets – Voluntary Commitments

Description

Represents acquisition of offsets to meet Cornell's voluntary "climate neutrality" commitment to the ACUPCC. Options include issuing requests for proposals, buying offsets over-the-counter (OTC) from offsets providers or aggregators, funding community-based offset projects, joining the Chicago Climate Exchange and purchasing from their pool of offsets, and buying offsets simultaneously with the procurement of goods and services (e.g. airfare or electricity).

Time Frame

Timing will depend on (1) milestones established by CAP to address non-covered Scope 1 and indirect Scope 3 emissions and/or achieve "climate neutrality", (2) volume of offsets created from Cornell projects that meet quality standards for "voluntary market", and (3) emissions reductions achieved through programs and actions

Assumptions

- Offsets from voluntary markets will complement use of Cornell-sourced offsets and direct actions taken to reduce the university's Scope 1 and Scope 3 emissions
- Offsets used for these purposes will meet Cornell established standards for quality, cost effectiveness and be aligned with the University's missions and sustainability goals
- Cornell will explore the possibility of a Community Offset Program to fund offsets from community based energy efficiency, renewable energy, methane capture and forestry projects, etc.
- Offsets acquired to meet voluntary commitments will be used to compensate for the 16,000 metric tons of Scope 1 emissions associated with non-central plant fuel combustion, Cornell Real Estate, and University fleet, and Scope 3 emissions associated with campus commuting (29,000 mtCO₂e) and Cornell-related travel (27,000 mtCO₂e)

Costs & Benefits

Capital Cost: N.A.

Annual Incremental Operating Cost: N.A..

Assumed cost of Offsets: For purposes of modeling, price of offsets from community based projects or voluntary over-the-counter market purchases is assumed to be 35% of the forecasted allowance price used by Cornell for the reference case

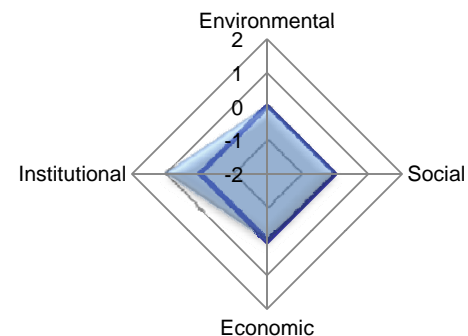
XX avg
annual

XX Total

Value in Tons of CO₂e

\$ / ton

IRR



Next Next Steps, Issues & Opportunities

- Recommend that Cornell consider establishing "Offset Czar" to manage Cornell Offset projects and coordinate offset procurement strategy; several million dollars of compliance and project costs are at stake and creating a position to direct offset activities is likely to be a good investment
- Collaborate with Tompkins County and Ithaca to identify high quality, cost-effective offset project opportunities
- Create funding mechanism by leveraging Cornell and local government funding with NYSEDA RGGI "allowance" revenues
- Financial exposure and benefits appear to justify position to manage Cornell's compliance and voluntary offsets portfolio

Offsets – Compliance

Description

Market purchases of compliance offsets as a complimentary measure to be used in conjunction with eligible Cornell-sourced offsets, allowance purchases and direct emissions reductions for the 160,000 mtCO₂e of GHG emissions associated with campus sources covered under federal climate legislation. Currently only Cornell's central plant may be a target for being a covered source under federal legislation.

Time Frame

Timing of market purchases of compliance offsets will depend on the passage and implementation of federal climate legislation, currently forecast for 2012, and Cornell's schedule for achieving "climate neutrality".

Assumptions

- Cornell will adopt a portfolio approach and purchase high quality, compliance offsets to make up the difference between emissions and Cornell-sourced offsets
- Market purchases of compliance offsets will be managed in conjunction with use of compliance eligible Cornell-sourced offsets, purchases of allowances and adoption of measures to reduce emissions associated with Cornell's central plant
- Compliance offsets will be purchased from projects aligned with the University's mission and sustainability goals
- Compliance offsets will be purchased up to the maximum allowed by federal regulations before allowances are purchased
- Eligible offsets likely to include projects currently defined by S. 3036 America's Climate Security Act 2007 and Dingell-Boucher draft legislation

Costs & Benefits

Capital Cost: N.A.

Annual Incremental Operating Cost: N.A.

Assumed cost of Offsets: For modeling purposes compliance offset pricing assumed to be 80% of forecasted allowance price presented in the Base case

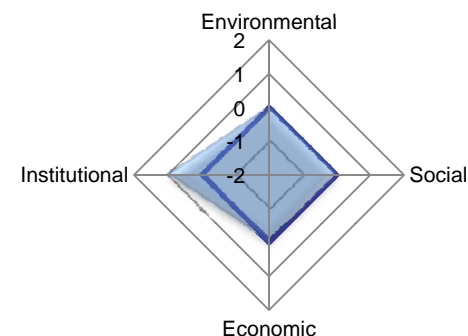
XX avg
annual

XX Total

Value in Tons of CO₂e

\$ / ton

IRR



Next Steps, Issues & Opportunities

- Financial exposure and benefits justifies position to manage Cornell's compliance and voluntary offsets portfolios
- Recommend that Cornell develop a business and risk management plan for addressing potential compliance obligations under future federal GHG regulations
- Cornell should consider whether to purchase and then bank allowances from RGGI as a mid-term strategy

Offsets – Travel

Description

Cornell's GHG inventory indicates that ground transportation and air travel associated with university related trips is 27,000 metric tons CO₂e in 2007. The ACUPCC requires Cornell to offset its business related travel. Cornell has two options for market purchases of travel offsets; OTC or through an RFP. As of 2009 there are at least 24 brokers that sell travel-related offsets over-the-counter (OTC) at prices ranging from \$5.00 metric ton to over \$30.00 metric ton CO₂e.

Time Frame

Timing of market purchases will depend on the milestones established by CAP to address Scope 3 emissions associated with business travel and/or achieve "climate neutrality", and success of airline efforts to reduce GHG emissions. For example British Airways has just announced a goal to reduce GHG emissions 50% by 2050.

Assumptions

- Cornell takes measures to reduce university related air and ground travel
- At least one international airline has a stated business objective to reduce GHG emissions by 50% by 2050
- Cornell purchases offsets from OTC broker specializing in travel-related offset products
- Travel-related offset will have certification/verification by VCS or Gold Standard
- Current OTC market price for offsets purchased from credible brokerage firm Enpaló is \$13.5-\$25.00
- If federal climate change regulations are in place then the petroleum refining or airline industry will be subject to compliance and will have taken measures to either purchase allowances, offsets or reduce direct GHG emissions

Costs & Benefits

Capital Cost: N.A.

Annual Incremental Operating Cost: For purposes of acquiring offsets for its voluntary ACUPCC commitment, cost of offsets will be assumed to be 35% of the forecasted allowance price used by Cornell for the reference case

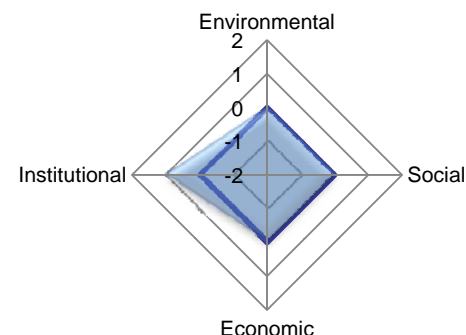
XX avg
annual

XX Total

Value in Tons of CO₂e

\$ / ton

IRR



Next Steps, Issues & Opportunities

- Financial exposure and benefits justifies full time position to manage Cornell's compliance and voluntary offsets portfolio
- Voluntary compliance with ACUPCC will require Cornell to decide best strategy for purchasing offsets for travel related emissions, i.e. OTC, RFP, or community based
- Recommend that Cornell develop a business and risk management plan for addressing potential compliance obligations under future federal GHG regulations



MEMORANDUM

Draft for Discussion Purposes Only

Page 1 of 26

WRITTEN TO: PCCIC, SUSTAINABLE DECISIONS WORKING GROUP

DATE: JANUARY 6, 2009

COPY TO: AFFILIATED ENGINEERS, INC.

REV 10

WRITTEN BY: ENERGY STRATEGIES, LLC

ENGAGEMENT: CORNELL CAP

REGARDING: FINANCIAL EXPOSURE TO U.S. CLIMATE ACTION POLICY

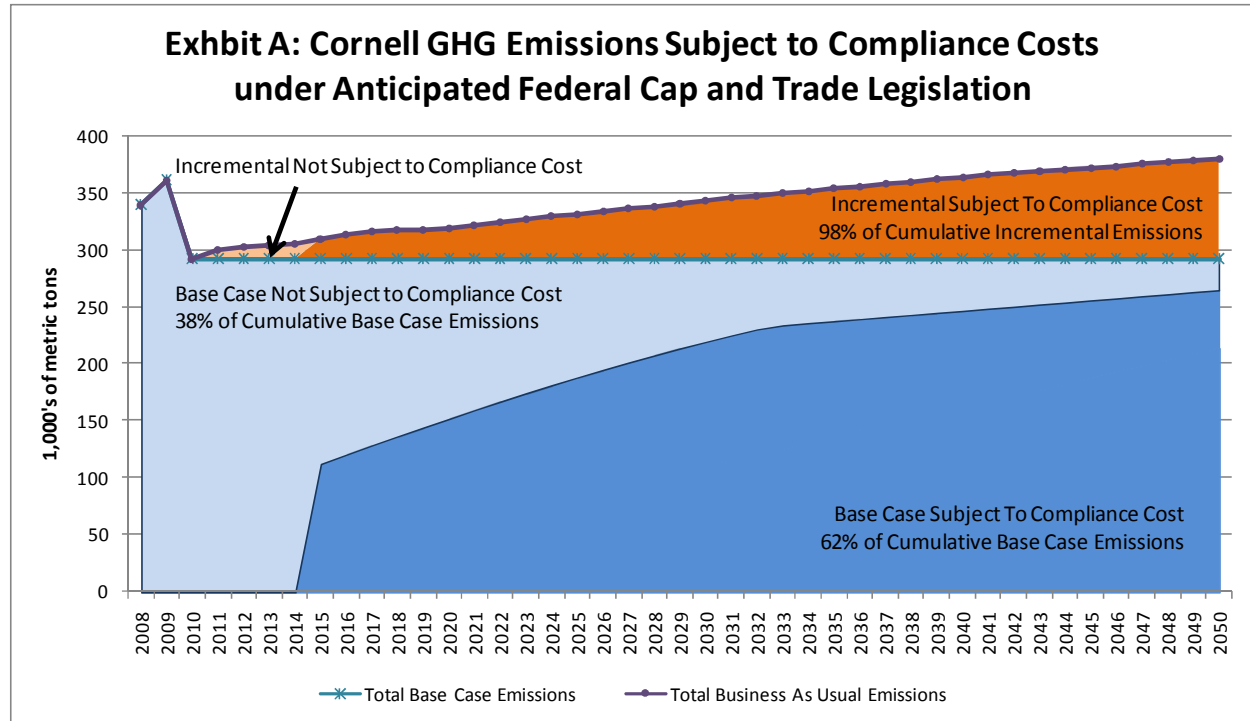
It is anticipated that federal climate change legislation will be enacted implementing a cap and trade system for greenhouse gases (GHG) not later than 2015. Virtually all of Cornell's GHG will likely be covered either directly or indirectly under the legislation. Accordingly, Cornell will bear the cost of compliance either directly or in the form of higher costs from its energy and transportation supply chains.

Cornell has completed an inventory of its greenhouse gases (GHG) under the American College and University Presidents Climate Commitment (ACUPCC). The inventory encompasses fuels consumed on campus to produce electricity, steam and hot water ("Scope 1"); purchased electricity ("Scope 2"), and transportation fuels used in commuting and air travel ("Scope 3"). The inventory reflects a total of about 319,000 metric tons (mt) of carbon dioxide equivalent (CO_{2e}) for FYE 2008. Future "Base Case" emissions, i.e. those related to decisions already made, will decline in 2010 with the commercial operation of the new natural gas cogeneration plant. Future "incremental" decisions, for example to construct additional, energy intensive research and educational facilities, will tend to increase GHG emissions.

Energy Strategies developed three federal climate change policy scenarios: "soft", "moderate", and "stringent". All three scenarios assume a cap and trade system is implemented as of January 1, 2015 with the annual cap defined as a percent of 2000 economy wide emissions. As suggested by their titles, the scenarios reflect varying degrees of mandated reductions as more fully discussed herein. Under the "moderate" scenario, it is estimated that over 60% of Cornell's Base Case cumulative emissions will be subject to a mandated compliance costs through 2050. Compliance costs could arise as a result of an economy wide cap on emissions or from the need to purchase allowances to emit amounts below the cap. Virtually all emissions arising from incremental decisions would be subject to a compliance cost. Exhibit A shows an estimate of the portion of Cornell's GHG emissions that are projected to be subject to compliance cost under the "moderate" policy scenario¹.

¹ Note that emissions forecasts in this document do not reflect detailed, updated forecasts that are being prepared as part of the CAP process.

REGARDING: FINANCIAL EXPOSURE TO U.S. CLIMATE ACTION POLICY (REV 10 - 1_6_09)



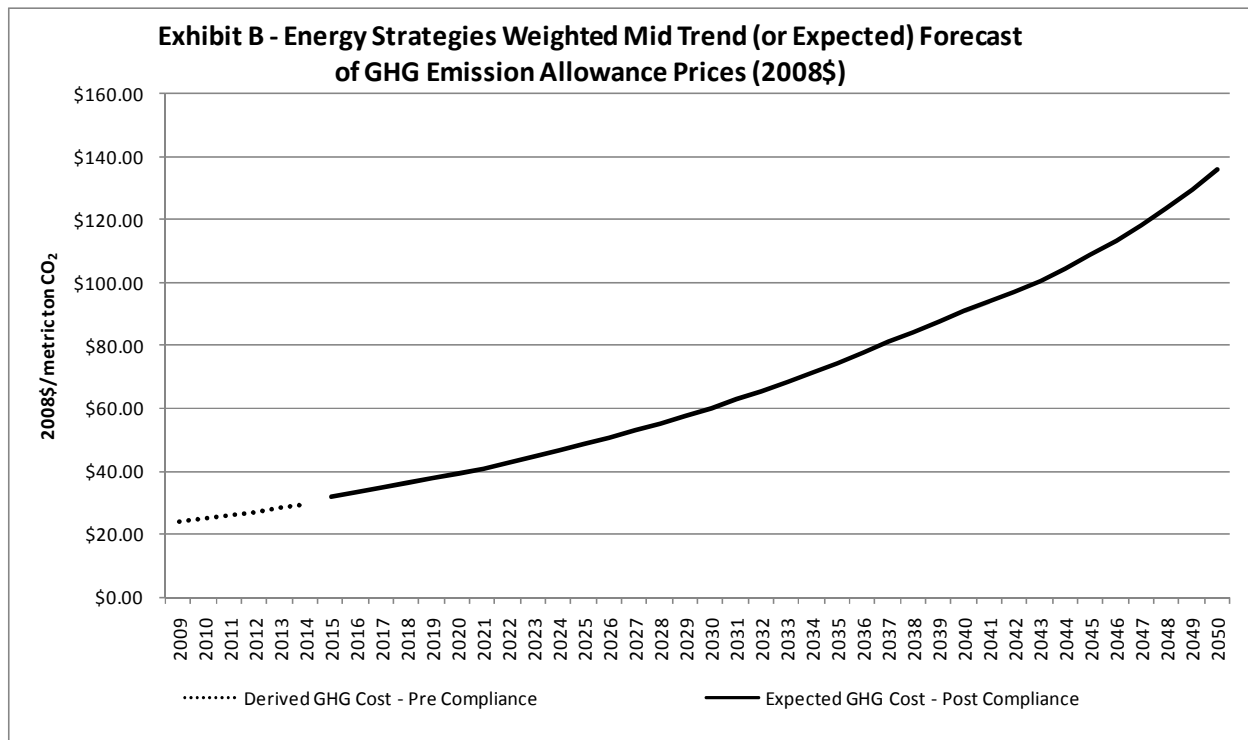
In order to estimate Cornell's financial exposure to federal mandates, a simplifying assumption was made that federal mandates are met by purchasing GHG emission allowances or project-based offset credits². Energy Strategies developed "high" (P90), "mid" (P50), and "low" (P10) trend forecasts of the cost of emission allowances starting in 2015 through 2050. The Energy Strategies forecasts are based, in part, on over 50 forecasts prepared by third parties that assessed legislative climate change initiatives in the 110th Congress. A "weighted mid" (or "expected") trend forecast was developed from the P10, P50, and P90 projections. This expected trend reflects a starting price of about \$32.00 per metric ton CO_{2e} in 2015 rising to \$60 in 2030 and \$136 in 2050 in constant 2008 dollars.

Exhibit B contains a graph showing Energy Strategies expected trend annual forecast of GHG allowance prices in constant 2008 dollars (solid sloping line) for the period 2015 through 2050. The annual expected trend prices can be used to calculate a "levelized" cost of about \$54.00 per metric ton CO_{2e} that is equivalent on a present value basis applying a discount rate of five percent. In Exhibit B, the expected trend annual forecast has been extended backward in time

² The CAP will reflect the preference of the University to meet GHG reduction objectives through direct avoidance and reduction of GHG emissions and the replacement of fossil fuels with renewable energy.

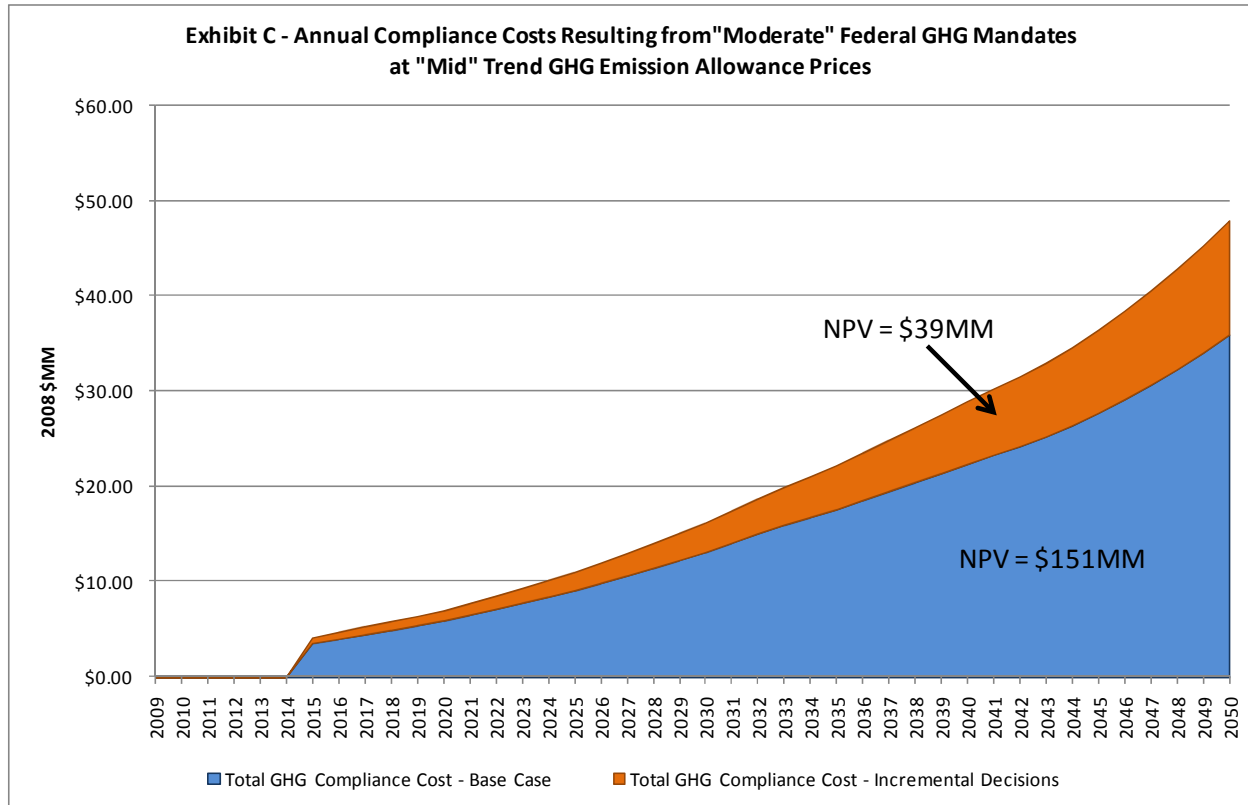
REGARDING: FINANCIAL EXPOSURE TO U.S. CLIMATE ACTION POLICY (REV 10 - 1_6_09)

(dotted line) to cover the period before 2015, i.e. before assumed compliance requirements. (Note: federal compliance mandates could be in effect as early as 2012).



Energy Strategies then estimated Cornell’s financial exposure to federal mandates under the three policy scenarios and for the range of projected allowance prices. Under the “moderate” federal climate change policy scenario, Cornell’s Base Case exposure to federal mandates, expressed as present value in 2008 dollars, is estimated to be between about \$50 million and \$300 million with an expected value of \$151 million. Financial exposure is sensitive to the speed and depth of GHG emission reductions required under federal legislation as well as to the extent to which Cornell’s emissions are exempted from the requirements. Under a “soft” climate legislation policy scenario that is assumed to exclude Cornell’s central plant from compliance, financial exposure could be under present value \$10 million at “low” trend allowance prices. Under “stringent” policy, exposure could be over present value \$385 million. Future incremental decisions add financial exposure. Refer to Exhibit C for projected annual compliance costs under “moderate” climate change policy and at “mid” trend allowance prices.

REGARDING: FINANCIAL EXPOSURE TO U.S. CLIMATE ACTION POLICY (REV 10 - 1_6_09)



One objective of this analysis is to provide a preliminary understanding of the nature and magnitude of Cornell's financial exposure to climate change legislation. However, a more important purpose is to secure support for formally incorporating future expected costs associated with GHG mandates into Cornell's decision making today. It is our intention as part of the Climate Action Plan's (CAP's) Sustainable Decision Framework to provide tools and processes to help incorporate costs of climate change in decision making at Cornell in the following ways:

- a. **In Preparation of the Climate Action Plan.** The process of preparing the Cornell Climate Action Plan provides a forum to understand climate change risks to the institution, to explore alternative responses, and to apply common sense risk management principles. The resulting CAP will recommend a carbon abatement portfolio of specific near-to-mid term actions and more general long-term options. In arriving at those recommendations, Cornell will consider a broad set of institutional, economic, environmental, and social criteria. As support for the

REGARDING: FINANCIAL EXPOSURE TO U.S. CLIMATE ACTION POLICY (REV 10 - 1_6_09)

recommendations, the CAP will identify how the recommended portfolio of actions is expected to perform relative (incrementally) to a “Base Case” and to other feasible alternative courses of action. It will be assumed that the Base Case and alternative portfolios will be subject to and must meet anticipated federal climate change compliance requirements. Accordingly, it is proposed that financial exposure to climate change legislation be incorporated in the Base Case and alternative portfolios using the general methodology outlined herein. The specific methodology will be refined as the CAP preparation proceeds.

- b. **In the Capital Investment Decision Process.** A part of the Sustainable Decision Framework will be a methodology and tools to “internalize” the cost/savings associated with changes in GHG emissions that would result from future capital investment decisions. This methodology will make it possible for Cornell to assure the costs associated with changes in GHG emissions resulting from a proposed capital investment are transparent and considered. It is anticipated that the methodology will be based, in part, on the emissions profile of marginal sources of electricity, steam, and chilled water; the forecasted market prices for GHG emission allowances; the forecasted prices for purchased energy incorporating carbon costs; and the actual cost for Cornell to abate incremental GHG emissions at the margin.
- c. **Purchased Energy Price Forecasts.** Cornell’s GHG emissions are primarily a result of combusting fossil fuels. Federal legislation will place the responsibility for mitigating GHG emissions at various points along the fossil fuel supply and consumption chain. For example, the point of regulation might be the refining industry for retail petroleum products, the local distribution company for retail natural gas, the local electric utility for purchased power; and Cornell for fuel consumed in its central combined heat and power plant. Accordingly, the methodology Cornell uses for purchased energy prices must consider the associated GHG emissions, federal climate change policy, points of regulation, and the forecasted market prices for carbon, i.e. GHG emission allowances.

It is worth noting that Cornell is far from alone in wrestling with how to incorporate the risks associated with climate change in their planning and financial disclosure. Seventy-nine percent of the S&P 500 respondents to the international Climate Disclosure Project reported risks from climate change. An increasing number of Energy Strategies U.S. clients are incorporating estimates of future GHG emissions subject to regulatory mandates and projected GHG emission allowance prices as a proxy for compliance costs into their long-term planning and capital investment decisions.

REGARDING: FINANCIAL EXPOSURE TO U.S. CLIMATE ACTION POLICY (REV 10 - 1_6_09)

Preparation of the CAP will entail further exploration of how best to incorporate the costs of climate change in Cornell's ongoing decisions. To the extent Cornell determines to integrate GHG costs into decisions prior to the completion of the CAP, the following should be considered:

- The use of the expected forecast for price allowances starting in 2015 doesn't reflect either the cost of GHG emissions prior to U.S. federal mandates or the uncertainty range with respect to future costs.
- The use of a levelized long-term cost imposes a cost premium on GHG in the early years incentivizing early action. However, the cost for decisions with short-lived consequences will likely be greater than the cost to achieve the same impact in the economy at large. In addition, a levelized cost may result in a discount on GHG costs in later years and underinvestment in long-term mitigation.
- The attribution of cost to GHG emissions before federal mandates recognizes that there is a social cost that is not internalized in the existing U.S. marketplace. However, any cost above that charged for abatement in the current "voluntary" market could result in an overpayment for the desired result.

1. A General Framework for Projected Greenhouse Gas Emissions³

Cornell University has completed its greenhouse gas (GHG) inventory for FYE 2008. Energy Strategies is working with Cornell to develop an updated forecast of GHG emissions in the absence of new initiatives to reduce emissions. Carbon dioxide equivalent (CO_{2e}) is the standard measure for greenhouse gas emissions, expressing the global warming potential (GWP) of various gases over 100 years in terms of carbon dioxide equivalents. Exhibit 1 provides an interim forecast of CO_{2e} emissions for two Cornell "Reference Cases":

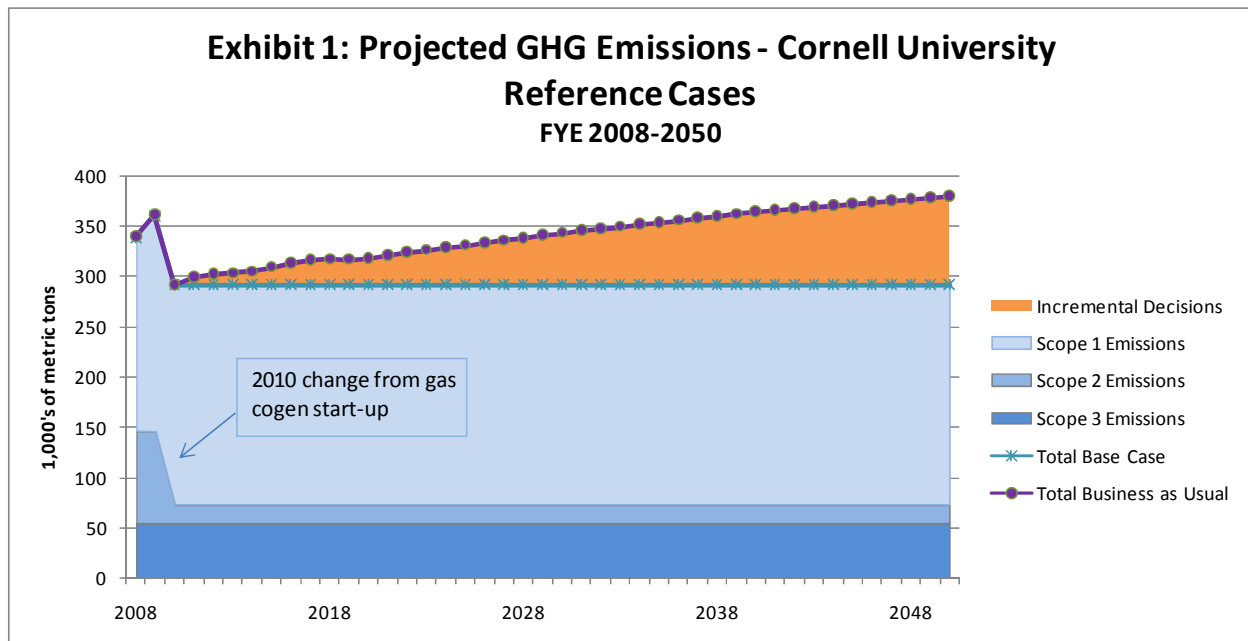
- 1) "Base Case" (blue area) that reflects only decisions already taken by the University, and
- 2) "Business-as-Usual Case" (blue plus orange areas) that includes net increases in emissions projected to occur under a business-as-usual (BAU) scenario as a result of future decisions ("incremental decisions", orange area).

Base Case emissions are divided into Scope 1, 2, and 3 categories which are used under The Climate Registry protocol adopted by the University. Scope 1 emissions arise primarily from the central utility plant. Scope 2 emissions are associated with electricity purchased from the local electric utility, NYSEG. Scope 3 emissions are from the combustion of fuel for commuting and

³ Note that emissions forecasts in this document do not reflect detailed, updated forecasts that are being prepared as part of the CAP process, and they do not include the potentially major impacts of high energy physics and computing projects that are under consideration.

REGARDING: FINANCIAL EXPOSURE TO U.S. CLIMATE ACTION POLICY (REV 10 - 1_6_09)

air travel. No effort is made in this analysis to attribute emissions from incremental decisions specifically to Scope 1, 2, or 3.



2. Increasing Likelihood of U.S. Climate Change Legislation

It is expected that federal climate change legislation will be enacted under the Obama administration. We can gain insight into what the legislation may require of emitters by looking at recent scientific analysis as well as proposed climate change legislation. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) reflects the views of hundreds of the world's top climate scientists. In the Fourth Assessment Report, the IPCC provides guidance on the level and timing of GHG abatement required to stabilize the climate at various levels. (See Exhibit 2 for a summary of IPCC climate stabilization scenarios.)

REGARDING: FINANCIAL EXPOSURE TO U.S. CLIMATE ACTION POLICY (REV 10 - 1_6_09)

Exhibit 2: IPCC Climate Stabilization Scenarios ¹						
IPCC Climate Stabilization Level Category	Concentration at Stabilization		Peaking Year for CO2 Emissions	Change in Global		
	CO ₂ ² (ppm)	CO ₂ - equivalent ³ (ppm)		CO2 Emissions in 2050 (% of 2000)	Average Temperature ⁴ (°C)	Average Sea Level Rise ⁵ (meters)
I	350 - 400	445 - 490	2000 - 2015	-85 to -50	2.0 - 2.4	0.4 - 1.4
II	400 - 440	490 - 535	2000 - 2020	-60 to -30	2.4 - 2.8	0.5 - 1.7
III	440 - 485	535 - 590	2010 - 2030	-30 to +5	2.8 - 3.2	0.6 - 1.9
IV	485 - 570	590 - 710	2020 - 2060	+10 to +60	3.2 - 4.0	0.6 - 2.4
V	570 - 660	710 - 855	2050 - 2080	+ 25 to + 85	4.0 - 4.9	0.8 - 2.9
VI	660 - 790	855 - 1130	2060 - 2090	+90 to +140	4.9 - 6.1	1.0 - 3.7

Notes to Exhibit 2

IPCC is the Intergovernmental Panel on Climate Change. Information is taken from the "Climate Change 2007: Synthesis Report", Table

1 5.1, page 67

2 2005 = 379 ppm

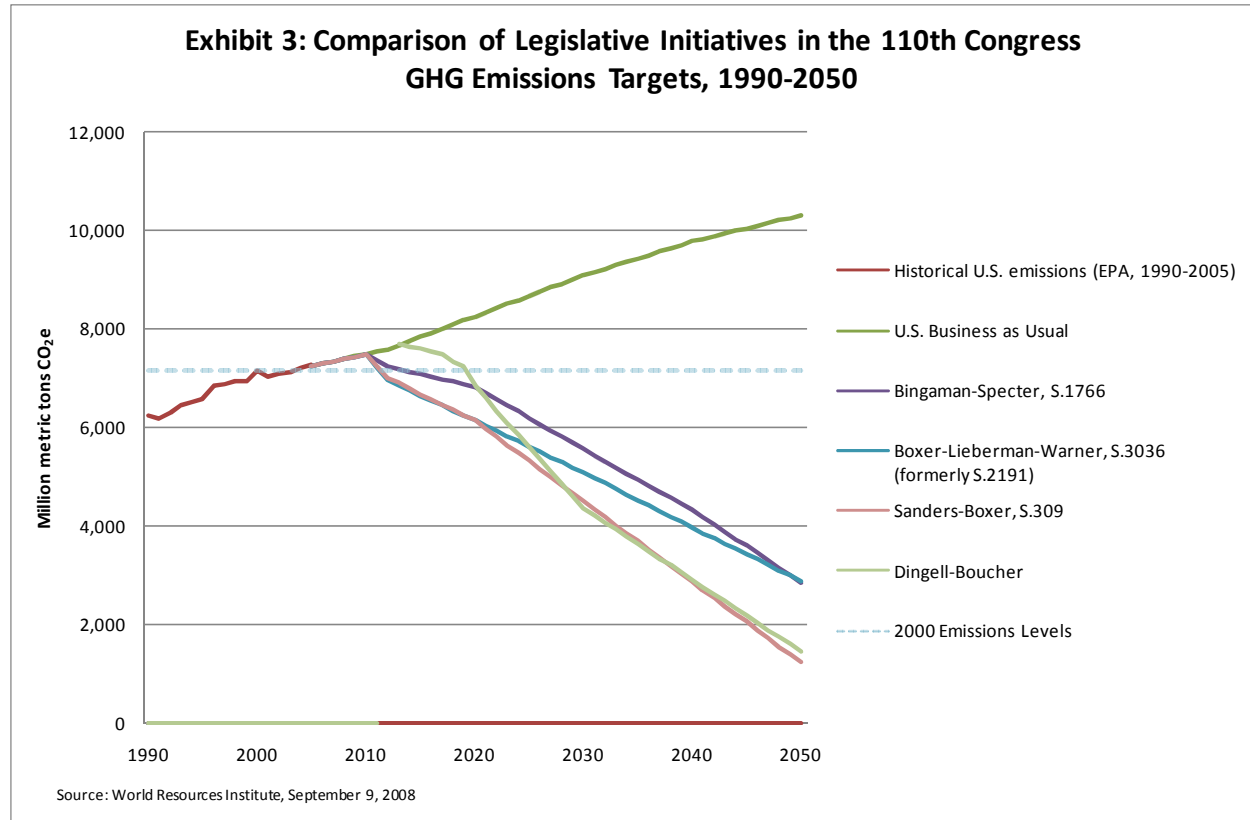
3 Includes greenhouse gases (GHGs) and aerosols; 2005 = 375 ppm

4 Above pre-industrial at equilibrium

5 Above pre-industrial at equilibrium from thermal expansion only

Legislative initiatives in the 110th Congress appear to generally conform to IPCC's Category I or II climate stabilization scenarios with respect to the year in which GHG emissions peak (i.e. by 2020) and Category I for the percent change in emissions in 2050 (i.e. a reduction of 50% to 80% below 2000 levels). There appears to be emerging consensus among scientists that climate stabilization policy should target ultimate concentrations of CO_{2e} at 445 to 490 ppm, IPCC Category I climate stabilization level. (Refer to Exhibit 3 for a graphic comparing GHG emission targets under key legislative initiatives in the 100th Congress. See Appendix A for a summary of proposed legislative terms.)

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3. The Sources of Cornell's Expected Financial Exposure Under Federal Legislation

Cornell's financial exposure to federal climate change legislation arises from the following:

- 1) The federal government will implement a cap and trade program under which covered entities will be required to buy rights (allowances) to emit. Over time the amount of allowances available will contract.
- 2) To have the intended effect, federal legislation must "cover" (i.e. impose restrictions) on the vast majority of GHG emissions economy-wide. Legislative initiatives have typically targeted coverage of 85% to 90% of all U.S. GHG emissions. In other words, it is unlikely that a significant portion of Cornell's emissions will somehow escape compliance mandates.
- 3) Cornell will not avoid the cost of GHG emissions abatement associated with its emissions regardless of where that abatement is imposed on the energy supply chain. The responsibility for reductions in Scope 1 emissions, i.e. from Cornell's central utility plant, will

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likely fall directly on the University. However, it will be the responsibility of the local electric utility, NYSEG, to reduce the carbon footprint attributed to the power it sells. But, Cornell and NYSEG's other customers will bear the cost of those reductions.

- 4) Entities such as Cornell and NYSEG that are held directly accountable for emission reductions will likely also be required to pay for a portion of the emissions that fall below their cap. Most proposed federal climate change legislation contemplates that a portion of an entity's emission allowances under the capped amount would need to be purchased through a market auction. Logically, Cornell will bear its share of such costs regardless of where they fall in the energy supply chain.

4. **Quantity of Cornell Emissions Subject to Abatement or Auction Costs (Compliance Costs)**

As a first step in quantifying Cornell's financial exposure to federal climate change legislation, we estimated the portion of the University's annual GHG emissions that will be subject to either abatement or auction costs. This calculation is not limited to costs incurred directly by Cornell, but encompasses the entire energy supply chain that Cornell accesses.

The portion of Cornell's emissions subject directly or indirectly to such costs will be a function of the terms of the federal legislation that is enacted. To assess a range of possible outcomes, Energy Strategies constructed three, simple, hypothetical climate change policy scenarios based on recent federal initiatives and the Fourth Assessment Report climate stabilization analysis. The three policy scenarios represent "stringent", "moderate", and "soft" approaches to reducing GHG emissions. For the purpose of this analysis, the important differences among policy scenarios relate to the rate at which GHG reduction is to occur, the targeted percent reduction by 2050, whether Cornell's central cogeneration plant is excluded, and the percentage of allocated allowances that must be purchased. Refer to Exhibit 4 for a summary of the hypothetical requirements under the three policy scenarios.

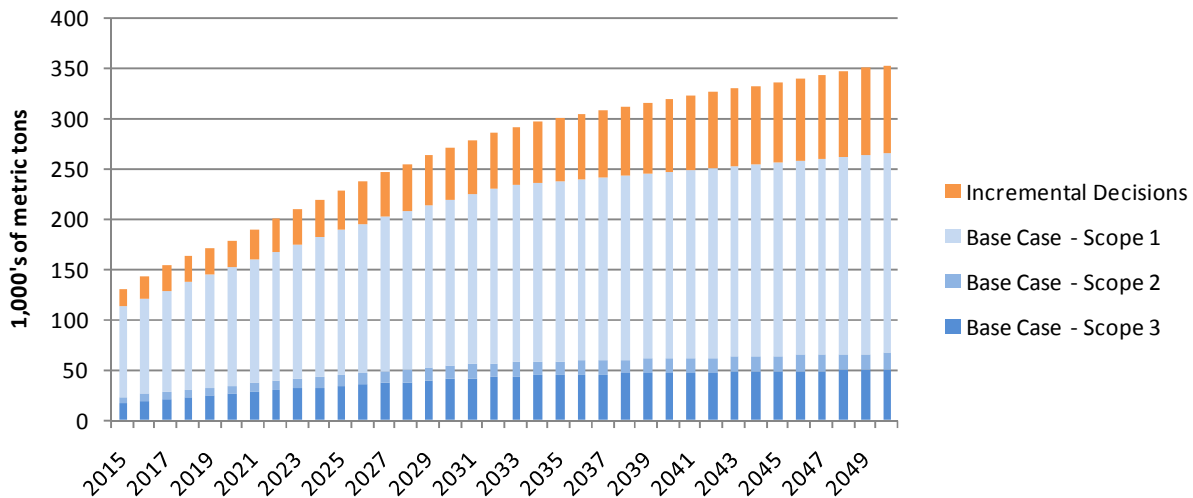
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Exhibit 4: Federal Climate Change Policy Scenarios						
Policy Scenario	Scope of Coverage	Cap (% below 2000 Levels)	Sectors Covered	Cornell Emissions Covered	Allocation (% Purchased)	Use of Offsets and Other Cost Controls
Energy Strategies "Stringent"	6 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, and SF ₆ Upstream for transport fuels & LDC natural gas; downstream for large coal users and large point sources	5% by 2015 15% by 2020 40% by 2030 80% by 2050	Economy-wide	Scope 1: direct at source Scopes 2,3: indirect through suppliers	Overall: 20% auction increasing to 60% Covered entity: 60% increasing to 100%	No safety valve U.S. offsets limited to 5% of compliance No Banking
Energy Strategies "Moderate"		1% by 2015 10% by 2020 30% by 2030 70% by 2050	Economy-wide	Scope 1: direct at source Scopes 2,3: indirect through suppliers	Overall: 15% auction increasing to 40% Covered entity: 30% increasing to 65%	No safety valve U.S. and international offsets limited to 10% of compliance Banking for 5 years
Energy Strategies "Soft"		1% by 2015 8% by 2020 20% by 2030 50% by 2050	Electric Power (Excluding Cogen), Transportation, & Manufacturing	Scope 1: excluded Scopes 2,3: indirect through suppliers	Overall: 10% auction Covered entity: 0% increasing to 30%	Safety valve in place U.S. and international offsets limited to 25% of compliance Unlimited banking

For each climate change policy scenario, Energy Strategies calculated the quantity of annual GHG emissions that would be subject to either an abatement cost or an auction cost. The amounts were estimated by Scope (1, 2, and 3) for the Base Case and for emissions resulting from incremental decisions as a group. Note, we have included Scope 3 commuting in the calculation although the costs would be incurred by faculty, staff, and students. Also, all emissions resulting from incremental decisions are assumed to be subject to an abatement cost in all policy scenarios. A sample of the resulting calculation of annual emissions subject to compliance cost is shown for the moderate policy scenario in Exhibit 5. See Appendix B for calculations of annual emissions subject to compliance cost for the stringent and soft policy scenarios.

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Exhibit 5: Emissions Subject to Compliance Cost Moderate Policy Scenario 2015-2050



5. Projected Financial Exposure

One way to quantify Cornell's financial exposure is to make the assumption that mandated emissions reductions at Cornell (generally for Scope 1) and along Cornell's energy supply chain (for Scopes 2 and 3) are achieved by purchasing GHG emission allowances or project-based offset credits. With respect to Scope 2 and 3 emissions, the costs incurred by the University's suppliers are assumed to be passed along in full to the University as part of the purchased energy (e.g., electricity, gasoline) or service (e.g. airline travel). In a mature emissions market⁴, the price of GHG emission allowances should reflect the current and future marginal cost of abatement in the economy at large. An estimate of the market-based emissions allowance price can also be applied to the annual quantity of allowances purchased at auction either directly by Cornell or on the University's behalf by entities in its energy supply chain. Under this approach, the net present value of the sum of the estimated annual allowance prices for mandated emission reductions and auction allowances costs is an estimate of total financial exposure.

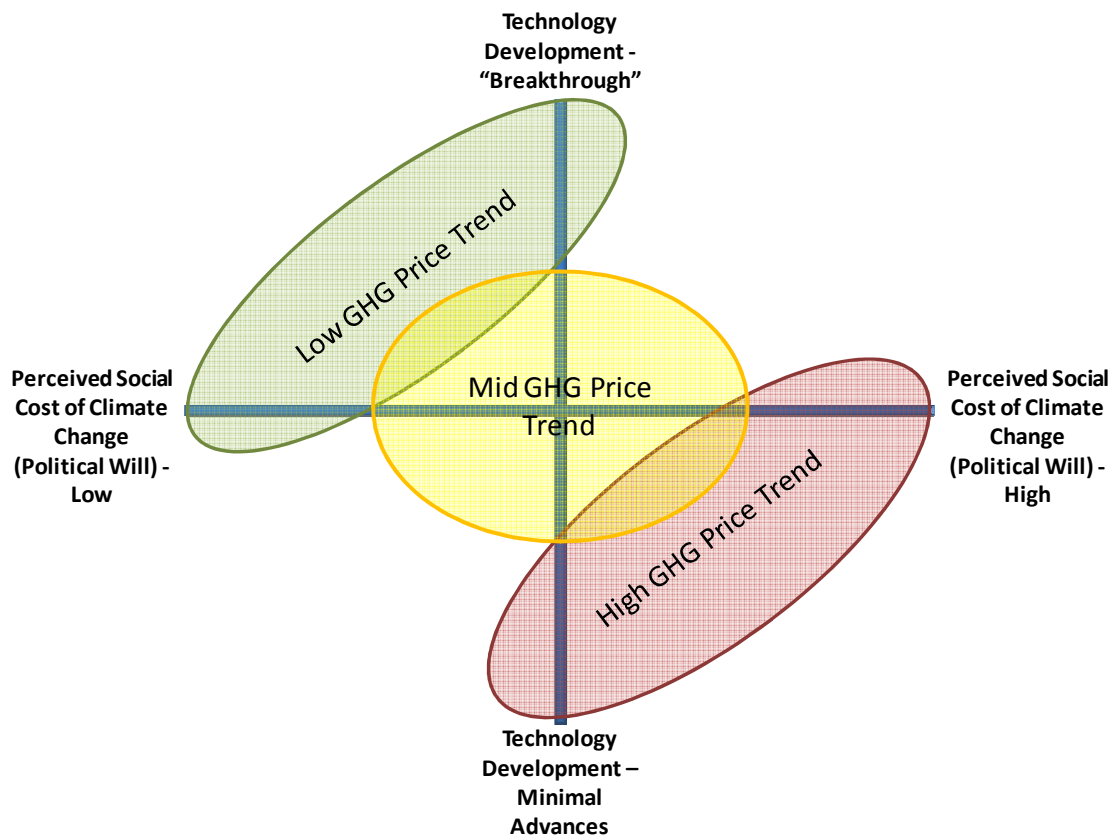
The trading of GHG emissions is in its infancy in the United States. However, a number of entities including the Environmental Protection Agency (EPA), the Nicholas Institute for

⁴ Like the market for SO₂ allowances.

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Environmental Policy Solutions at Duke University, and MIT have developed estimates for the market equilibrium cost of emission allowances under various legislative initiatives starting in 2015. In addition, in 2005 the European Union (EU) started the world's largest mandatory GHG emission allowance trading program. Drawing on the third party forecasts and EU market data, Energy Strategies has developed a preliminary "low trend", "mid-trend (unweighted)", mid-trend (weighted) and "high trend" forecast for the price of allowances in a future, U.S. cap-and-trade market. Exhibit 6 for a mapping of the future state of two key drivers (technological advance and perceived social cost) underlying Energy Strategies' GHG emission allowance price projections.

Exhibit 6: Key drivers of Energy Strategies' GHG emission allowance price projections



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In the foreground of Exhibit 7, the annual projected GHG emission allowance prices are shown for Energy Strategies low trend (P10), mid-trend (un-weighted or p50), mid-trend (weighted or expected value), and high trend (P90) forecasts. The Energy Strategies forecasts have been overlain on a selection of fifty-four third party forecasts which are shown as dotted lines in the background. Note, the Energy Strategies forecasts do not reflect a rigorous, statistical analysis of the third party forecasts.

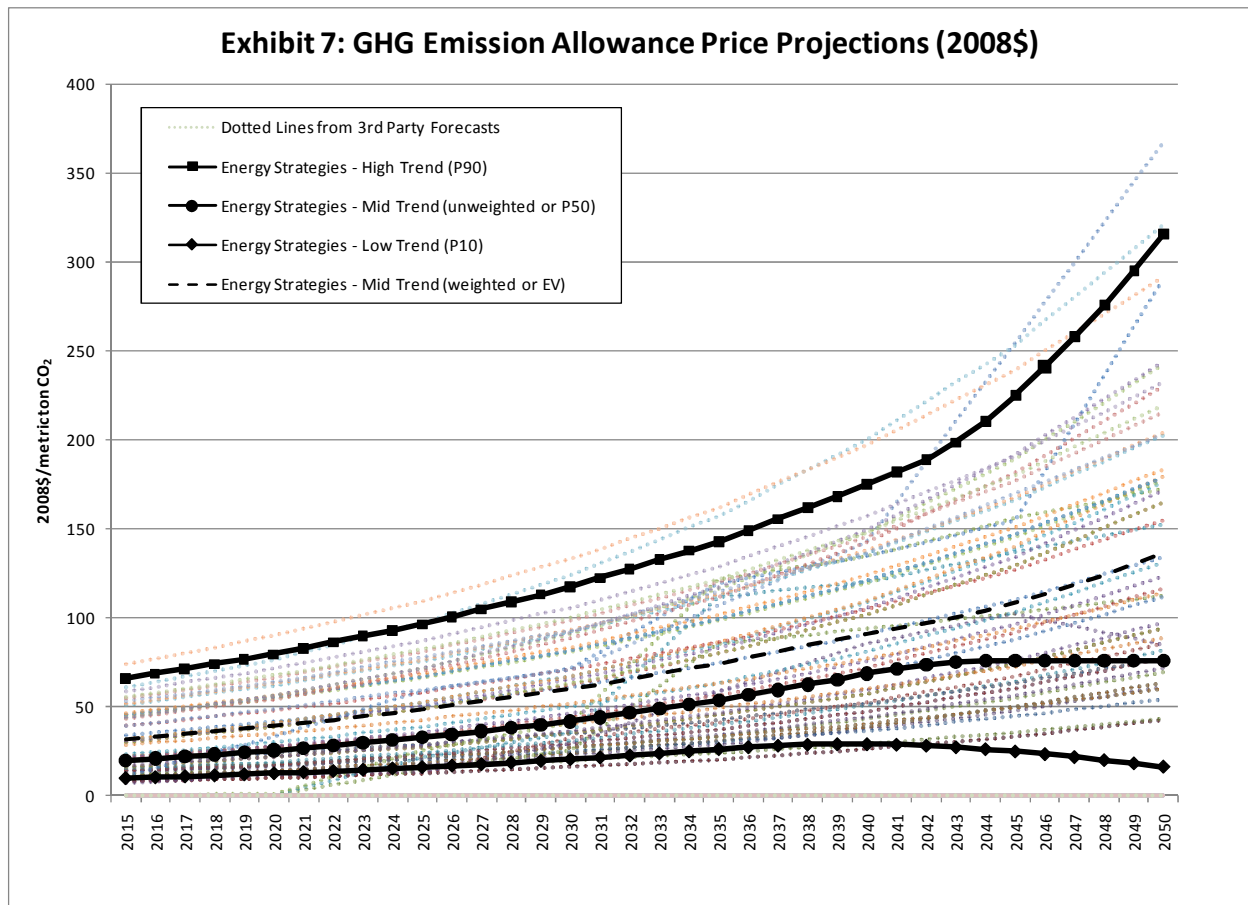
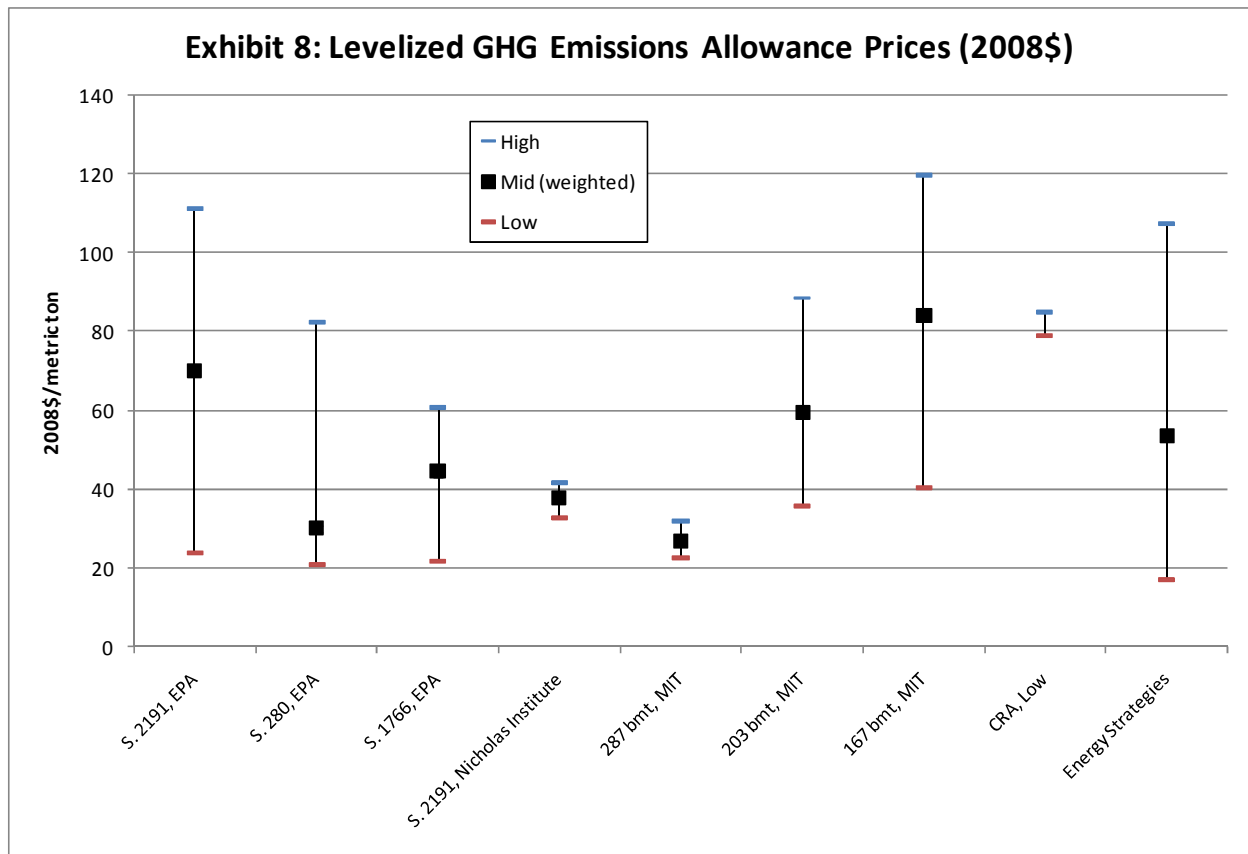


Exhibit 8 compares the range of levelized⁵ costs for the selected third party and Energy Strategies projections. It should be noted that the levelized cost of the Energy Strategies forecasts are closely aligned with the sample of third party forecasts. The levelized cost of low trend (P10) and if the high trend (P90) projections corresponds closely to the average levelized costs of the lowest and highest ten percent of the third party forecasts. About half the third

⁵ Levelized Cost - the present value of a stream of annual projected GHG emission allowance prices from 2015 through 2050, converted to a constant annual price that results in an equivalent present value. A discount rate of 5% was used.

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party forecasts have a levelized cost that is above the levelized cost of the mid-trend (un-weighted or P50) Energy Strategies forecast. However, Energy Strategies has shaped each of the forecasts over time to be consistent with the underlying vision for technology advancement and perceived social cost. This perhaps best illustrated by the low trend forecast where technological breakthroughs are assumed to actually lower the cost of abatement after 2040.

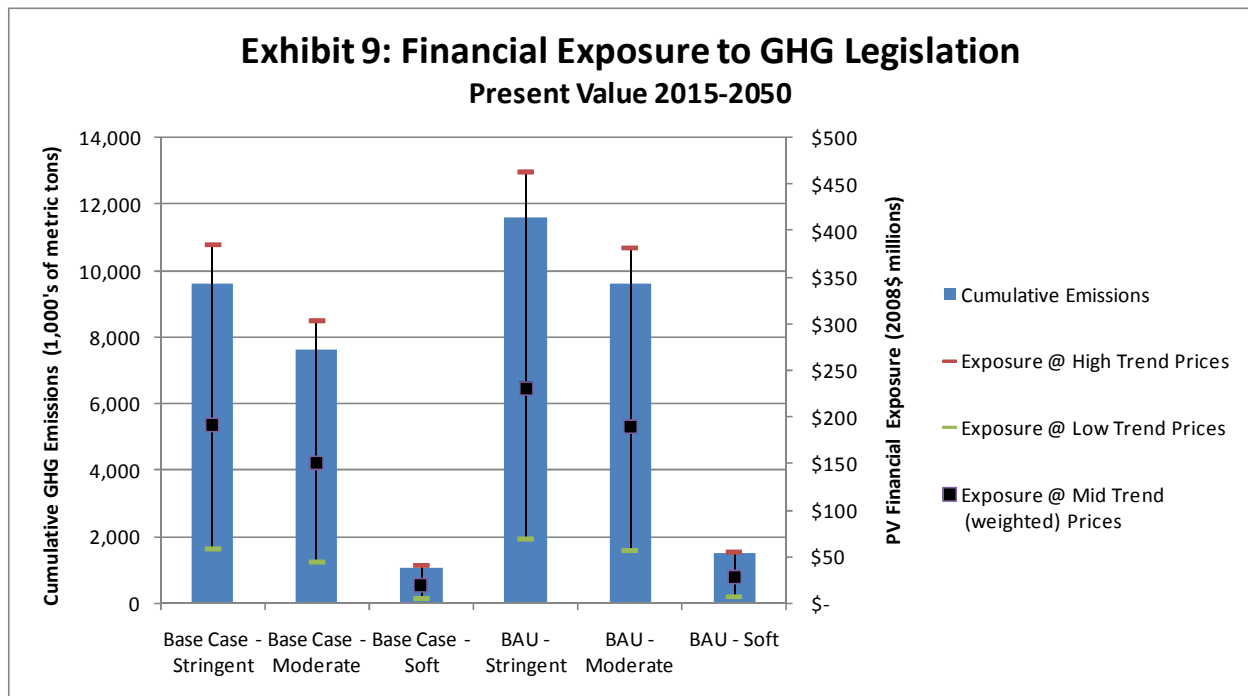


Refer to Appendix C for a summary of selected third party GHG emission allowance price forecasts. See Appendix D for a table containing the annual Energy Strategies GHG emission allowance price forecasts for 2015 through 2050.

Energy Strategies has applied each of the four allowance price forecasts to the estimate of the quantity of Cornell emissions subject to compliance cost under each of the three climate change policy scenarios to calculate the range of the University's financial exposure to climate change legislation. In Exhibit 9, the financial exposure is expressed as the net present value (NPV) of annual compliance costs for the both the Base Case and Business As Usual Case. For

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example, under moderate climate change policy and given decisions already made (Base Case), the NPV of compliance cost ranges from \$46 million to \$304 million with an expected value of about \$151 million. For the Base Case across all policy scenarios, the financial exposure to compliance cost ranges from a high of \$385 million (stringent policy, high trend allowance price) to a low of \$6 million (soft policy, low trend allowance price). Exhibit 9 also shows the cumulative quantity of GHG emissions that is subject to compliance cost.



6. Internalizing GHG Costs Before Federal Mandates

Federal mandates are expected to phase in starting as early as 2012 with a fully functioning cap-and-trade market for GHG emission allowances in effect by 2015. Cornell's financial exposure to GHG emission costs under federal mandates is estimated above. It is our opinion that federal climate legislation will likely result in Cornell incurring significant compliance costs. There is a remaining question as to what extent Cornell should choose to internalize GHG emission costs on a voluntary basis, i.e. above and beyond mandated compliance costs. This question is relevant both to the interim period before federal legislation, and thereafter. In this section, we provide information that may be useful in thinking about how to internalize GHG emission costs in the period before federal legislation is fully implemented.

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In signing the American College and University Presidents Climate Commitment (ACUPCC), President David J. Skorton affirmed Cornell University's belief in: 1) the scientific support for climate change, 2) climate change as an ethical issue, and 3) a significant and increasing "cost" to the global emission of GHG caused by humans.

"We, the undersigned presidents and chancellors of colleges and universities, are deeply concerned about the unprecedented scale and speed of global warming and its potential for large-scale, adverse health, social, economic and ecological effects. We recognize the scientific consensus that global warming is real and is largely being caused by humans."⁶

The ACUPCC provides guidance that the "internalization of at least some of the true costs of carbon emissions is an important consideration in taking a strategic approach to GHG neutrality, and a potentially effective driver for accelerating internal reductions."⁷ In the U.S., climate change is a classic case of a "negative economic externality", i.e. where costs imposed by an entity on others fall largely outside the cost structure of the entity. An entity emitting greenhouse gases into the atmosphere imposes costs on present and future generations while the emitter avoids the vast majority of the consequences of its actions. There are two general approaches to estimating the "true costs of carbon emissions": 1) costs to society and 2) the cost of abatement.

Most studies of the social costs of climate change to date have estimated resulting reductions in an economy's Gross Domestic Product (GDP). Conservative estimates seem to place the social cost at between 0% and 3% of annual global GDP so long as temperature increases are limited to 2-3°C. However, in the absence of significant change in human behavior, temperatures are expected to increase by more than 3°C and social costs of climate change will be accelerated and more severe. Some analysis concludes that a 5-6°C warming would result in a 5-10% loss in global GDP with costs born disproportionately by poorer countries. Energy Strategies has not identified a well documented, third party estimate of social costs expressed in annual costs per metric ton⁸.

With respect to the cost of abatement, it was stated above that the price of GHG emission allowances in a mature emissions market should reflect the marginal cost of abatement in the

⁶ American College and University Presidents Climate Commitment, 1st paragraph.

⁷ "Investing in Carbon Offsets: Guidelines for ACUPCC Institutions", Revised August 2008, American College and University Presidents Climate Commitment, page 9

⁸ As an example of a third party estimate, in February 2007, Lehman Brothers estimated social costs assuming 2-5°C warming to rise from "perhaps \$20 per tonne today to over \$80 by 2050." Detailed support for the estimate was not provided in the documentation.

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economy at large. There is not currently a transparent, liquid market for GHG credits in the U.S. that reflects legislative mandates for long-term climate stabilization. However, there are “voluntary” markets. The most visible public voluntary market is the Chicago Climate Exchange. The Chicago Climate Exchange (CCX) describes itself as follows:

“launched in 2003, (CCX) is the world’s first and North America’s only active voluntary, legally binding integrated trading system to reduce emissions of all six major greenhouse gases (GHGs), with offset projects worldwide. CCX emitting Members make a voluntary but legally binding commitment to meet annual GHG emission reduction targets. Those who reduce below the targets have surplus allowances to sell or bank; those who emit above the targets comply by purchasing CCX Carbon Financial Instrument® (CFI®) contracts.”⁹

Apart from the CCX trading system, there are a number of privately brokered transactions in the voluntary marketplace. The privately brokered transactions typically are structured to comply with various quality standards for verified emission reductions (VERs). Quality standards include CCX, the California Climate Action Registry (CCAR), the Voluntary Carbon Standard (VCS), and the Gold Standard (listed in general ascending order of stringency). A representative recent request for proposals involving high quality, privately brokered VERs reflected pricing starting at about \$5.50 in 2008 rising to about \$7.20 in 2013 (expressed in constant 2008 dollars).

In addition to the voluntary U.S. marketplace, the Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort by New York and nine other Northeast and Mid-Atlantic states to limit greenhouse gas emissions. RGGI is the first mandatory, market-based CO₂ emissions reduction program in the United States. RGGI participating states are using a market-based cap-and-trade approach that establishes a multi-state CO₂ emissions budget (cap) for the electricity sector that will decrease gradually until it is 10 percent lower in 2018 than at the start. RGGI held its first auction of emission allowances in September 2008 with a resulting clearing price of \$3.07 per metric ton of CO₂e. Allowances may be banked indefinitely. RGGI allows covered entities to employ offsets (qualified greenhouse gas emissions reduction or sequestration projects at sources beyond the electricity sector) to help meet compliance obligations.

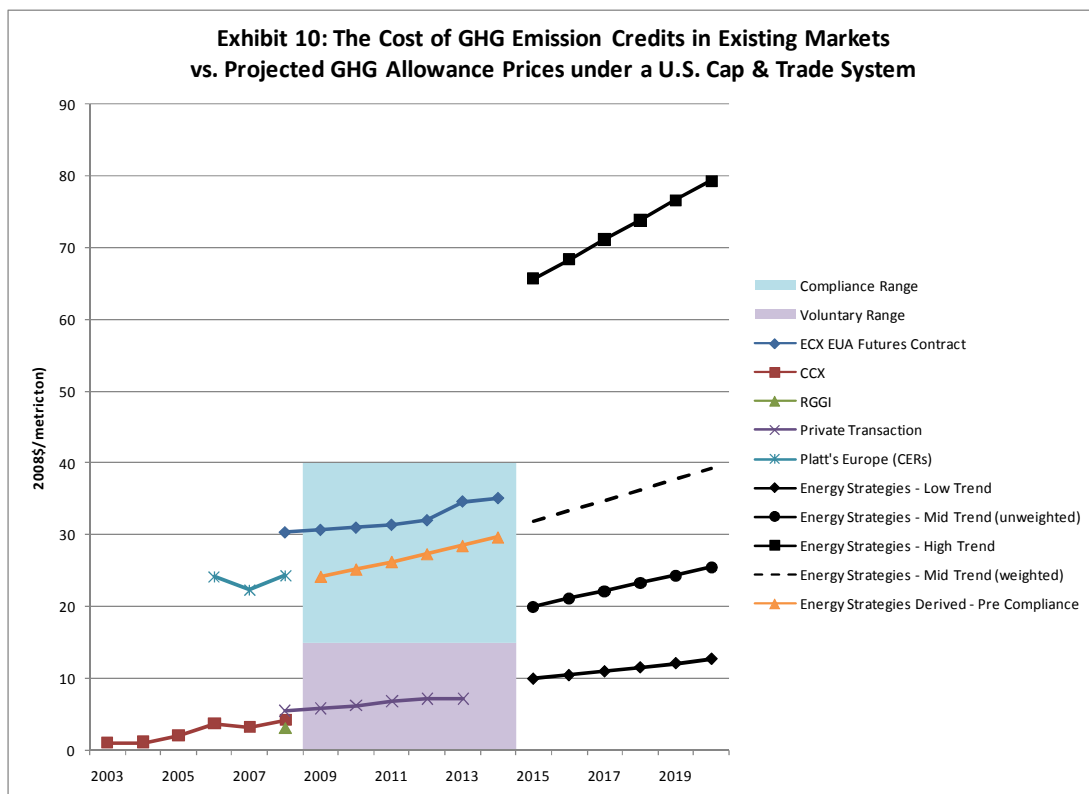
Outside the U.S., there are relatively transparent, efficient markets for GHG credits that typically reflect the requirements of the Kyoto Protocol to the United Nations Framework on Climate Change. Perhaps the most noteworthy is the European Climate Exchange (ECX). ECX “manages the marketing and product development for ECX Carbon Financial Instruments (ECX

⁹ Source: CCX website.

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CFIs), listed and admitted to trading on the ICE Futures Europe's electronic platform. ECX / ICE Futures Europe is the most liquid platform for carbon emissions trading, attracting over 85% of the exchange-traded volume in the European carbon market. ECX Emissions Contracts include standardized futures and options based on EU Allowances (EUAs) and Certified Emission Reductions (CERs).¹⁰ Since 2005, European CERs have typically traded in the range of \$20-\$25 per metric ton. ECX EUA futures contracts recently traded in the range \$30 per metric ton for the near term, rising to almost \$35 per metric ton for 2014 (expressed in constant 2008 dollars).

Exhibit 10 plots costs experienced in the existing voluntary and compliance markets discussed above along with Energy Strategies forecasts of GHG emission allowance prices once a U.S. cap and trade system is in place, i.e. starting in 2015. To provide further context, Energy Strategies mid trend (weighted) forecast has been extended backward in time to cover the period before compliance mandates, i.e. 2009 through 2014.



¹⁰ ECX website.

APPENDIX A

Appendix A: Cap-and-Trade Proposals in the 110th Congress as of October 20, 2008						
Policy Scenario	Scope of Coverage	Cap	Sectors Covered	Allocation	Offsets and Other Cost Controls	Early Action
Boxer-Lieberman-Warner S. 3036 - Substitute amendment to S. 2191 considered by full Senate in June 2008 Lieberman-Warner Climate Security Act of 2008	6 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, and SF ₆ Upstream for transport fuels & natural gas; downstream for large coal users and GHG manufacturers; separate HFC cap	4% below 2005 level in 2012 19% below 2005 level in 2020 71% below 2005 level in 2050	Economy-wide	Sector allowances total 75.5% in 2012, including: 18% to power plants and 11% to manufacturers (transitions to zero in 2031); 12.75% to electricity and natural gas local distribution companies for consumers, 15% to states, etc. Increasing auction: 24.5% in 2012 rising to 58.75% from 2032- 2050 4.25% set-aside for domestic agriculture and forestry	30% limit on supply of domestic and international offsets, with additional limits on each category Creates cost-containment auction using future year allowances Borrowing up to 15% per company Creates Carbon Market Efficiency Board to monitor trading and implement specific cost relief measures, including increased borrowing and expanded offsets	5% of allowances reserved for early actors starting in 2012 with all value distributed within 4 years of enactment
Lieberman-Warner S. 2191 Climate Security Act of 2008	6 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, and SF ₆ Upstream for transport fuels & natural gas; downstream for large coal users and GHG manufacturers	2005 level in 2012 1990 level in 2020 65% below 1990 level in 2050 ; 1.8%/year reduction from 2012 to 2050	Economy-wide	Sector allowances total 75.5% in 2012, including: 19% to power plants and 20% to manufacturers (transitions to zero in 2031); 11% to electricity and natural gas local distribution companies for consumers, 11% to states, etc. Increasing auction: 21.5% in 2012 rising to 69.5% by 2031 then held constant. 5% set-aside for domestic agriculture and forestry	Offset credits from surplus offset allowances in U.S. to satisfy up to 15% of compliance obligation International offset credits if meeting EPA eligibility criteria may satisfy up to 15% of compliance obligations Carbon Market Efficiency Board may increase the 15% limit on use of banked or offset credits if market price of credits exceeds a CBO benchmark price. Board is further authorized after review of program performance to lengthen payback period and lower interest rate; and loosen national cap provided no increase in total program emissions	5% (declines to 1%; ends in 2016; granted reductions back to 1994) of allowances reserved for early actors starting in 2012
Bingaman-Specter S. 1766 – 7/11/2007 Low Carbon Economy Act	6 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, and SF ₆ Upstream for natural gas & petroleum; downstream for coal	Start at 2012 level in 2012 2006 level in 2020 1990 level in 2030 President may set long-term target ≥60% below 2006 level by 2050 contingent upon international effort	Economy-wide	Some sector allocations are specified including: 9% to states, 53% to industry declining 2%/year starting in 2017 Increasing auction: 24% from 2012-2017, rising to 53% in 2030 5% set-aside of allowances for agricultural	Provides certain initial categories including bio sequestration and industrial offsets President may implement use of international offsets subject to 10% limit \$12/ton CO ₂ e “technology accelerator payment” (i.e., safety valve) starting in 2012 and increasing 5%/year above inflation	From 2012-2020, 1% of allowances allocated to those registering GHG reductions prior to enactment

APPENDIX A CONTINUED

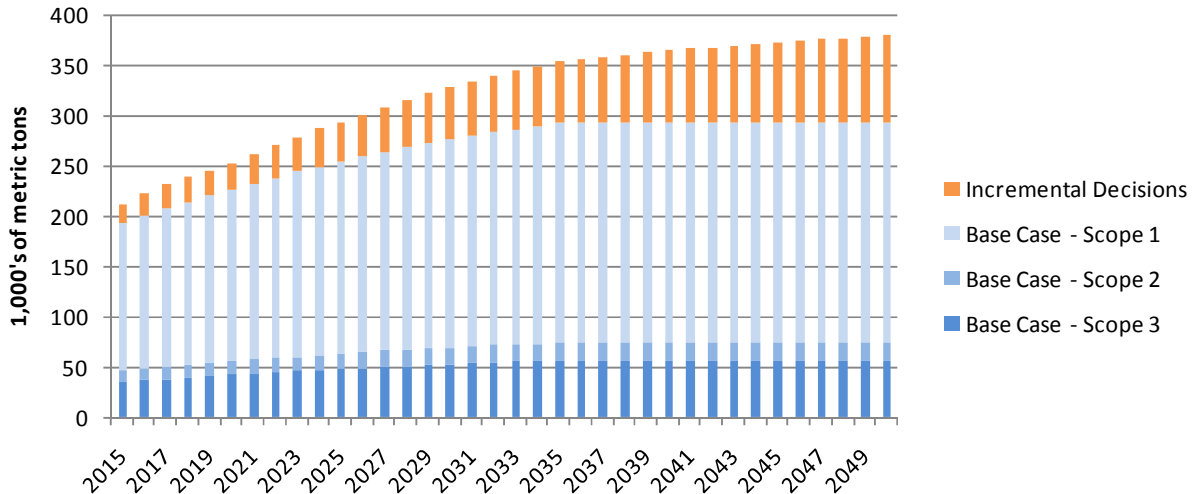
Appendix A: Cap-and-Trade Proposals in the 110th Congress as of October 20, 2008						
Policy Scenario	Scope of Coverage	Cap	Sectors Covered	Allocation	Offsets and Other Cost Controls	Early Action
Sanders-Boxer S.309 – 1/16/2007 Global Warming Pollution Reduction Act	6 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, and SF ₆ Point of regulation not specified	Start at 2010 level in 2010; 2%/year reduction from 2010-2020 1990 level in 2020 27% below 1990 level in 2030 53% below 1990 level in 2040 80% below 1990 level in 2050	Economy-wide	Cap and trade permitted but not required. Allocation criteria include transition assistance and consumer impacts	Includes provision for offsets generated from biological sequestration “Technology-indexed stop price” freezes cap if prices high relative to tech options	Program may recognize early reductions made under state or local laws
McCain-Lieberman S.280 – 1/12/2007 Climate Stewardship and Innovation Act	6 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, and SF ₆ Upstream for transportation sector; downstream for electric utilities & large sources	2004 level in 2012 1990 level in 2020 20% below 1990 level in 2030 60% below 1990 level in 2050	Economy-wide	Administrator determines allocation/auction split; considering consumer impact, competitiveness, etc.	30% limit on use of international credits and domestic reduction or sequestration offsets Borrowing for 5-year periods with interest	Credit for reductions before 2012 Early actors may use offsets to meet 40% of reductions
Dingell-Boucher Discussion Draft- 10/7/2008	7 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆ , and NF ₃ Upstream for transport fuels & natural gas; downstream for electric utilities & large sources	6% below 2005 level in 2020 44% below 2005 level in 2030 80% below 2005 level in 2050	Economy-wide	Four allowance value distribution options: 1) most value to covered entities, 2) less value to covered entities and more value to complementary GHG reduction initiatives than first option, 3) some value to adaptation, and 4) most value to consumer rebates and no value to covered entities or adaptation. All options include 100% auction by 2026	Increasing use of offsets (includes domestic and international): 5% initially reaching 35% by 2024 Cost-containment auction using future year reserve allowances Borrowing up to 15% per company with interest Creates carbon market oversight entity within FERC	3% of allowances for early actors in 2012 and transitioning to zero in 2026
Doggett H.R. 6316 – 6/19/2008 Climate Market, Auction, Trust & Trade Emissions Reduction System Act of 2008 (Climate Matters Act of 2008)	6 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆ Upstream for transport fuels & natural gas; downstream for large sources and large coal users	Start at 2012 level in 2012 1990 level in 2020 80% below 1990 level in 2050		5% of allowances to power plants and 10% to energy-intensive manufacturers in 2012 (transitions to zero in 2020) 85% of auction revenues directed to Citizen Protection Trust fund for consumer assistance, adaptation, technology, early action, etc.	Overall limit of 25% on use of offsets with further limit on types: 10% domestic offsets; 15% international emission allowances; and 15% international forest allowances Creates Carbon Market Efficiency Board to monitor market and implement cost relief including increased borrowing and offsets	1% of Citizen Protection Trust Fund for early action in 2012, phasing to zero in 2015

APPENDIX A CONTINUED

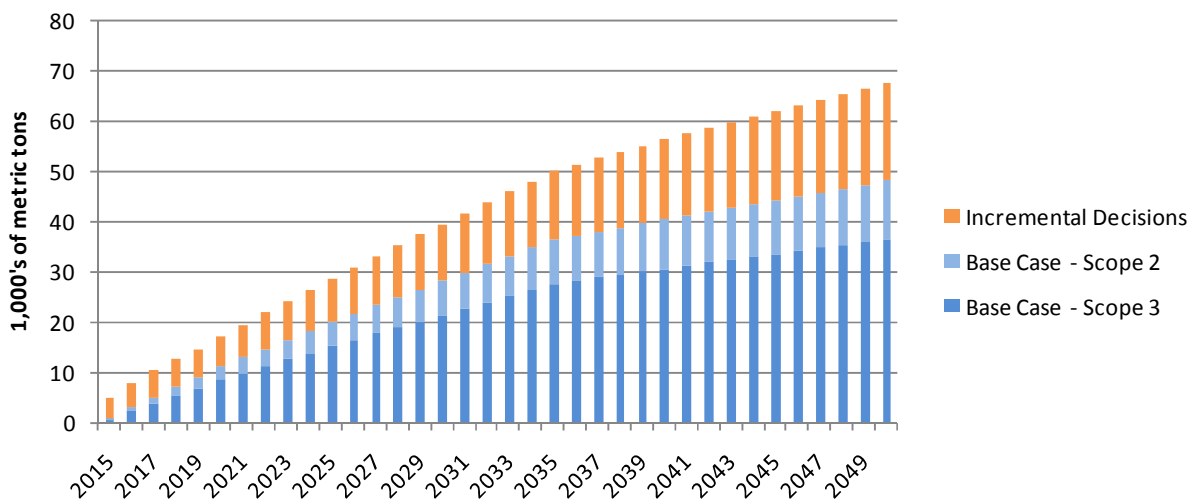
Appendix A: Cap-and-Trade Proposals in the 110th Congress as of October 20, 2008						
Policy Scenario	Scope of Coverage	Cap	Sectors Covered	Allocation	Offsets and Other Cost Controls	Early Action
Markey H.R. 6186 – 6/4/2008 Investing in Climate Action and Protection Act (iCAP Act)	7 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆ , and NF ₃ Upstream for transport fuels, downstream for electric utilities and large sources, natural gas at LDCs	2005 level in 2012 20% below 2005 levels in 2020 85% below 2005 levels in 2050	Economy-wide	6% of allowances to manufacturers from 2012-2020 Increasing auction: 94% from 2012-2019 rising to 100% from 2020-2050 Over 50% of auction proceeds used for tax credits/rebates to households for increases in energy costs	15% limit on use of domestic offsets 15% limit on use of international emission allowances or offset credits Creates carbon market oversight and enforcement office within FERC to monitor the market for allowances, derivatives, and offset credits Borrowing for 5-year periods with 10% interest costs	Program seeks not to penalize states and early reductions in distributing energy efficiency funds
Waxman H.R.1590 – 3/20/2007 Safe Climate Act of 2007	6 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, and SF ₆ Point of regulation not specified	2009 level in 2010; 2%/year reduction 2011-2020 1990 levels in 2020; 5%/year reduction 2020-2029 5%/year reduction from 2030-2050 80% below 1990 in 2050		Determined by the President; requires unspecified amount of allowances to be auctioned	Not specified	Goal to “recognize and reward early reductions”
Olver-Gilchrest H.R. 620 – 1/22/2007 Climate Stewardship Act	6 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, and SF ₆ Upstream for transportation sector; downstream for electric utilities & large sources	2004 level in 2012 1990 level in 2020 22% below 1990 level in 2030 70% below 1990 levels in 2050		Administrator determines allocation/auction split; considering consumer impact, competitiveness, etc.	15% limit on use of international credits and domestic reduction or sequestration offsets Borrowing for 5-year periods with interest	Credit for reductions before 2012; early actors may use offsets to meet 35% of reductions

APPENDIX B

Emissions Subject to Compliance Cost Stringent Policy Scenario 2015-2050



Emissions Subject to Compliance Cost Soft Policy Scenario 2015-2050



APPENDIX C

Summary of selected third party GHG emission allowance price forecasts (2008 \$/tCO₂e)

	Source	Bill#	Scenario Description	Levelized Cost	2015	2020	2025	2030	2035	2040	2045	2050
1	MIT		Safety Valve: US and Rest of World Pursue Mitigation (SV USA+ROW)	\$14.56	7.77	9.92	12.66	16.15	20.62	26.31	33.58	42.86
2	MIT		Safety Valve: US Only Pursues Mitigation (SV USA only)	\$14.56	7.77	9.92	12.66	16.15	20.62	26.31	33.58	42.86
3	MIT	287	287 bmt US Only	\$17.96	11.05	13.44	16.36	19.90	24.21	29.46	35.84	43.60
4	EPA	280	S. 280 Scenario Allowing Unlimited Offsets, IGEM	\$20.71	11.06	14.38	17.70	23.23	28.76	37.61	47.57	60.84
5	EPA	1766	S. 1766, Unlimited Int'l Offsets, IGEM	\$21.47	11.06	14.38	18.80	24.34	30.97	38.72	49.78	63.05
6	EPA	1766	S. 1766, No TAP - Unlimited Int'l Offsets, IGEM	\$21.47	11.06	14.38	18.80	24.34	30.97	38.72	49.78	63.05
7	MIT	287	287 bmt US + DEV	\$22.31	13.72	16.70	20.31	24.72	30.07	36.58	44.51	54.15
8	MIT		Safety Valve: Safety Valve Price Revised in 2030, US and Rest of World Pursue Mitigation (SV Double)	\$22.60	7.77	9.92	12.66	32.29	41.22	52.60	67.14	85.69
9	EPA	2191	S. 2191 w/ Unlimited Offsets, IGEM	\$23.84	12.17	16.59	21.02	26.55	33.18	43.14	55.31	69.69
10	EPA	1766	S. 1766, ADAGE	\$24.48	13.27	16.59	21.02	27.65	34.29	44.25	56.41	71.90
11	MIT	287	Nuclear Expansion: 287 bmt (287 bmt Nuclear)	\$24.63	15.15	18.43	22.42	27.28	33.19	40.39	49.14	59.78
12	MIT	287	287 bmt SEC	\$24.63	15.15	18.43	22.42	27.28	33.19	40.39	49.14	59.78
13	EPA	280	S.280 Senate Scenario, ADAGE	\$26.51	14.38	17.70	23.23	29.87	37.61	47.57	60.84	77.43
14	EPA	280	S. 280 Scenario with Low International Actions, ADAGE	\$26.51	14.38	17.70	23.23	29.87	37.61	47.57	60.84	77.43
15	MIT	287	287 bmt NO BANKING (287 bmt TR)	\$26.75	0.01	0.14	14.48	25.55	85.62	93.74	102.82	112.48
16	MIT	287	287 bmt NB	\$27.84	6.95	11.57	13.37	29.01	58.73	85.51	102.54	84.81
17	EPA	280	S. 280 Scenario with Lower Nuclear Power Generation, ADAGE	\$28.03	15.49	18.80	24.34	30.97	39.82	50.88	64.16	81.86
18	MIT	287	287 bmt Nobio TR	\$31.76	19.53	23.77	28.91	35.18	42.80	52.07	63.36	77.08
19	MIT	287	287 bmt	\$31.87	19.60	23.85	29.02	35.31	42.96	52.26	63.59	77.36
20	EPA	280	S.280 Senate Scenario, IGEM	\$31.94	16.59	22.12	27.65	35.40	45.35	57.52	74.11	94.02
21	EPA	280	S. 280 Scenario with Low International Actions, IGEM	\$31.94	16.59	22.12	27.65	35.40	45.35	57.52	74.11	94.02
22	Nicholas	2191	Lieberman-Warner Residential-Commercial Scenario, ADAGE	\$32.77	17.37	22.23	28.43	36.39	46.57	59.40	75.88	96.90
23	MIT	203	203 bmt NO BANKING (287 bmt TR)	\$35.75	0.02	0.38	21.45	35.31	111.62	120.03	136.74	152.28
24	MIT	203	203 bmt US Only	\$36.51	22.46	27.32	33.24	40.44	49.21	59.87	72.84	88.62
25	Nicholas	2191	Lieberman-Warner Core Scenario, ADAGE	\$37.69	20.02	25.55	32.74	41.81	53.54	68.36	87.28	111.39
26	EPA	280	S. 280 Scenario with No Carbon, Capture & Storage Technology, ADAGE	\$39.84	21.02	27.65	34.29	44.25	56.41	71.90	91.81	116.15
27	MIT	167	167 bmt NO BANKING (287 bmt TR)	\$40.29	0.03	0.79	25.30	40.41	121.39	134.23	155.72	172.15
28	Nicholas	2191	Lieberman-Warner Tighter Cap Scenario, ADAGE	\$41.60	22.12	28.21	36.06	46.24	59.07	75.44	96.35	122.89
29	EPA	1766	S. 1766, No TAP - 10% Int'l Offsets, IGEM	\$44.36	23.23	29.87	38.72	49.78	63.05	80.75	102.87	130.53
30	MIT	203	203 bmt US + DEV	\$46.94	28.87	35.13	42.74	52.00	63.26	76.97	93.65	113.93
31	MIT	203	203 bmt SEC	\$55.05	33.86	41.20	50.13	60.99	74.20	90.27	109.83	133.63
32	EPA	2191	S. 2191 w/ Low International Action, ADAGE	\$56.20	29.87	38.72	48.67	61.95	79.64	101.77	129.42	164.82
33	EPA	1766	S. 1766, No Technology Accelerator Payment (TAP), ADAGE	\$56.34	29.87	38.72	48.67	63.05	79.64	101.77	129.42	164.82
34	EPA	1766	S. 1766, No TAP - No CCS Subsidy, ADAGE	\$58.40	30.97	39.82	50.88	65.26	82.96	105.09	133.85	171.46
35	EPA	2191	S. 2191, ADAGE	\$60.32	32.08	40.93	53.10	67.48	85.17	108.40	138.27	175.88
36	EPA	1766	S. 1766, No Technology Accelerator Payment (TAP), IGEM	\$60.66	32.08	40.93	53.10	67.48	86.28	109.51	140.48	179.20
37	MIT	203	203 bmt NB	\$63.55	11.12	33.58	58.90	71.34	119.38	134.38	154.41	289.54
38	MIT		Quadratic Path: 50% Below 1990 Levels (230 bmt)	\$63.75	39.21	47.70	58.04	70.61	85.91	104.53	127.17	154.73
39	MIT	203	Nuclear Expansion: 203 bmt (203 bmt Nuclear)	\$73.02	44.91	54.64	66.48	80.89	98.41	119.73	145.67	177.23
40	MIT	167	167 bmt SEC	\$73.60	45.27	55.08	67.01	81.53	99.19	120.68	146.83	178.64

APPENDIX C CONTINUED

Summary of selected third party GHG emission allowance price forecasts (2008 \$/tCO₂e)

	Source	Bill#	Scenario Description	Levelized Cost	2015	2020	2025	2030	2035	2040	2045	2050
41	MIT	203	203 bmt	\$73.60	45.27	55.08	67.01	81.53	99.19	120.68	146.83	178.64
42	MIT		Quadratic Path: 80% Below 1990 Levels (206 bmt)	\$75.34	46.34	56.38	68.59	83.45	101.53	123.53	150.30	182.86
43	CRA	Low	No Banking	\$78.99	39.59	48.97	59.91	70.85	106.80	142.74	254.75	366.76
44	EPA	2191	S. 2191 w/ Constrained Nuclear and Biomass, ADAGE	\$79.50	43.14	54.20	69.69	88.49	111.72	142.70	181.41	230.08
45	EPA	280	S. 280 Scenario with No Offsets, IGEM	\$82.35	44.25	56.41	71.90	90.71	116.15	148.23	189.15	242.25
46	EPA	2191	S. 2191, IGEM	\$82.79	44.25	56.41	71.90	91.81	117.25	149.33	191.37	243.36
47	MIT	167	167 bmt US Only	\$83.45	51.33	62.45	75.98	92.44	112.47	136.84	166.48	202.55
48	MIT	167	167 bmt US + DEV	\$84.03	51.69	62.88	76.51	93.08	113.25	137.79	167.64	203.96
49	CRA	High	Banking	\$84.88	53.14	63.56	78.14	92.73	114.61	136.49	169.83	203.17
50	MIT	203	203 bmt Nobio TR	\$88.66	54.54	66.35	80.73	98.22	119.50	145.39	176.89	215.21
51	MIT	167	Nuclear Expansion: 167 bmt (167 bmt Nuclear)	\$90.40	55.61	67.65	82.31	100.14	121.84	148.24	180.35	219.43
52	MIT	167	167 bmt	\$95.62	58.81	71.56	87.06	105.92	128.87	156.79	190.76	232.09
53	EPA	2191	S. 2191 w/ Constrained Nuclear, Biomass and CCS, ADAGE	\$111.49	60.84	76.33	97.34	123.89	157.08	200.22	253.31	320.79
54	MIT	167	167 bmt Nobio TR	\$119.96	73.79	89.77	109.22	132.88	161.67	196.70	239.32	291.17

APPENDIX D

GHG Emission Allowance Price Forecasts (2008\$/metric ton CO ₂)				
	Energy Strategies - Mid Trend (weighted)	Energy Strategies - Low Trend	Energy Strategies - Mid Trend (unweighted)	Energy Strategies - High Trend
Levelized Cost	\$53.67	\$16.85	\$36.52	\$107.62
Year				
2015	\$31.91	\$10.00	\$20.02	\$65.72
2016	\$33.36	\$10.50	\$21.13	\$68.44
2017	\$34.81	\$11.03	\$22.23	\$71.16
2018	\$36.27	\$11.58	\$23.34	\$73.89
2019	\$37.74	\$12.16	\$24.45	\$76.61
2020	\$39.22	\$12.76	\$25.55	\$79.33
2021	\$41.04	\$13.40	\$26.99	\$82.73
2022	\$42.88	\$14.07	\$28.43	\$86.13
2023	\$44.72	\$14.77	\$29.87	\$89.53
2024	\$46.58	\$15.51	\$31.30	\$92.93
2025	\$48.45	\$16.29	\$32.74	\$96.33
2026	\$50.72	\$17.10	\$34.56	\$100.51
2027	\$53.00	\$17.96	\$36.37	\$104.68
2028	\$55.30	\$18.86	\$38.18	\$108.86
2029	\$57.61	\$19.80	\$40.00	\$113.04
2030	\$59.94	\$20.79	\$41.81	\$117.21
2031	\$62.77	\$21.83	\$44.16	\$122.33
2032	\$65.62	\$22.92	\$46.50	\$127.44
2033	\$68.49	\$24.07	\$48.85	\$132.56
2034	\$71.38	\$25.27	\$51.19	\$137.68
2035	\$74.29	\$26.53	\$53.54	\$142.79
2036	\$77.74	\$27.59	\$56.50	\$149.13
2037	\$81.12	\$28.42	\$59.47	\$155.46
2038	\$84.41	\$28.99	\$62.43	\$161.80
2039	\$87.60	\$29.28	\$65.40	\$168.13
2040	\$90.93	\$29.28	\$68.67	\$174.86
2041	\$94.08	\$28.99	\$71.41	\$181.85
2042	\$97.03	\$28.41	\$73.56	\$189.13
2043	\$100.39	\$27.56	\$75.03	\$198.58
2044	\$104.24	\$26.45	\$75.78	\$210.50
2045	\$108.71	\$25.13	\$75.78	\$225.23
2046	\$113.47	\$23.62	\$75.78	\$241.00
2047	\$118.54	\$21.97	\$75.78	\$257.87
2048	\$123.97	\$20.21	\$75.78	\$275.92
2049	\$129.80	\$18.39	\$75.78	\$295.23
2050	\$136.08	\$16.55	\$75.78	\$315.90

**SUPPLEMENT TO:
MEMORANDUM FOR DISCUSSION:**

**FINANCIAL EXPOSURE TO U.S. CLIMATE ACTION POLICY
MAY 2009 (REV-1)**



**PREPARED BY:
ENERGY STRATEGIES, LLC
215 SOUTH STATE STREET, SUITE 200
SALT LAKE CITY, UT 84111**

NOTE AND DISCLAIMER: The following memorandum was prepared for Cornell University's Presidents Climate Commitment Implementation Committee (PCCIC) by Energy Strategies, LLC, an Energy Consulting firm headquartered in Salt Lake City, Utah. This document is being used by the PCCIC members and sub-committees to evaluate possible methods of "internalizing" a value of carbon that may aid in the process of planning to reach climate neutrality. The assumptions and calculations made in this document are neither approved nor endorsed by Cornell University nor are they being used for current operational decision making. The information, analysis and conclusions found in this document are based on publicly available information regarding possible Federal Cap and Trade legislative scenarios as of May 2009. The analysis and conclusions in this document are subject to change with emerging developments. Alternative GHG management policy scenarios, e.g. a federal carbon tax and EPA regulation under the Clean Air Act, were not evaluated as part of this analysis. Energy Strategies should be credited as part of any reproductions or references to this document. Persons or parties with comments or questions regarding this document should contact one of following representatives of Energy Strategies, LLC at (801)355-4365: Nick Travis, Jeff Burks, Justin Farr, or Rob McKenna.

WRITTEN TO: PCCIC, SUSTAINABLE DECISIONS WORKING GROUP

DATE: MAY 18, 2009

COPY TO: AFFILIATED ENGINEERS, INC.

REV 10 - SUPPLEMENT

WRITTEN BY: ENERGY STRATEGIES, LLC

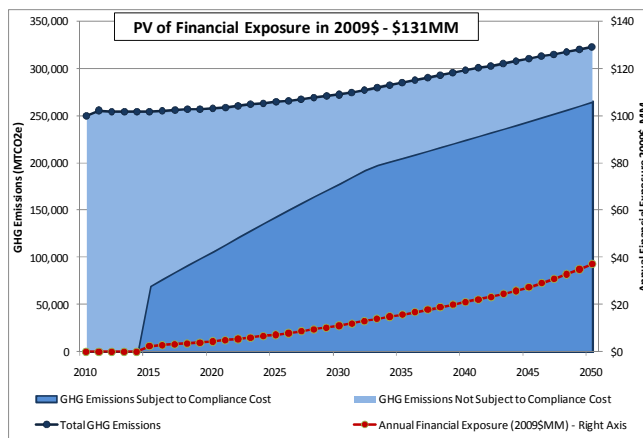
ENGAGEMENT: CORNELL CAP

REGARDING: FINANCIAL EXPOSURE TO U.S. CLIMATE ACTION POLICY

In January 2009, Energy Strategies LLC provided a memorandum for discussion on Cornell University's "Financial Exposure to U.S. Climate Action Policy". The basic premise of the memorandum was that federal legislation will mandate significant reductions in U.S. greenhouse gas (GHG) emissions. Using a cap and trade legislative framework, we illustrated how regulation would result in future costs to Cornell. Increasing "carbon prices" would be attributed in the economy at large to Cornell's energy supplies and transportation services. For the preliminary "business as usual" (BAU) base case, we provided an estimate that future carbon prices would add \$151 million present value (PV) to future costs of energy and transportation. This calculation assumed moderate scenarios with respect to legislation and technology advances.

Since January, the body of scientific research and activities in Washington continue to support the expectation that an economy-wide price will be assigned to carbon. (See updated discussion of federal GHG regulation below). Over this time, we have worked with the Cornell CAP team to refine our estimate of Cornell's financial exposure to future carbon prices under the BAU Base Case as well as under alternative courses of action. The updated estimate of financial exposure in the BAU Base Case is \$131 million assuming moderate legislative and technology scenarios. (See Exhibit 1). The \$20 million decrease since January reflects: 1) exclusion of scope 3 commuting emissions from Cornell's financial exposure, and 2) a reduction in the assumed BAU growth in energy consumption.

Exhibit 1: Cornell University Financial Exposure to Federal GHG Regulation, BAU Base Case



There has been no attempt to revise assumptions with respect to policy scenarios and future carbon prices (GHG emission allowance prices). The range of uncertainty remains high with respect to these assumptions. However, we have extended our modeling functionality to provide an estimate of financial exposure across a full range of legislative and technology scenarios. Exhibit 2 reflects BAU Base Case financial exposure ranging from a present value of \$21 million (weak legislation coupled with technology breakthroughs) to \$345 million (stringent legislation with minimal advances).

Exhibit 2: Financial Exposure Under Varying Scenarios

		Range of PV of GHG Financial Exposure		
		Legislative Scenario		
		Weak	Moderate	Stringent
Technology Scenario	Breakthrough Advances	\$21 MM	\$70 MM	\$118 MM
	Moderate Advances	\$40 MM	\$131 MM	\$251 MM
	Minimal Advances	\$52 MM	\$193 MM	\$345 MM

Update on Federal GHG Regulation

Prospects remain strong for Climate Change Legislation in the 111th Congress. President Obama is the first U.S. president to call for a mandatory, economy-wide cap-and-trade program to reduce greenhouse gas (GHG) emissions. Soon after he was elected, the President-elect declared that his presidency would mark a new chapter in executive branch leadership on climate change and it would "...start with a federal cap-and-trade system. We'll establish strong annual targets that set us on a course to reduce emissions to their 1990 levels by 2020." ¹

In a February 2009 address to a joint session of Congress the President requested legislation that would place a "market based cap on carbon pollution", and the President's 2010 budget included revenues from a 100% auction of allowances under a national cap-and-trade program.

¹ Address to the *Global Climate Summit*, November 18, 2008.

The budget also included several principles on what the administration wanted to see out of a cap-and-trade program, including emission targets that cut U.S. greenhouse gas levels 14 percent from 2005 levels by 2020 and by 2050 cuts of 83 percent from 2005 levels.

In the Congress, Rep. Henry Waxman (D-CA), Chairman of the House Committee on Energy and Commerce, and Rep. Edward Markey (D-MA), Chairman of the Subcommittee on Energy and Environment, released a March 31st discussion draft of comprehensive climate and clean energy legislation entitled the "*American Clean Energy and Security Act of 2009*". Chairman Waxman's stated objective is to bring the bill up for a vote to the full Committee by Memorial Day, 2009.

The *American Clean Energy and Security Act of 2009* continues to evolve rapidly. In its initial draft form, it called for an economy-wide cap-and-trade program covering 85% of the U.S. economy and seven greenhouse gases (GHG) and would begin to take effect in 2012. The target is to reduce economy wide GHG emissions by 20% below a 2005 emissions baseline by 2020, by 42 percent in 2030 and by 85 percent in 2050. Under the program electric utilities, industrial processes, manufacturers and other large stationary sources that emit 25,000 tons CO₂e or more per year will be covered under the cap and trade program. Under the bill EPA is also required to develop emissions standards for small sources that emit more than 10,000 tons CO₂e per year.

In addition, the Environmental Protection Agency (EPA) is increasingly involved in GHG regulation. On March 10, 2009, the EPA Administrator signed a proposed rule that will require mandatory reporting of greenhouse gas (GHG) emissions from large sources in the United States. In general, EPA proposes that suppliers of fossil fuels or industrial greenhouse gases, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions submit annual reports to EPA, so this reporting requirement will likely apply to Cornell University. The gases covered by the proposed rule are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulfur hexafluoride (SF₆), and other fluorinated gases including nitrogen trifluoride (NF₃) and hydrofluorinated ethers (HFE). The new reporting requirements would apply to approximately 13,000 facilities, accounting for about 85 percent to 90 percent of greenhouse gases emitted in the United States.

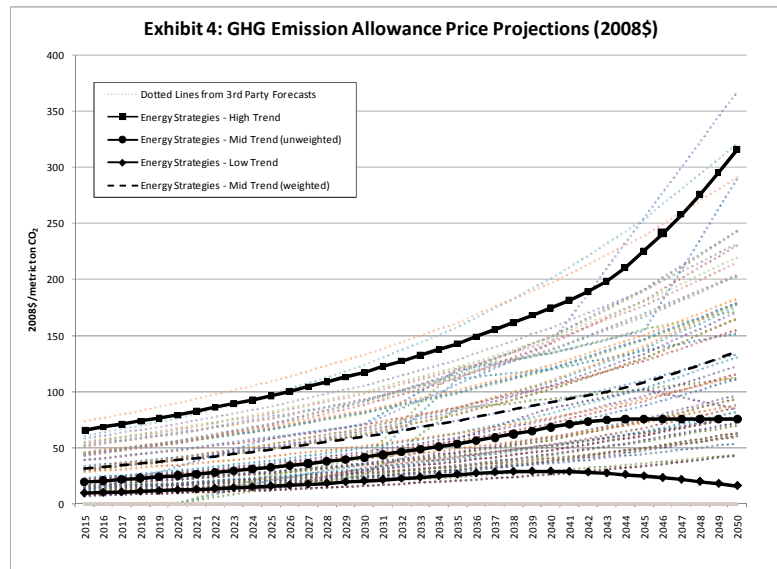
Moreover, on April 17th, the U.S. Environmental Protection Agency ("EPA") released a proposed rule under the federal Clean Air Act ("CAA") that moved the federal government closer to regulating GHG emissions. EPA's finding comes more than two years after the Supreme Court issued its decision in *Massachusetts v. EPA*. In that decision the Court concluded that carbon dioxide and other GHGs endangered public health and welfare and fit the definition of a pollutant, therefore were subject to regulation under the CAA.

Energy Strategies continues to apply the legislative policy scenarios and carbon price forecasts presented in the January memorandum and included as Exhibits 3 and 4 below.

Exhibit 3: Federal Climate Change Policy Scenarios

Exhibit 3: Federal Climate Change Policy Scenarios						
Policy Scenario	Scope of Coverage	Cap (% below 2000 Levels)	Sectors Covered	Cornell Emissions Covered	Allocation (% Purchased)	Use of Offsets and Other Cost Controls
Energy Strategies "Stringent"	6 GHGs—CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, and SF ₆ Upstream for transport fuels & LDC natural gas; downstream for large coal users and large point sources	5% by 2015	Economy-wide	Scope 1: direct at source Scopes 2,3: indirect through suppliers	60% increasing to 100%	No safety valve U.S. offsets limited to 5% of compliance No Banking
		15% by 2020				
		40% by 2030				
		80% by 2050				
Energy Strategies "Moderate"		1% by 2015	Economy-wide	Scope 1: direct at source Scopes 2,3: indirect through suppliers	30% increasing to 65%	No safety valve U.S. and international offsets limited to 10% of compliance Banking for 5 years
		10% by 2020				
		30% by 2030				
		70% by 2050				
Energy Strategies "Soft"		1% by 2015	Electric Power (Excluding Cogen), Transportation, & Manufacturing	Scope 1: excluded Scopes 2,3: indirect through suppliers	0% increasing to 30%	Safety valve in place U.S. and international offsets limited to 25% of compliance Unlimited banking
		8% by 2020				
		20% by 2030				
		50% by 2050				

Exhibit 4: GHG Emission Allowance Price Projections



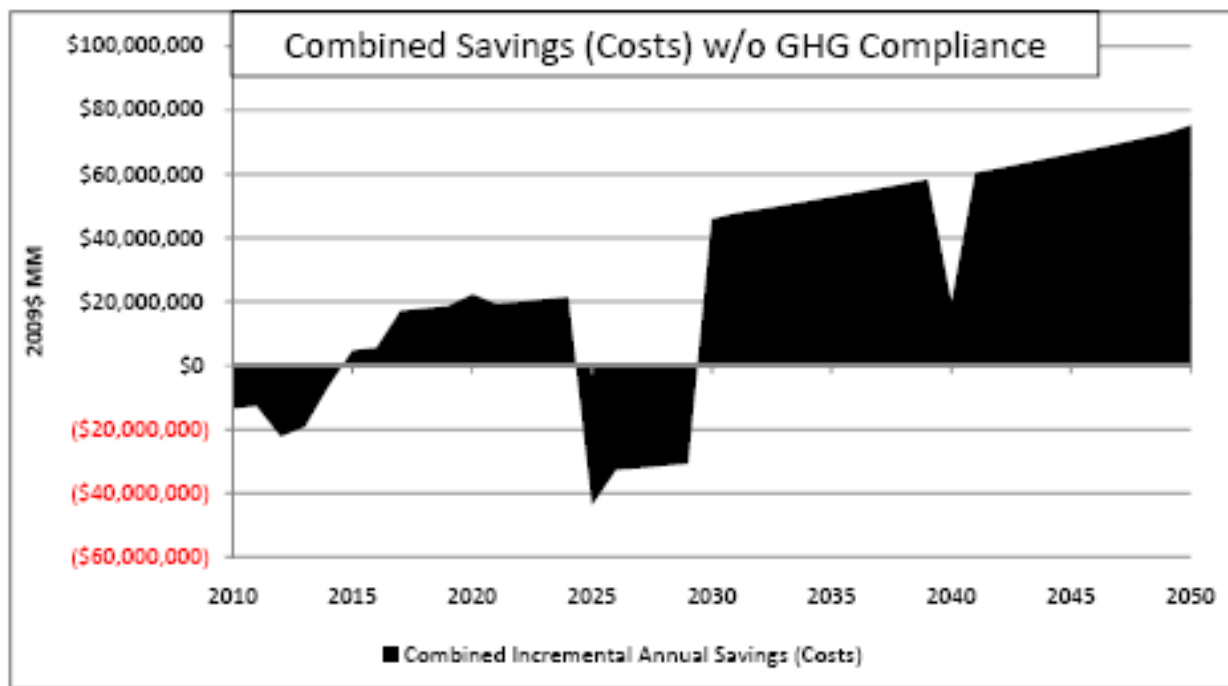
Additional Financial Analysis

The analysis tool used to calculate the greenhouse gas (GHG) emissions associated with the Climate Action Plan (CAP) actions also provided an estimate of the financial impact of the plan.

Four graphic displays of the results were prepared. The convention of each is that positive values represent income (savings) to the university, while negative values represent expenditures (costs).

Graph 1 provides an estimate of the combined savings over time.

Graph 1: Combined Value of the CAP Actions Over Time



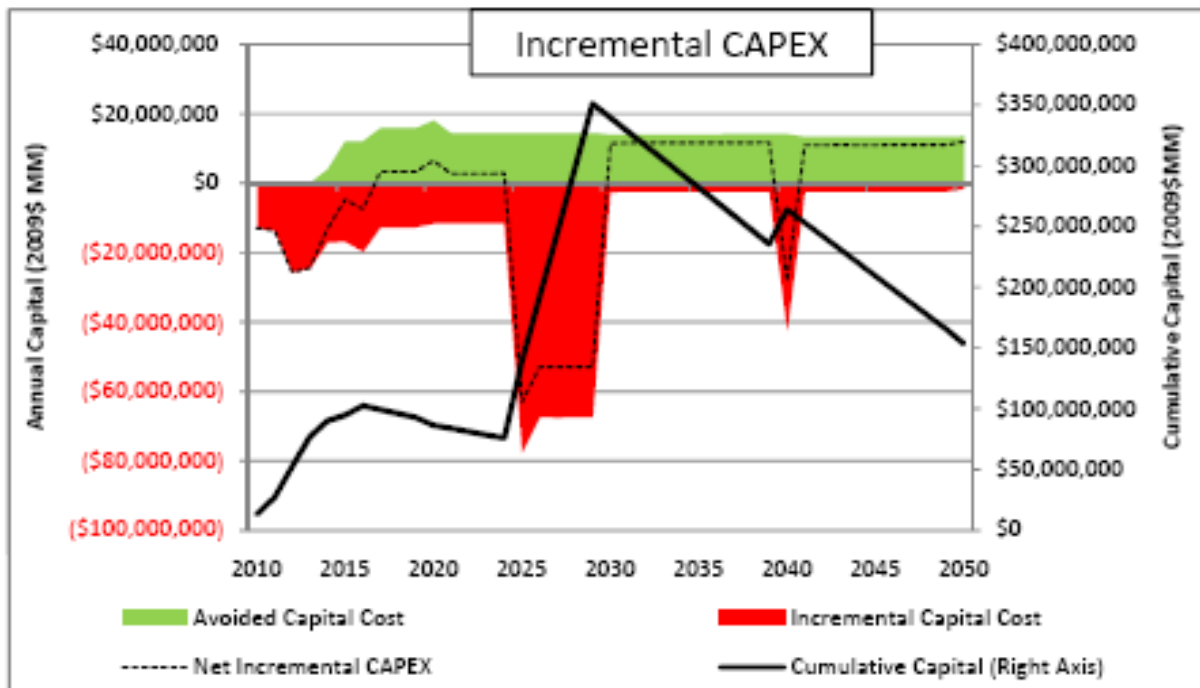
The costs (negative savings) at the start of the graph represent the early investment in programs, systems, and technology needed to create future savings; the negative savings in years 2025 through 2029 reflect the most substantial investment included in the actions, the “hybrid” Engineered Geothermal Systems and Biogas plant option. The principal expenditure of this action is associated with transforming the campus steam system into a hot water heating system, a necessary feature for incorporating lower grade energy sources. The additional “value” of the hot water distribution system, which results in significantly less energy loss and requires much less maintenance over time, is not factored into the analysis, but adds to future value.

The overall benefit of the CAP was derived by adding the component costs/benefits. Graphs which display these components of cost were also produced by the analysis tool. The resulting graphs follow:

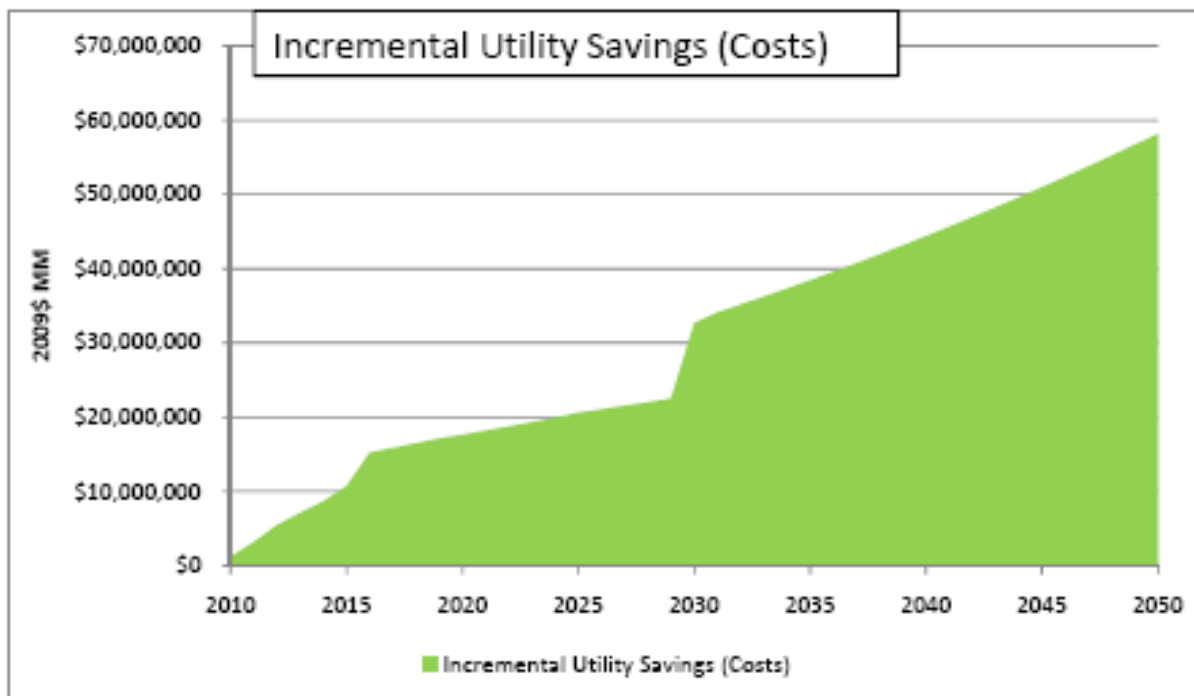
- Graph 2: Capital Expenses (CAPEX) over time
- Graph 3: Incremental Utility savings over time

- Graph 4: Incremental Operating Expenses (OPEX) over time. Utility savings are not included.

Graph 2: Capital Expenses (CAPEX) over time



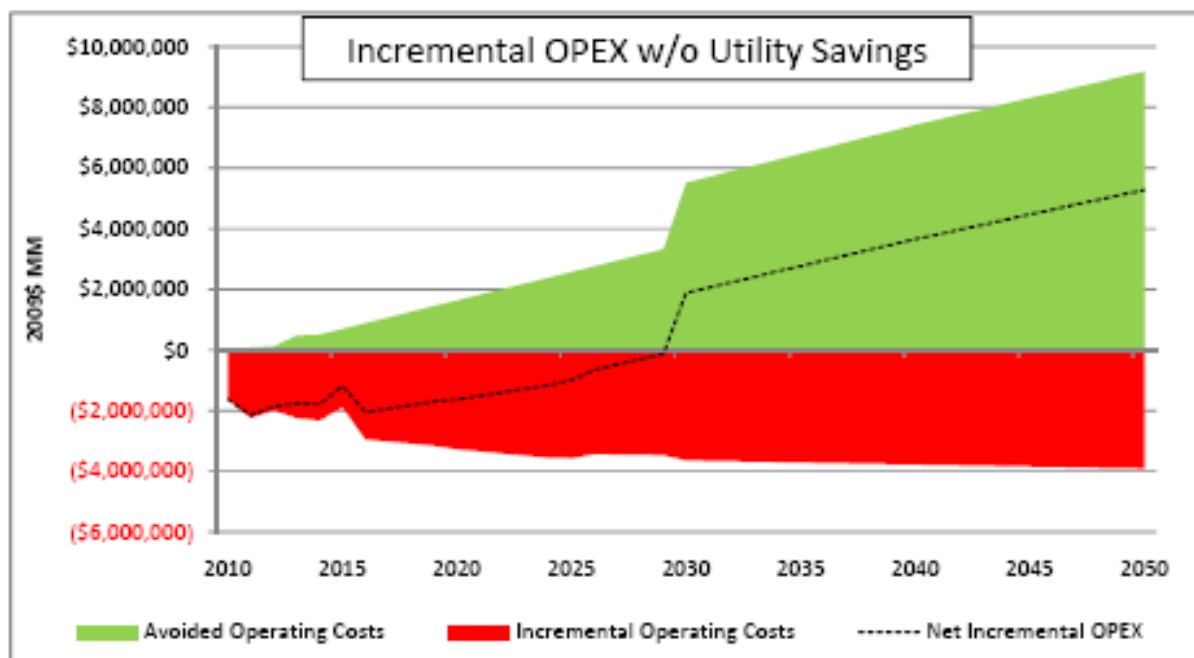
Graph 3: Incremental Utility savings over time



As Graph 3 demonstrates, the primary positive financial benefit of the CAP is in the reduction in utility costs over time. This is the natural result of reducing energy expenditures associated with fossil fuels, which result in net greenhouse gas (GHG) emissions, the target of the CAP.

The final component of costs evaluated, operating costs (OPEX) is also presented. There are both additional and reduced staffing requirements associated with various actions; there are also impacts to operating and maintenance costs (some positive, some negative) associated with various actions. The overall impact starts out slightly negative but reaches a “break-even” point in about 2030 and is positive thereafter.

Graph 4: Incremental Operating Expenses (OPEX) over time.



All costs are measured relative to the Base Case, as discussed in the CAP summary. The Base Case is the “business and usual” scenario reflective of current University operations.

Financial Impacts Not Included. While these financial impacts are significant, there was no accounting for any additional benefits associated with the prominent research or educational programs associated with the CAP, nor of any good will or positive public relations, nor of job creation, nor of any other secondary efforts of the CAP. In reality, these benefits may greatly exceed the “single bottom line” benefits presented herein.



Redesigned Tower Road Streetscape



Redesigned Library Plaza connecting the Arts Quad and Ho Plaza

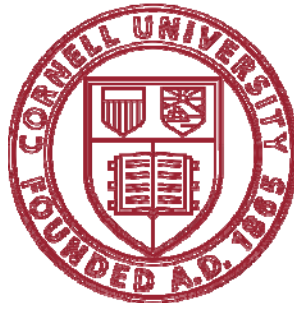


Restored view west from Wee Stinky Glen in Founders Greenway



Alumni Quad and a new academic hub in East Center





Cornell University

**MEETING THE AMERICAN COLLEGE AND
UNIVERSITY PRESIDENTS
CLIMATE COMMITMENT**

ROLE OF OFFSETS

PREPARED BY:
ENERGY STRATEGIES, LLC
215 SOUTH STATE STREET, SUITE 200
SALT LAKE CITY, UT 84111



Introduction

On February 27, 2007, Cornell University President David Skorton signed the American Colleges and University Presidents Climate Commitment, joining 581 other college and university presidents who have pledged to reduce and offset greenhouse gas (GHG) emissions and become “climate neutral”.

The ACUPCC defines Climate Neutrality as “having no net GHG emissions, to be achieved by minimizing GHG emissions as much as possible and using carbon offsets or other measures to mitigate the remaining emissions”. To achieve climate neutrality under the terms of the ACUPCC, all Scope 1 and 2 emissions and Scope 3 emissions from commuting and air travel paid for by or through the university, must be neutralized.¹

This white paper describes the options available to Cornell University to offset their greenhouse gas (GHG) emissions pursuant to climate neutrality commitments and potential federal GHG emissions regulations. The purpose is to inform decisions by Cornell University on the role offsets could play in meeting Cornell’s climate neutrality commitment, including the types of offsets, timing of investment, the potential supply of offsets within Cornell’s land holdings, the ability of offset projects to meet Cornell University’s potential compliance obligations under federal climate legislation in addition to advancing Cornell’s climate neutrality commitment; and the types of standards and guidelines Cornell should consider following in developing an offset portfolio.

Defining Carbon Offsets

In general, GHG offsets represent a real reduction, sequestration, destruction or avoidance of greenhouse gas (GHG) emissions that can be measured and quantified, and originate from projects or activities outside the boundary of a regulatory program or an entity’s carbon footprint.²

¹ The ACUPCC *Implementation Guide*, defines three categories of GHG emissions for accounting and inventory reporting purposes. Scope 1 GHG emissions refer to direct GHG emissions “owned and controlled” by Cornell including; on-campus stationary combustion of fossil fuels; mobile combustion of fossil fuels by Cornell-owned/controlled vehicles; and “fugitive emissions” from intentional or unintentional releases of GHG”, including methane emissions from farm animals. Scope 2 refers to indirect emissions associated with the production of electricity purchased from NYSEG or other electric distribution companies serving the Cornell system. Scope 3 emissions are indirect GHG emissions that associated with activities that are a direct consequence of Cornell University’s mission and operations but are from sources not owned or controlled by Cornell.

² The American College and University Presidents Climate Commitment document, “Investing in Carbon Offsets: Guidelines for ACUPCC Institutions”, November 2008 v1.0, defines a carbon offset as a reduction or removal of carbon dioxide equivalent (CO₂e) greenhouse gas (GHG) emissions that is used to counterbalance or compensate for (“offset”) emissions from other activities; offset projects reducing GHG emissions outside of an entity’s boundary generate credits that can be purchased by that entity to meet its own targets for reducing GHG emissions within its boundary.

The concept of carbon dioxide (CO₂e) offsetting stems from the idea that addressing climate change does not hinge on where the CO₂e emissions reductions occur. From a scientific perspective, GHG emissions assimilate and accumulate uniformly across the earth's atmosphere. The geographical location of greenhouse gas emissions – or a reduction of greenhouse gases -- is immaterial to its impacts on climate change. The net result of reducing, sequestering, destroying or avoiding one metric of CO₂e in Ithaca, New York is equivalent to reducing or sequestering one ton of CO₂e in Ithaca, Georgia. As such purchases of credible and high quality offsets are be regarded as an investment in real GHG emissions reductions.

Carbon offsets have been an important element of the climate debate since the mid 1990s. Offsets have been purchased by companies and institutions to achieve *voluntary* GHG emissions reductions not immediately possible through direct emissions reductions or avoidance of on-site emissions. In the United States the Northeast's mandatory Regional Greenhouse Gas Initiative recognizes offsets while several U.S. domestic cap-and-trade programs introduced in the 110th and 111th Congress have included offsets as an important cost containment measure that can substantially reduce the overall cost of achieving emission reduction for regulated entities.

Types of Offsets

There are numerous types of offset projects that can generally be grouped into four broad categories; fossil fuel reduction; sequestration; methane capture and combustion; and industrial gas destruction and other.

Offsets created by reducing use of fossil fuels may be achieved through projects that invest in energy efficiency, fuel switching and renewable energy projects. Energy efficiency projects reduce GHG emissions by reducing the use of fossil fuels through the adoption of more energy efficient technologies, processes, practices and standards. Examples of energy efficiency measures include insulating buildings so less energy is required to maintain a given temperature setting; installing more efficient lighting and heating, ventilation and cooling equipment in homes and commercial buildings; improving fuel efficiency of motor vehicles; and improving the efficiency of industrial and commercial power generation, motors, boilers and furnaces. The biggest challenge to energy efficiency projects creating credible offsets is the issue of ownership of the emissions reduction and double counting. Between electric and natural gas efficiency projects, natural gas offers the best opportunity for creating credible offsets.

Fuel switching projects create legitimate offsets by replacing fossil fuels with no- or low-GHG emitting fuel sources. An example of a fuel switching offset project common to campuses would be the conversion of a central plant from burning coal to natural gas since natural gas

releases half the GHG emissions. Similarly, converting a vehicle fleet to burn biodiesel or run on electric motors is another fuel switching project that reduces HG emissions and could be counted as an offset projects.

Table 1

Range of Potential Offset Projects				
Category	Type	Sector/Source	Offset Project Options	Type of GHG Emissions Reduction
Fossil Fuel Reduction	Energy Efficiency	Buildings and Equipment	Energy efficiency retrofit-Fuels	Direct
		Transportation	Energy efficiency retrofit-Electric	Indirect/Avoidance
			MPG vehicle fuel efficiency	Direct
			Fleet idling management	Direct
	Fuel Switching	Power Generation	Cogeneration	Direct
		Transportation	Biofuels	Direct
		Power Generation	Co-firing w/ biofuels	Direct
		Central Plant	Co-firing w/ biofuels	Direct
	Renewable Energy	Grid Connected	Photovoltaic solar power	Indirect/Avoidance
			Solar thermal	Indirect/Avoidance
			Geothermal	Indirect/Avoidance
			Wind	Indirect/Avoidance
			Hydro	Indirect/Avoidance
			Biomass	Indirect/Avoidance
Sequestration	Biological	Forest Management	Afforestation/Reforestation	Sequestration
			Intensive Forest Management	Sequestration
			Avoided deforestation (REDD)	Sequestration
			No tillage	Sequestration
	Geological	Soil	Range land management	Sequestration
		Capture and Sequestration	Bio-char	Sequestration
			Power Plant	Sequestration
			Industrial Processes	Sequestration
Fugitive Methane	Capture and Combustion	Agriculture	Manure Management	Direct
		Municipal	Land fill gas	Direct
		Coal Mines /gas wells	Wastewater	Direct
			Vent and Flare	Direct
Industrial Gas	Capture and Destruction	HFC-23		Direct
		Sulfur Hexafluoride (SF6)		Direct
		N2O		Direct
				Direct

Offsets can potentially be created by investing in renewable energy projects as a strategy to avoid the GHG emissions associated with combustion of fossil fuels in the generation of electricity. Renewable energy projects include solar PV, solar thermal, wind, geothermal, some types of hydro and biomass. In fact, renewable energy projects are a common form of offset under the Kyoto Protocol's Clean Development Mechanism.³ A characteristic of these projects is that they avoid emissions that might otherwise have occurred or they result in an emissions reduction at a location other than the renewable project site. These types of projects are particularly challenging as offset projects in the U.S. because they result in indirect emissions reductions and it is very difficult to determine the legal ownership of the emission reduction. Moreover, due to the interconnected nature of electricity grid it is nearly impossible to accurately determine which fossil generating units dispatch was affected by the project. *Accordingly, indirect emissions reduction projects like renewable energy are not generally recognized as offsets under the ACUPCC Protocol.*⁴

This is also true of renewable energy certificates (RECs). Even though RECs have been traded in voluntary carbon markets and counted by some companies and institutions as a credit against their GHG emissions, a REC is not an offset or an allowance and does not necessarily represent a reduction in existing GHG emissions and therefore cannot be used as a credit against scope 1 and scope 3 emissions.

RECs do have a limited but important role to play as one element of a portfolio of actions Cornell University can take to achieve "climate neutrality." RECs can still be used by an institution or individual to demonstrate a valid claim they are purchasing zero-emissions electricity. Where RECs are certified and tracked by a registry, sold only once and then retired they offer a mechanism to obtain electricity with zero-CO₂e emissions. In this way RECs can be used for purposes of the ACUPCC and other voluntary "climate neutrality" commitments as a credible measure to mitigate the carbon foot print associated purchased electricity even though they are not considered a viable offset.

Sequestration projects represent activities that directly remove and store GHG from the atmosphere, permanently captures and prevents GHG from being emitted into the atmosphere, or avoids the release of stored carbon into the atmosphere. Afforestation, in which trees are planted to remove CO₂e from the atmosphere, is one of several "biological" sequestration

³ The Clean Development Mechanism (CDM) is an arrangement under the Kyoto Protocol allowing industrialized nations with a mandatory GHG emissions reduction obligation to invest in projects that reduce GHG emissions in developing countries. An essential feature of an approved CDM carbon offset project is that it has established that the planned reduction would not have occurred without the additional incentive provided by monetary value of the offset. This concept is known as "additionality". The CDM is supervised by the CDM Executive Board and is under the guidance of the Conference of the Parties of the United Nations Framework Convention on Climate Change.

⁴ American College and University Presidents Climate Commitment, "Investing in Carbon Offsets: Guidelines for ACUPCC Institutions", November 2008 v1.0, page 40.

projects that can generate credible offsets and include forest management or soil conservation/tillage practices. Geologic sequestration involves the capture of CO₂e from the flue gas emitted in the generation of electricity or other industrial processes and storage of the captured CO₂e in geologic formations that prevents its release back into the atmosphere. While “biological” sequestration offsets are common in both voluntary and mandatory carbon markets there is less familiarity and more questions around the viability of geologic sequestration as an economical and reliable offset at this time.

Methane has a global warming potential 23 times that of CO₂. When combusted each molecule of methane is converted to one molecule of CO₂, resulting in a 96% reduction of the global warming impact of methane. Methane-based offset projects consist of the capture and combustion or containment of methane generated by farm animals, landfills, municipal wastewater and sewage treatment plants, oil, gas and coal production, and other industrial waste. Methane capture and combustion projects represent the second most popular type of offset project in the voluntary over-the-counter market and generate the third highest volume of offsets worldwide under the CDM. As generators of offsets, these projects are economical, have well established protocols, are easy to monitor and recognized as highly credible in both voluntary and mandatory markets.

Finally, industrial pollutants such as hydrofluorocarbons (HFCs), SF₆ and perfluorocarbons (PFCs) have a greenhouse gas warming potential many thousands of times greater than carbon dioxide by volume. Because these pollutants are easily captured and destroyed at their source, they present a large and low-cost source of carbon offsets. As a category, HFCs, PFCs, and N₂O reductions represent over 70% of offsets issued under the CDM though a very small part of the voluntary market. The ACUPCC guidelines point to a number of reasons why industrial gas destruction offsets might not be compatible with offset strategies of American colleges and universities⁵, still they remain a recognized offset in both voluntary and compliance frameworks.

Offset Quality

Underlying the discussion above is an acknowledgement that the project-type represents a necessary condition but alone is not sufficient to ensure a project will be recognized as a credible source of offsets. Certain “quality” conditions must be met as well. Standards, verification protocols and establishment of independent registries have become the means by which offset quality is being established and measured.

For various reasons skepticism surrounds carbon offsets. Offsets have either been perceived as producing little or no real GHG emissions reduction benefit, a way of buying one’s way out of

⁵ Ibid, p. 45

an obligation to reduce actual GHG emissions or are used to by corporations or institutions merely as a tool to “green-wash”. This type of concern is best exemplified by the negative media attention that accompanied Dell Computers’ announcement that it had achieved “carbon neutrality” in a December, 30, 2008 article in the Wall Street Journal.

Concerns about offset quality in recent years have given rise to increased use of registries, and standards by participants in the voluntary markets to establish legitimacy of offsets as a GHG emissions reduction measure. These standards are being established to ensure that offsets are real, able to be verified, accurately measured, and represent an emissions reduction over and above what otherwise would have occurred.

Table 2
Key Offsets Quality Criteria

Criteria	Description
Real	GHG emission reductions should represent actual net emission reductions and must be established from a credible baseline.
Measurable	Emission reductions from offset projects must be accurately quantified.
Additional	Offset project reductions must be “in addition to” reductions that would have occurred without the offset project or the incentives provided by offset credits.
Permanent	Because offset credits are used in lieu of an on-site reduction, it is important to ensure that the offset credits either represent a permanent reduction or contractually require replacement if they are reversed.
Monitored and Verified	Offset projects must be monitored to ensure that emission reductions are occurring and verified according to accepted methodologies and regulations by an independent third party or a government agency .
Registered	Offset credits should be serialized and accounted for in a recognized registry or other approved tracking system.
Leakage	Leakage should be addressed in an offset program design to avoid unintended increase in GHG emissions outside of the project’s boundary that occurs as a result of the project.
Ownership	To avoid double counting clear and uncontested title to offset credits is necessary, and transfer of ownership must be unambiguous and documented.

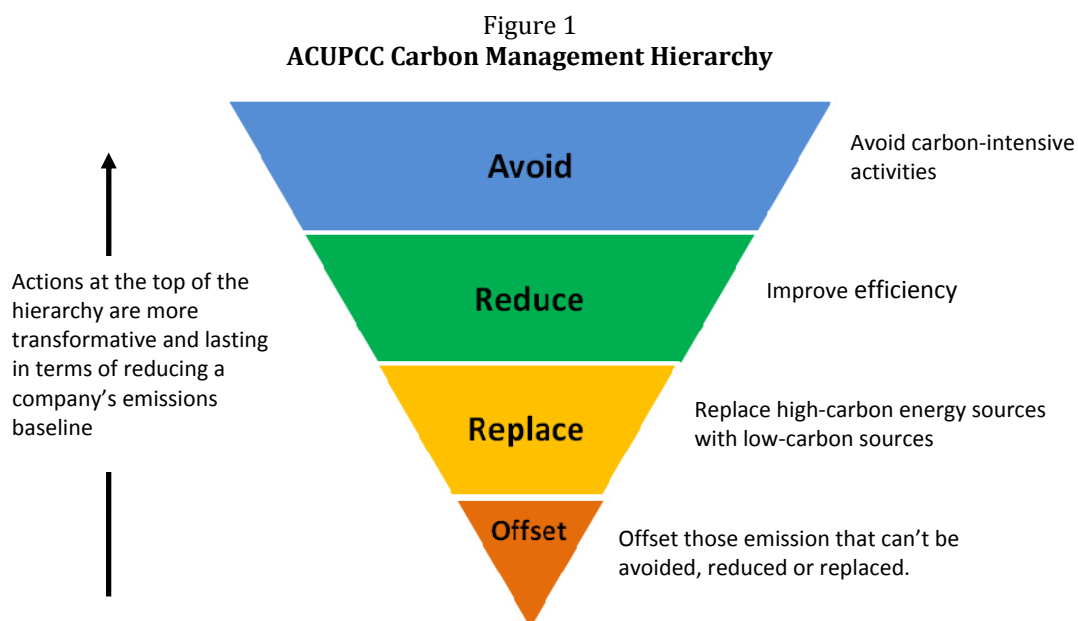
Today a number of standards and protocols exist to against which offset quality can be established. The best standards require offsets be derived from projects that can demonstrate they are additional, real, permanent, measurable, verified, have clear ownership of title, and take place during a period of time that is aligned with the emissions they are intended to offset. Increasingly offset transactions are being verified to a specific third party standard. The

Voluntary Carbon Standard, CDM, CCX, VER+ and Gold Standard are growing in recognition and in 2007 were cited by Ecosystem Marketplace as the most frequently used standards by the voluntary offset market.⁶

Accordingly, an important consideration for Cornell University in looking to acquire offsets is the institution's reputation and the importance of avoiding offsets with questionable impact on greenhouse gas emissions. The credibility of Cornell's voluntary commitment can be protected by ensuring that any purchased offsets meet strict quality criteria and follow recognized protocols.

Offsets and the ACUPCC

In *"Investing in Carbon Offsets: Guidelines for ACUPCC Institutions, Accompanying Document to the ACUPCC Voluntary Offset Protocol"*, the ACUPCC outlines a "carbon management hierarchy, depicted below.⁷ The guidelines are not intended to be "prescriptive". As part of fulfilling their ACUPCC commitment, each signatory is encouraged to evaluate and consider what role, if any, carbon offsets will play in their climate action plan according to their unique circumstances.



⁶ Ecosystem Marketplace and New Carbon Finance. May 2008. *State of the Voluntary Carbon Markets 2008*, Page 53.

⁷ Burtis, B. and Watt, I. (2008) "Getting to Zero: Defining Corporate Carbon Neutrality." Clean Air-Cool Planet and Forum for the Future. Portsmouth, NH. Accessed June 2008. www.cleanair-coolplanet.org

The ACUPCC acknowledges that in the short run it will be very difficult for institutions to achieve climate neutrality without offsets.⁸ Still, for purposes of the ACUPCC agreement the following guidelines are offered:

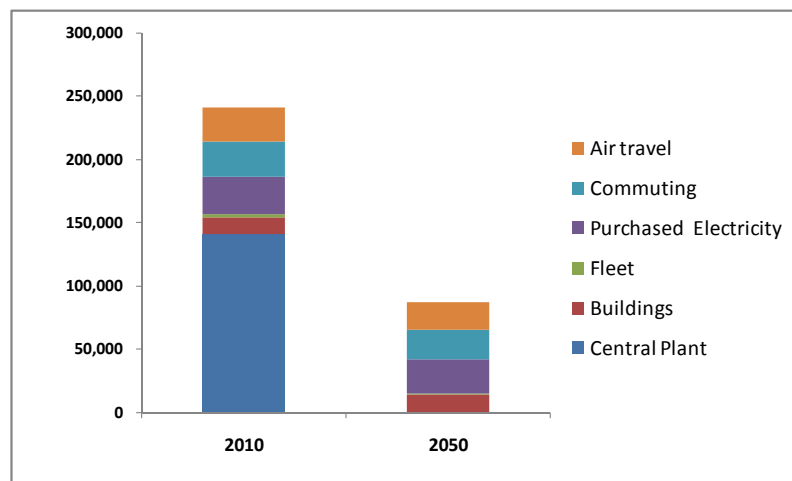
“...the short term use of high quality offsets can be an effective way to drive real reductions in GHG emissions now, and can serve as a useful tool for internalizing the costs of GHG emissions and accelerating innovation on campuses to reduce GHG emissions more quickly. As such the ACUPCC supports art investment in offsets as an effective way to help create a GHG-free future.”⁹

As such, the guidelines recommend that institutions take actions at each level of the carbon management hierarchy “simultaneously” with the objective of acquiring offsets only when internal reduction activities have been initiated.

Cornell’s Opportunity to Use Offsets

Depending on the greenhouse gas emissions reductions achieved through the other wedge strategies, and the target date for achieving climate neutrality, Cornell’s opportunity to use offsets could be substantial. Under the ACUPCC agreement all of Cornell’s GHG emissions, Figure 2, must be reduced or offset. At one extreme, if Cornell were to set a date to be climate neutral starting in 2010, the University would face having to acquire offsets to compensate for about 240,894 metric tons of CO₂e emissions based on Cornell’s projected emissions inventory.

Figure 2
Cornell’s GHG Emissions 2010 and 2050



Alternatively, if Cornell were to set a target date of 2050 to reach climate neutrality, and did not acquire offsets until all campus emissions reductions projects had been implemented and

⁸ American College and University Presidents Climate Commitment, “Investing in Carbon Offsets: Guidelines for ACUPCC Institutions”, November 2008 v1.0, page 10.

⁹ Ibid, page 10

the target date had been reached, then the University would be faced with a significantly smaller investment in offsets to meet its climate neutrality objective.

The principle factors that will determine the volume of Cornell's offset purchases are: (1) the volume of project-based offsets the University develops on Cornell owned-lands or in surrounding community; (2) the extent to which it achieves direct emissions reductions of Scope 1-3 sources; and (3) time frame and milestones the University sets for achieving climate neutrality.

It is also important that Cornell's strategy for purchasing and acquiring offsets recognize the difference between offsets needed for its voluntary climate neutrality commitment and an emissions reduction obligation it would face under a mandatory federal cap and trade program. By virtue of the volume of tons of CO₂e emitted from its central plant Cornell may be covered under future mandatory GHG regulations and may wish to use offsets to contribute to meeting an emissions compliance obligation.

Table 3
Eligible Offset Projects Under Proposed Federal and Regional Programs

	ACUPCC Offset Categories	S. 1766 Bingaman-Specter	S. 3036 Lieberman-Warner	Dingell-Boucher Draft Legislation 2008	RGGI Regional Greenhouse Gas Initiative
Regulatory Authority		Mandatory	Mandatory	Mandatory	Mandatory
		President	EPA Administrator		State DEQ
Eligible Activities	Fossil Fuel Reductions	Reductions in Non covered Sectors	Reductions in non covered sources		Energy efficiency projects that reduce fossil fuels use
	Sequestration	Geological Sequestration	Afforestation, reforestation and forest management	Afforestation, reforestation, forest management	
			Ag and rangeland sequestration	Agriculture soil sequestration	Sequestration through afforestation
	Fugitive Methane	Land fill gas	Methane capture and combustion - Non Agri Activities	Landfill gas methane capture and combustion	Landfill methane capture and combustion
		Muni Wasterwater		Waste water management	
		Animal Waste	Manure management - methane capture and combustion	Agriculture manure management	Methane reduction from farming
		Coal Mine Methane		Coal mine methane	Energy efficiency projects that reduce fuels use
	Industrial Gases	Reductions in SF ₆			Reductions in SF ₆
	Other	Removal of GHG precursors		Nitrogen fertilizers	
		Other approved activities	Other approved activities		

Under a mandatory cap-and-trade regime, the state or federal government determines which facilities are covered and sets an overall emissions cap. This cap is the sum of all allowed emissions from entities covered by the regulation. Once the cap has been set, *emissions allowances* (rights to emit) are created and issued directly to sources of emissions or auctioned. *Each allowance authorizes the release of a one ton of carbon dioxide equivalent (CO₂e).* At the end of each year entities covered under the cap must submit allowances equivalent to the level of emissions for which they are responsible.

Under federal cap and trade legislation compliance can be achieved through a combination of direct emissions reductions, purchase of allowances or the purchase of compliance-eligible offsets.¹⁰ For example the Lieberman- Warner bill, S. 3036, America's Climate Security Act of 2007 allows covered entities to use offsets to cover up to 30% of their allowances through the use of domestic and international offsets.

Accordingly, a mandatory federal requirement to reduce GHG emissions could motivate Cornell to accelerate its plans to acquire offsets and use as a strategy to minimize cost of compliance with federal GHG regulations.

Creating an Offsets Portfolio for Cornell

There are several ways Cornell could approach acquiring offsets to meet its climate neutrality obligation or emissions reduction obligation under a federal cap and trade program. The two most common approaches are buying offsets in volume through a request-for-proposal (RFP) or as over-the-counter purchases through third party brokers.

Under an RFP Cornell would specify the volume, minimum quality standards, offset types and timelines they would be willing to accept for the based on how the offsets would be used, i.e. voluntary or compliance.

In meeting its voluntary ACUPCC "climate neutrality" commitment Cornell has a good deal of freedom in using offsets and the flexibility to think "out-of-the- box" and explore opportunities to develop non- traditional offset programs and projects. Community-based offsets may be an economically viable option for the University that would provide co-benefits to the local community and promote Cornell's mission of service. In recognition of the unique relationship between the University and the surrounding community, Cornell could issue an RFP specifically requesting offsets generated from projects aligned with the *Energy and Climate Change Elements of the Tompkins County Comprehensive Plan*.

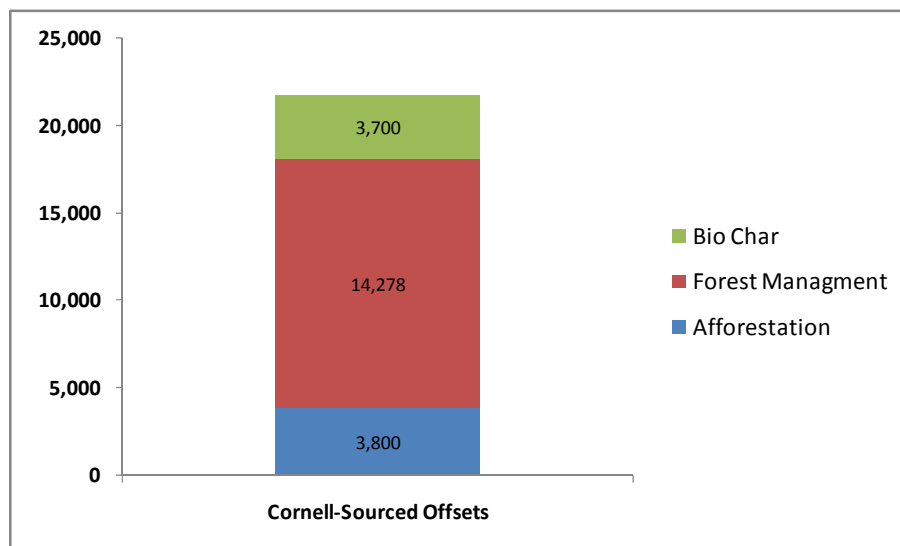
¹⁰ Under Lieberman-Warner the number of offsets that can be used to meet compliance obligations under the cap is 30 percent; 15 percent domestic and 15 percent international. Dingell Boucher limits use of domestic and international offsets to 5% for the period 2012-2017 then allows the use of a combination of domestic and international offsets to grow to 15% in 2018-2020, 30 percent in 2021-2024 and 35 % beyond 2025

Another approach would be for Cornell to join the Chicago Climate Exchange and purchase offsets from the CCX's pool of carbon financial instruments. Either approach can be used for voluntary or compliance purposes.

Cornell could also buy offsets with the procurement of goods and services. One option currently available is the simultaneous purchase of offsets when University related air travel is purchased to compensate for GHG emissions associated with the travel. Airlines and third parties affiliated with internet based travel providers currently provide this service.

Cornell could also enter the offsets market as a developer of offsets. The opportunity for Cornell-sourced offsets to contribute to both the University's voluntary climate neutrality commitment and emissions reductions obligations under federal GHG regulations is not insignificant. According to research of the Offset Wedge Working Group afforestation, forest management and, the CURBI biochar research demonstration projects appear to have the potential to generate over 20,000 metric tons of CO₂e offsets per year.

Figure 3
Annual Offsets from Cornell-Sourced Sequestration Projects



The vast majority of these offsets are generated from afforestation and forest management projects that appear to be cost competitive with forestry offsets currently traded in the voluntary and mandatory carbon markets. Moreover, afforestation projects are already recognized as eligible for use under current mandatory GHG regulations and forest management offsets appear likely to be included in future U.S. regulatory regimes.

According to figures developed by CURBI and the Forestry Department, Cornell managed forests could potentially contribute an average of more than 18,000 of compliance-eligible offsets per year over a 50 year period. This figure equates to over 10% of the compliance obligations the University might face under federal climate regulations.

Decision Criteria for Acquiring Offsets

Offsets should be regarded as one GHG emissions investment opportunity among a diverse portfolio of options that will contribute to Cornell achieving climate neutrality over the long term. The potential costs Cornell faces to federal legislation and acquiring offsets to fulfill Cornell's climate neutrality commitment is large enough to justify a very deliberate and strategic approach to management of Cornell's offset portfolio. Accordingly, Cornell would benefit from developing a business plan that could be used to guide its acquisition, purchase and management of offsets. The goal would be to create a portfolio of offsets that perform well according to several overarching principles:

1. *Aligned with Cornell's Core Mission* -- Offsets used by Cornell as a CAP measure should have a strong tie to Cornell's core mission, i.e. teaching, research, or outreach and/or to the local community. Both ACUPCC publications, *Investing in Carbon Offsets: Guidelines for ACUPCC Institutions* and the *ACUPCC Voluntary Carbon Offsets Protocol*, recognize that offsets projects and purchases can be designed in a way that add value and are aligned with the education, research and community service mission of institutions of higher education.
2. *Strategic* – Offsets represent real emissions reductions of GHG. They are a tool the University can use strategically to manage compliance costs and meet both voluntary and mandatory climate commitments.
3. *Quality* – In acquiring or developing offsets Cornell should adopt a minimum quality standard that ensures offsets acquired by Cornell for both voluntary and compliance purposes are additional, real, measurable, verifiable, owned, and permanent. Offsets acquired by Cornell to compensate for its GHG emissions should be registered with a reputable carbon registry and accounted for with a unique serial number.
4. *Cascading Benefits* – Offsets acquired or developed by Cornell should provide additional societal and environmental co-benefits. Cornell University's acquisition of offsets can be structured in a way that places a high priority on offsets from projects with demonstrated educational, environmental and social co-benefits and support more sustainable communities.

5. *Added Value* – Cornell should not regard itself as just a potential buyer of offsets. Cornell’s expertise in environmental science, natural resources, agriculture, business and law could be used to contribute to the development of protocols, practices, hedging strategies and other business models related to development, market purchases and banking of voluntary and compliance offsets. Cornell should be engaged at different points along the offset value chain including as developer, purchaser, research center, technology incubator and policy leader.
6. *Portfolio Diversity* – Development of an offsets portfolio for Cornell should include a range of project types, suppliers, and be sourced from a number of geographic locations that provide diverse opportunities for innovation, academic collaboration, civic engagement, and other local community and environmental benefits.

Conclusions

Offsets have two important roles to play in Cornell’s efforts to address climate change. In the context of its voluntary commitment to the ACUPCC, offsets are regarded as complementary to direct emissions reductions and intended to be paired with internal reductions to enable Cornell to be “climate neutral”.

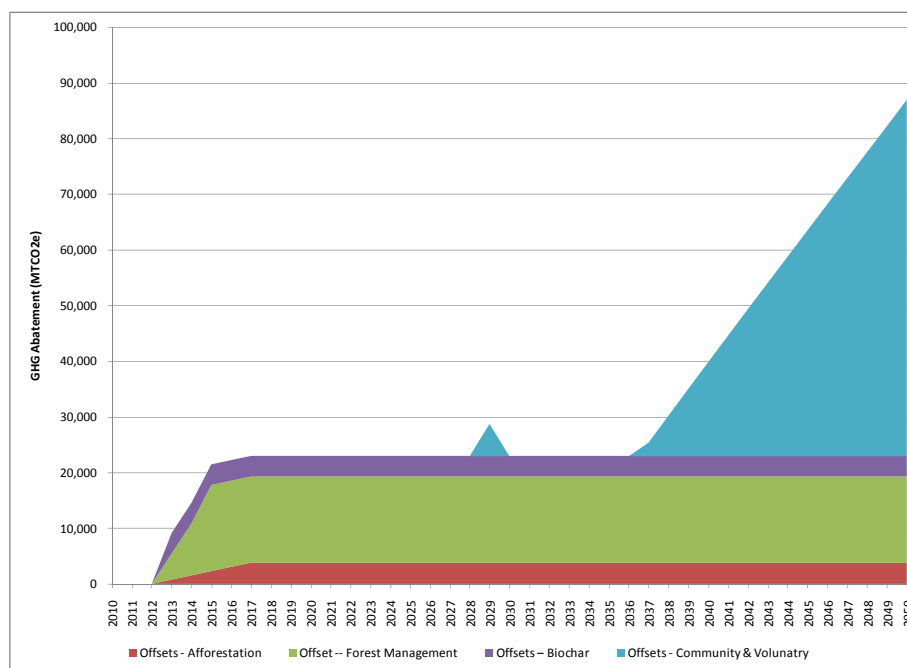
One of the attractive features of using offsets is the flexibility to design acquisition strategies that are aligned with the mission of Cornell and provide an opportunity to strengthen local stakeholder and community relationships. Cornell’s portfolio of GHG mitigation measures reflects this strategic role the University envisions for offsets.

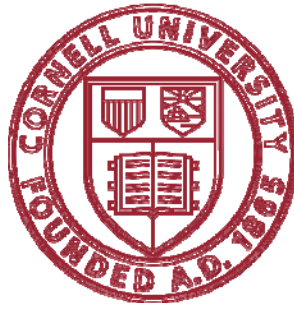
The development of mission-linked afforestation, forest management and biochar offsets on Cornell-owned lands starting in 2013 support the land grant mission of the University. Moreover, given forecasts of future the costs of carbon under federal cap and trade legislation, Cornell’s approach to developing over 20,000 metric tons of CO₂e offsets per year likely will save the University millions of dollars in “avoided” market purchases of offsets.

In the later years of the plan, Cornell will place a high priority on working with the local community to develop offset projects. Beginning in 2037 Cornell will consistently be in the market for offsets to maintain its path to climate neutrality. Its purchase of offsets is estimated to start at 2,249 mtCO₂e in 2037 and grow to over 64,000 mtCO₂e by 2050. Community-based offsets could provide an economically viable opportunity for the University to meet its demand for offsets while at the same time strengthening its ties to the local community and building sustainable development capacity in the local economy. In recognition of this unique relationship between the University and the surrounding community, Cornell will issue RFPs specifically requesting offsets generated by projects from the immediate Ithaca and Tompkins County communities and surrounding areas.

A second role for offsets, and one that is becoming increasingly relevant, is as a measure used to comply with a mandatory GHG emissions requirements. By virtue of the size of its central plant there is a high probability that Cornell could have an emissions compliance obligation under future federal GHG regulations. Offsets offer an opportunity for Cornell to strategically manage its emissions compliance obligation and at the same time minimize costs.

Figure 4
Cornell University's Climate Action Plan
Offset Portfolio 2013 - 2050





Cornell University

**MEETING THE AMERICAN COLLEGE AND
UNIVERSITY PRESIDENTS
CLIMATE COMMITMENT**

ROLE OF OFFSETS

PREPARED BY:
ENERGY STRATEGIES, LLC
215 SOUTH STATE STREET, SUITE 200
SALT LAKE CITY, UT 84111



Introduction

On February 27, 2007, Cornell University President David Skorton signed the American Colleges and University Presidents Climate Commitment, joining 581 other college and university presidents who have pledged to reduce and offset greenhouse gas (GHG) emissions and become “climate neutral”.

The ACUPCC defines Climate Neutrality as “having no net GHG emissions, to be achieved by minimizing GHG emissions as much as possible and using carbon offsets or other measures to mitigate the remaining emissions”. To achieve climate neutrality under the terms of the ACUPCC, all Scope 1 and 2 emissions and Scope 3 emissions from commuting and air travel paid for by or through the university, must be neutralized.¹

This white paper describes the options available to Cornell University to offset their greenhouse gas (GHG) emissions pursuant to climate neutrality commitments and potential federal GHG emissions regulations. The purpose is to inform decisions by Cornell University on the role offsets could play in meeting Cornell’s climate neutrality commitment, including the types of offsets, timing of investment, the potential supply of offsets within Cornell’s land holdings, the ability of offset projects to meet Cornell University’s potential compliance obligations under federal climate legislation in addition to advancing Cornell’s climate neutrality commitment; and the types of standards and guidelines Cornell should consider following in developing an offset portfolio.

Defining Carbon Offsets

In general, GHG offsets represent a real reduction, sequestration, destruction or avoidance of greenhouse gas (GHG) emissions that can be measured and quantified, and originate from projects or activities outside the boundary of a regulatory program or an entity’s carbon footprint.²

¹ The ACUPCC *Implementation Guide*, defines three categories of GHG emissions for accounting and inventory reporting purposes. Scope 1 GHG emissions refer to direct GHG emissions “owned and controlled” by Cornell including; on-campus stationary combustion of fossil fuels; mobile combustion of fossil fuels by Cornell-owned/controlled vehicles; and “fugitive emissions” from intentional or unintentional releases of GHG”, including methane emissions from farm animals. Scope 2 refers to indirect emissions associated with the production of electricity purchased from NYSEG or other electric distribution companies serving the Cornell system. Scope 3 emissions are indirect GHG emissions that associated with activities that are a direct consequence of Cornell University’s mission and operations but are from sources not owned or controlled by Cornell.

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			No tillage	Sequestration
	Geological	Soil	Range land management	Sequestration
			Bio-char	Sequestration
			Power Plant	Sequestration
			Industrial Processes	Sequestration
Fugitive Methane	Capture and Combustion	Agriculture	Manure Management	Direct
		Municipal	Land fill gas	Direct
		Coal Mines /gas wells	Wastewater	Direct
			Vent and Flare	Direct
Industrial Gas	Capture and Destruction	HFC-23		Direct
		Sulfur Hexafluoride (SF6)		Direct
		N2O		Direct
				Direct

Offsets can potentially be created by investing in renewable energy projects as a strategy to avoid the GHG emissions associated with combustion of fossil fuels in the generation of electricity. Renewable energy projects include solar PV, solar thermal, wind, geothermal, some types of hydro and biomass. In fact, renewable energy projects are a common form of offset under the Kyoto Protocol's Clean Development Mechanism.³ A characteristic of these projects is that they avoid emissions that might otherwise have occurred or they result in an emissions reduction at a location other than the renewable project site. These types of projects are particularly challenging as offset projects in the U.S. because they result in indirect emissions reductions and it is very difficult to determine the legal ownership of the emission reduction. Moreover, due to the interconnected nature of electricity grid it is nearly impossible to accurately determine which fossil generating units dispatch was affected by the project. *Accordingly, indirect emissions reduction projects like renewable energy are not generally recognized as offsets under the ACUPCC Protocol.*⁴

This is also true of renewable energy certificates (RECs). Even though RECs have been traded in voluntary carbon markets and counted by some companies and institutions as a credit against their GHG emissions, a REC is not an offset or an allowance and does not necessarily represent a reduction in existing GHG emissions and therefore cannot be used as a credit against scope 1 and scope 3 emissions.

RECs do have a limited but important role to play as one element of a portfolio of actions Cornell University can take to achieve "climate neutrality." RECs can still be used by an institution or individual to demonstrate a valid claim they are purchasing zero-emissions electricity. Where RECs are certified and tracked by a registry, sold only once and then retired they offer a mechanism to obtain electricity with zero-CO₂e emissions. In this way RECs can be used for purposes of the ACUPCC and other voluntary "climate neutrality" commitments as a credible measure to mitigate the carbon foot print associated purchased electricity even though they are not considered a viable offset.

Sequestration projects represent activities that directly remove and store GHG from the atmosphere, permanently captures and prevents GHG from being emitted into the atmosphere, or avoids the release of stored carbon into the atmosphere. Afforestation, in which trees are planted to remove CO₂e from the atmosphere, is one of several "biological" sequestration

³ The Clean Development Mechanism (CDM) is an arrangement under the Kyoto Protocol allowing industrialized nations with a mandatory GHG emissions reduction obligation to invest in projects that reduce GHG emissions in developing countries. An essential feature of an approved CDM carbon offset project is that it has established that the planned reduction would not have occurred without the additional incentive provided by monetary value of the offset. This concept is known as "additionality". The CDM is supervised by the CDM Executive Board and is under the guidance of the Conference of the Parties of the United Nations Framework Convention on Climate Change.

⁴ American College and University Presidents Climate Commitment, "Investing in Carbon Offsets: Guidelines for ACUPCC Institutions", November 2008 v1.0, page 40.

projects that can generate credible offsets and include forest management or soil conservation/tillage practices. Geologic sequestration involves the capture of CO₂e from the flue gas emitted in the generation of electricity or other industrial processes and storage of the captured CO₂e in geologic formations that prevents its release back into the atmosphere. While “biological” sequestration offsets are common in both voluntary and mandatory carbon markets there is less familiarity and more questions around the viability of geologic sequestration as an economical and reliable offset at this time.

Methane has a global warming potential 23 times that of CO₂. When combusted each molecule of methane is converted to one molecule of CO₂, resulting in a 96% reduction of the global warming impact of methane. Methane-based offset projects consist of the capture and combustion or containment of methane generated by farm animals, landfills, municipal wastewater and sewage treatment plants, oil, gas and coal production, and other industrial waste. Methane capture and combustion projects represent the second most popular type of offset project in the voluntary over-the-counter market and generate the third highest volume of offsets worldwide under the CDM. As generators of offsets, these projects are economical, have well established protocols, are easy to monitor and recognized as highly credible in both voluntary and mandatory markets.

Finally, industrial pollutants such as hydrofluorocarbons (HFCs), SF₆ and perfluorocarbons (PFCs) have a greenhouse gas warming potential many thousands of times greater than carbon dioxide by volume. Because these pollutants are easily captured and destroyed at their source, they present a large and low-cost source of carbon offsets. As a category, HFCs, PFCs, and N₂O reductions represent over 70% of offsets issued under the CDM though a very small part of the voluntary market. The ACUPCC guidelines point to a number of reasons why industrial gas destruction offsets might not be compatible with offset strategies of American colleges and universities⁵, still they remain a recognized offset in both voluntary and compliance frameworks.

Offset Quality

Underlying the discussion above is an acknowledgement that the project-type represents a necessary condition but alone is not sufficient to ensure a project will be recognized as a credible source of offsets. Certain “quality” conditions must be met as well. Standards, verification protocols and establishment of independent registries have become the means by which offset quality is being established and measured.

For various reasons skepticism surrounds carbon offsets. Offsets have either been perceived as producing little or no real GHG emissions reduction benefit, a way of buying one’s way out of

⁵ Ibid, p. 45

an obligation to reduce actual GHG emissions or are used to by corporations or institutions merely as a tool to “green-wash”. This type of concern is best exemplified by the negative media attention that accompanied Dell Computers’ announcement that it had achieved “carbon neutrality” in a December, 30, 2008 article in the Wall Street Journal.

Concerns about offset quality in recent years have given rise to increased use of registries, and standards by participants in the voluntary markets to establish legitimacy of offsets as a GHG emissions reduction measure. These standards are being established to ensure that offsets are real, able to be verified, accurately measured, and represent an emissions reduction over and above what otherwise would have occurred.

Table 2
Key Offsets Quality Criteria

Criteria	Description
Real	GHG emission reductions should represent actual net emission reductions and must be established from a credible baseline.
Measurable	Emission reductions from offset projects must be accurately quantified.
Additional	Offset project reductions must be “in addition to” reductions that would have occurred without the offset project or the incentives provided by offset credits.
Permanent	Because offset credits are used in lieu of an on-site reduction, it is important to ensure that the offset credits either represent a permanent reduction or contractually require replacement if they are reversed.
Monitored and Verified	Offset projects must be monitored to ensure that emission reductions are occurring and verified according to accepted methodologies and regulations by an independent third party or a government agency .
Registered	Offset credits should be serialized and accounted for in a recognized registry or other approved tracking system.
Leakage	Leakage should be addressed in an offset program design to avoid unintended increase in GHG emissions outside of the project’s boundary that occurs as a result of the project.
Ownership	To avoid double counting clear and uncontested title to offset credits is necessary, and transfer of ownership must be unambiguous and documented.

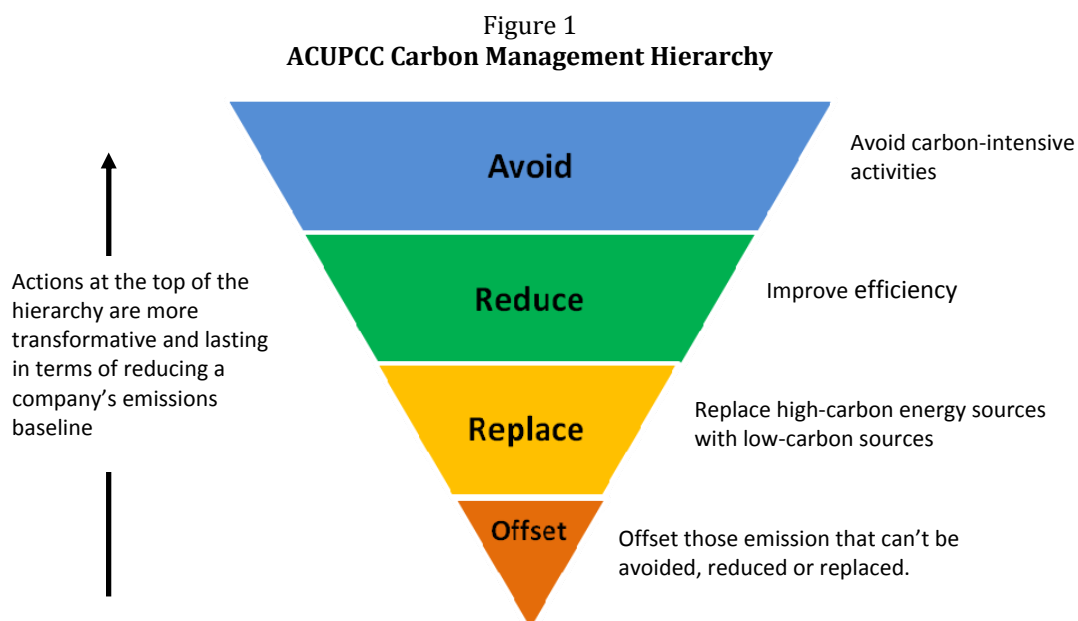
Today a number of standards and protocols exist to against which offset quality can be established. The best standards require offsets be derived from projects that can demonstrate they are additional, real, permanent, measurable, verified, have clear ownership of title, and take place during a period of time that is aligned with the emissions they are intended to offset. Increasingly offset transactions are being verified to a specific third party standard. The

Voluntary Carbon Standard, CDM, CCX, VER+ and Gold Standard are growing in recognition and in 2007 were cited by Ecosystem Marketplace as the most frequently used standards by the voluntary offset market.⁶

Accordingly, an important consideration for Cornell University in looking to acquire offsets is the institution's reputation and the importance of avoiding offsets with questionable impact on greenhouse gas emissions. The credibility of Cornell's voluntary commitment can be protected by ensuring that any purchased offsets meet strict quality criteria and follow recognized protocols.

Offsets and the ACUPCC

In *"Investing in Carbon Offsets: Guidelines for ACUPCC Institutions, Accompanying Document to the ACUPCC Voluntary Offset Protocol"*, the ACUPCC outlines a "carbon management hierarchy, depicted below.⁷ The guidelines are not intended to be "prescriptive". As part of fulfilling their ACUPCC commitment, each signatory is encouraged to evaluate and consider what role, if any, carbon offsets will play in their climate action plan according to their unique circumstances.



⁶ Ecosystem Marketplace and New Carbon Finance. May 2008. *State of the Voluntary Carbon Markets 2008*, Page 53.

⁷ Burtis, B. and Watt, I. (2008) "Getting to Zero: Defining Corporate Carbon Neutrality." Clean Air-Cool Planet and Forum for the Future. Portsmouth, NH. Accessed June 2008. www.cleanair-coolplanet.org

The ACUPCC acknowledges that in the short run it will be very difficult for institutions to achieve climate neutrality without offsets.⁸ Still, for purposes of the ACUPCC agreement the following guidelines are offered:

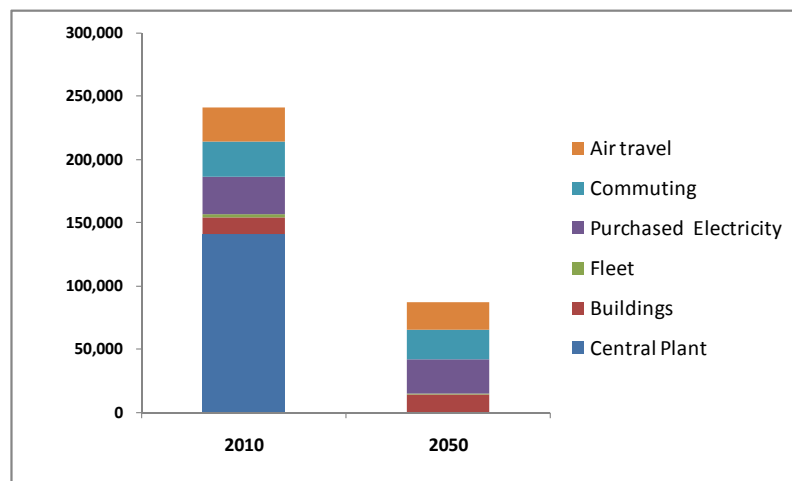
“...the short term use of high quality offsets can be an effective way to drive real reductions in GHG emissions now, and can serve as a useful tool for internalizing the costs of GHG emissions and accelerating innovation on campuses to reduce GHG emissions more quickly. As such the ACUPCC supports art investment in offsets as an effective way to help create a GHG-free future.”⁹

As such, the guidelines recommend that institutions take actions at each level of the carbon management hierarchy “simultaneously” with the objective of acquiring offsets only when internal reduction activities have been initiated.

Cornell’s Opportunity to Use Offsets

Depending on the greenhouse gas emissions reductions achieved through the other wedge strategies, and the target date for achieving climate neutrality, Cornell’s opportunity to use offsets could be substantial. Under the ACUPCC agreement all of Cornell’s GHG emissions, Figure 2, must be reduced or offset. At one extreme, if Cornell were to set a date to be climate neutral starting in 2010, the University would face having to acquire offsets to compensate for about 240,894 metric tons of CO₂e emissions based on Cornell’s projected emissions inventory.

Figure 2
Cornell’s GHG Emissions 2010 and 2050



Alternatively, if Cornell were to set a target date of 2050 to reach climate neutrality, and did not acquire offsets until all campus emissions reductions projects had been implemented and

⁸ American College and University Presidents Climate Commitment, “Investing in Carbon Offsets: Guidelines for ACUPCC Institutions”, November 2008 v1.0, page 10.

⁹ Ibid, page 10

the target date had been reached, then the University would be faced with a significantly smaller investment in offsets to meet its climate neutrality objective.

The principle factors that will determine the volume of Cornell's offset purchases are: (1) the volume of project-based offsets the University develops on Cornell owned-lands or in surrounding community; (2) the extent to which it achieves direct emissions reductions of Scope 1-3 sources; and (3) time frame and milestones the University sets for achieving climate neutrality.

It is also important that Cornell's strategy for purchasing and acquiring offsets recognize the difference between offsets needed for its voluntary climate neutrality commitment and an emissions reduction obligation it would face under a mandatory federal cap and trade program. By virtue of the volume of tons of CO₂e emitted from its central plant Cornell may be covered under future mandatory GHG regulations and may wish to use offsets to contribute to meeting an emissions compliance obligation.

Table 3
Eligible Offset Projects Under Proposed Federal and Regional Programs

	ACUPCC Offset Categories	S. 1766 Bingaman-Specter	S. 3036 Lieberman-Warner	Dingell-Boucher Draft Legislation 2008	RGGI Regional Greenhouse Gas Initiative
Regulatory Authority		Mandatory	Mandatory	Mandatory	Mandatory
		President	EPA Administrator		State DEQ
Eligible Activities	Fossil Fuel Reductions	Reductions in Non covered Sectors	Reductions in non covered sources		Energy efficiency projects that reduce fossil fuels use
	Sequestration	Geological Sequestration	Afforestation, reforestation and forest management	Afforestation, reforestation, forest management	
			Ag and rangeland sequestration	Agriculture soil sequestration	Sequestration through afforestation
	Fugitive Methane	Land fill gas	Methane capture and combustion - Non Agri Activities	Landfill gas methane capture and combustion	Landfill methane capture and combustion
		Muni Wasterwater		Waste water management	
		Animal Waste	Manure management - methane capture and combustion	Agriculture manure management	Methane reduction from farming
		Coal Mine Methane		Coal mine methane	Energy efficiency projects that reduce fuels use
	Industrial Gases	Reductions in SF ₆			Reductions in SF ₆
	Other	Removal of GHG precursors		Nitrogen fertilizers	
		Other approved activities	Other approved activities		

Under a mandatory cap-and-trade regime, the state or federal government determines which facilities are covered and sets an overall emissions cap. This cap is the sum of all allowed emissions from entities covered by the regulation. Once the cap has been set, *emissions allowances* (rights to emit) are created and issued directly to sources of emissions or auctioned. *Each allowance authorizes the release of a one ton of carbon dioxide equivalent (CO₂e).* At the end of each year entities covered under the cap must submit allowances equivalent to the level of emissions for which they are responsible.

Under federal cap and trade legislation compliance can be achieved through a combination of direct emissions reductions, purchase of allowances or the purchase of compliance-eligible offsets.¹⁰ For example the Lieberman- Warner bill, S. 3036, America's Climate Security Act of 2007 allows covered entities to use offsets to cover up to 30% of their allowances through the use of domestic and international offsets.

Accordingly, a mandatory federal requirement to reduce GHG emissions could motivate Cornell to accelerate its plans to acquire offsets and use as a strategy to minimize cost of compliance with federal GHG regulations.

Creating an Offsets Portfolio for Cornell

There are several ways Cornell could approach acquiring offsets to meet its climate neutrality obligation or emissions reduction obligation under a federal cap and trade program. The two most common approaches are buying offsets in volume through a request-for-proposal (RFP) or as over-the-counter purchases through third party brokers.

Under an RFP Cornell would specify the volume, minimum quality standards, offset types and timelines they would be willing to accept for the based on how the offsets would be used, i.e. voluntary or compliance.

In meeting its voluntary ACUPCC "climate neutrality" commitment Cornell has a good deal of freedom in using offsets and the flexibility to think "out-of-the- box" and explore opportunities to develop non- traditional offset programs and projects. Community-based offsets may be an economically viable option for the University that would provide co-benefits to the local community and promote Cornell's mission of service. In recognition of the unique relationship between the University and the surrounding community, Cornell could issue an RFP specifically requesting offsets generated from projects aligned with the *Energy and Climate Change Elements of the Tompkins County Comprehensive Plan*.

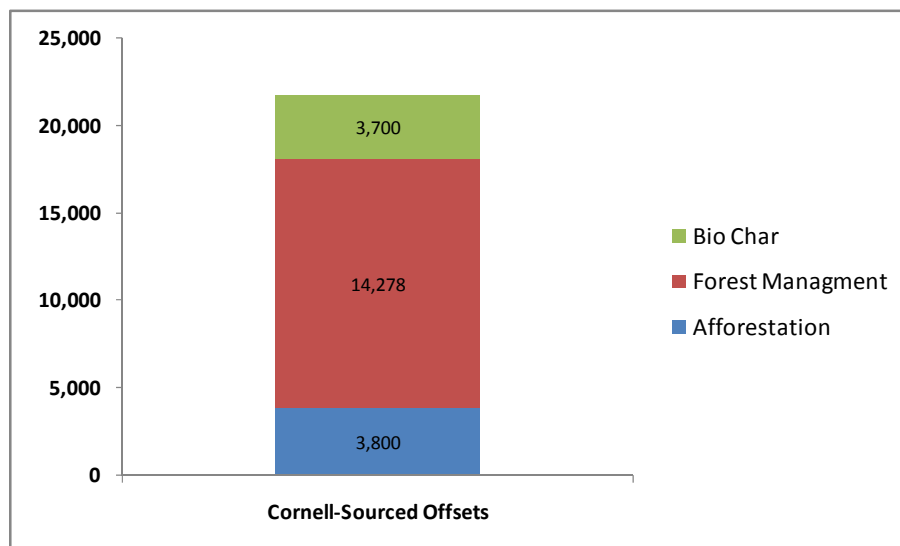
¹⁰ Under Lieberman-Warner the number of offsets that can be used to meet compliance obligations under the cap is 30 percent; 15 percent domestic and 15 percent international. Dingell Boucher limits use of domestic and international offsets to 5% for the period 2012-2017 then allows the use of a combination of domestic and international offsets to grow to 15% in 2018-2020, 30 percent in 2021-2024 and 35 % beyond 2025

Another approach would be for Cornell to join the Chicago Climate Exchange and purchase offsets from the CCX's pool of carbon financial instruments. Either approach can be used for voluntary or compliance purposes.

Cornell could also buy offsets with the procurement of goods and services. One option currently available is the simultaneous purchase of offsets when University related air travel is purchased to compensate for GHG emissions associated with the travel. Airlines and third parties affiliated with internet based travel providers currently provide this service.

Cornell could also enter the offsets market as a developer of offsets. The opportunity for Cornell-sourced offsets to contribute to both the University's voluntary climate neutrality commitment and emissions reductions obligations under federal GHG regulations is not insignificant. According to research of the Offset Wedge Working Group afforestation, forest management and, the CURBI biochar research demonstration projects appear to have the potential to generate over 20,000 metric tons of CO₂e offsets per year.

Figure 3
Annual Offsets from Cornell-Sourced Sequestration Projects



The vast majority of these offsets are generated from afforestation and forest management projects that appear to be cost competitive with forestry offsets currently traded in the voluntary and mandatory carbon markets. Moreover, afforestation projects are already recognized as eligible for use under current mandatory GHG regulations and forest management offsets appear likely to be included in future U.S. regulatory regimes.

According to figures developed by CURBI and the Forestry Department, Cornell managed forests could potentially contribute an average of more than 18,000 of compliance-eligible offsets per year over a 50 year period. This figure equates to over 10% of the compliance obligations the University might face under federal climate regulations.

Decision Criteria for Acquiring Offsets

Offsets should be regarded as one GHG emissions investment opportunity among a diverse portfolio of options that will contribute to Cornell achieving climate neutrality over the long term. The potential costs Cornell faces to federal legislation and acquiring offsets to fulfill Cornell's climate neutrality commitment is large enough to justify a very deliberate and strategic approach to management of Cornell's offset portfolio. Accordingly, Cornell would benefit from developing a business plan that could be used to guide its acquisition, purchase and management of offsets. The goal would be to create a portfolio of offsets that perform well according to several overarching principles:

1. *Aligned with Cornell's Core Mission* -- Offsets used by Cornell as a CAP measure should have a strong tie to Cornell's core mission, i.e. teaching, research, or outreach and/or to the local community. Both ACUPCC publications, *Investing in Carbon Offsets: Guidelines for ACUPCC Institutions* and the *ACUPCC Voluntary Carbon Offsets Protocol*, recognize that offsets projects and purchases can be designed in a way that add value and are aligned with the education, research and community service mission of institutions of higher education.
2. *Strategic* – Offsets represent real emissions reductions of GHG. They are a tool the University can use strategically to manage compliance costs and meet both voluntary and mandatory climate commitments.
3. *Quality* – In acquiring or developing offsets Cornell should adopt a minimum quality standard that ensures offsets acquired by Cornell for both voluntary and compliance purposes are additional, real, measurable, verifiable, owned, and permanent. Offsets acquired by Cornell to compensate for its GHG emissions should be registered with a reputable carbon registry and accounted for with a unique serial number.
4. *Cascading Benefits* – Offsets acquired or developed by Cornell should provide additional societal and environmental co-benefits. Cornell University's acquisition of offsets can be structured in a way that places a high priority on offsets from projects with demonstrated educational, environmental and social co-benefits and support more sustainable communities.

5. *Added Value* – Cornell should not regard itself as just a potential buyer of offsets. Cornell’s expertise in environmental science, natural resources, agriculture, business and law could be used to contribute to the development of protocols, practices, hedging strategies and other business models related to development, market purchases and banking of voluntary and compliance offsets. Cornell should be engaged at different points along the offset value chain including as developer, purchaser, research center, technology incubator and policy leader.
6. *Portfolio Diversity* – Development of an offsets portfolio for Cornell should include a range of project types, suppliers, and be sourced from a number of geographic locations that provide diverse opportunities for innovation, academic collaboration, civic engagement, and other local community and environmental benefits.

Conclusions

Offsets have two important roles to play in Cornell’s efforts to address climate change. In the context of its voluntary commitment to the ACUPCC, offsets are regarded as complementary to direct emissions reductions and intended to be paired with internal reductions to enable Cornell to be “climate neutral”.

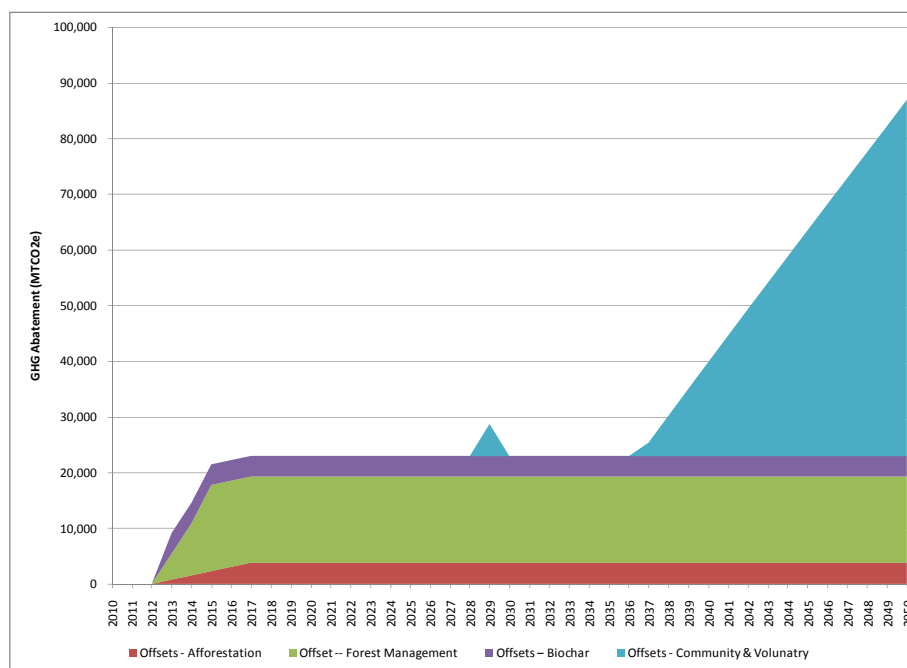
One of the attractive features of using offsets is the flexibility to design acquisition strategies that are aligned with the mission of Cornell and provide an opportunity to strengthen local stakeholder and community relationships. Cornell’s portfolio of GHG mitigation measures reflects this strategic role the University envisions for offsets.

The development of mission-linked afforestation, forest management and biochar offsets on Cornell-owned lands starting in 2013 support the land grant mission of the University. Moreover, given forecasts of future the costs of carbon under federal cap and trade legislation, Cornell’s approach to developing over 20,000 metric tons of CO₂e offsets per year likely will save the University millions of dollars in “avoided” market purchases of offsets.

In the later years of the plan, Cornell will place a high priority on working with the local community to develop offset projects. Beginning in 2037 Cornell will consistently be in the market for offsets to maintain its path to climate neutrality. Its purchase of offsets is estimated to start at 2,249 mtCO₂e in 2037 and grow to over 64,000 mtCO₂e by 2050. Community-based offsets could provide an economically viable opportunity for the University to meet its demand for offsets while at the same time strengthening its ties to the local community and building sustainable development capacity in the local economy. In recognition of this unique relationship between the University and the surrounding community, Cornell will issue RFPs specifically requesting offsets generated by projects from the immediate Ithaca and Tompkins County communities and surrounding areas.

A second role for offsets, and one that is becoming increasingly relevant, is as a measure used to comply with a mandatory GHG emissions requirements. By virtue of the size of its central plant there is a high probability that Cornell could have an emissions compliance obligation under future federal GHG regulations. Offsets offer an opportunity for Cornell to strategically manage its emissions compliance obligation and at the same time minimize costs.

Figure 4
Cornell University's Climate Action Plan
Offset Portfolio 2013 - 2050





Your Checklist

- ✓ Adjust your laptop's power settings to save energy
- ✓ Rethink bottled water
- ✓ Wash your laundry in cold water
- ✓ Get an Ithaca Carshare membership for grocery trips
- ✓ Bring your own bag when shopping
- ✓ Use a reusable coffee mug
(Cornell Dining coffee shops sell them!)
- ✓ Go out of your way to find recycling receptacles
- ✓ Get involved on campus!

Sponsored by the Presidents Climate Commitment in Action Committee (PCCIC), Cornell Utilities and Energy Management, Office of Environmental Compliance and Sustainability, and the Sustainability Hub.

{ SUSTAINABLE CORNELL }

One **SMALL** Act

One **BIG** Impact

How **YOU** Can Make a Difference on Campus



SUSTAINABILITY
AT CORNELL

Sustainability ~

Why should I care?

"Each of us has a part to play in sustainability at Cornell. What piece of the puzzle do you hold?" President David Skorton



Climate Change is happening, and it's happening faster than we expected.

We are in a crucial time – our current actions will affect the future of our planet, and of the human race.

“More and more colleges are getting serious about going green. In June (2007), 284 university presidents representing some of the nation's most influential schools announced an agreement pledging to make their campuses “carbon neutral.”

The message was clear. **“We’re saying that sustainability is no longer an elective,”** says Cornell president David Skorton. ”

NewsWeek, June 2007

On February 23, 2007, President Skorton signed the President's Climate Commitment, pledging Cornell to carbon neutrality by 2050.



AMERICAN COLLEGE & UNIVERSITY
PRESIDENTS CLIMATE COMMITMENT

- ✓ As the land-grant institution of New York, Cornell is uniquely positioned to work on sustainability issues that benefit the whole state.
- ✓ Check out cutting-edge research development at Cornell's Center for a Sustainable Future: www.sustainablefuture.cornell.edu.



Engineers for a Sustainable World

Active group of engineers with several innovative projects, such as Drive not to Drive: rso.cornell.edu/esw/; or contact Nick Chisholm (noc3)

KyotoNOW!

Campaigned for the President's Climate Commitment several years ago; focused on energy and political activism: rso.cornell.edu/kyotonow/, or contact Fil Eden (wje6)

Roots and Shoots

Focused on environmental education; runs an Earth Day 5K and volunteers at the local ScienCenter: rootsandshoots.cornell.googlepages.com; or contact Lura Salm (lss67)

Society for Natural Resource Conservation

Has focused on double-sided printing, composting, and most recently plastic reduction: rso.cornell.edu/snrc; or contact Sherry Martin (sm674)

Solar Decathlon

Project to design and build a solar-powered house: cusd.cornell.edu

Sustainable Enterprise Association

Undergraduate component of the graduate group NetImpact, connected with the Johnson Graduate School of Business: johnson.cornell.edu/sge/programs/studentorgs/sea.html



Sustainability Hub

Focuses on projects for a more sustainable campus, such as Greeks Go Green, Back to the Tap, and waste reduction in Collegetown; also organizes campus events such as Earth Day: rso.cornell.edu/sustainabilityhub/; or contact Christina Copeland (cpc53)

Want to get more involved?



Check out these student groups!

Visit their websites, or email the contact person listed. They all welcome new members.

Automotive X-Prize

Project to design, build, and market a car that will get 100+ mpg: cornellaxp.com

Big Red Bikes

Recently branched off from the Sustainability Hub to focus on creating a campus bike-share system: contact Pat Farnach (paf52)

Cornell Computer Reuse Association (CCRA)

Collects and refurbishes computers to donate internationally to community centers, orphanages, and other organizations: rso.cornell.edu/ccra/

Cornell Organization for Labor Action

Activism for labor rights on campus and nationally: colanet.org; or contact Fil Eden (wje6)

Cornell Public Service Center

Promotes leadership development and social change: psc.cornell.edu

Dilmun Hill

Cornell's student-led organic farm: cuaes.cornell.edu/cals/cuaes/ag-operations/dilmun-hill/



YOU can help Cornell reach our goal of climate neutrality.

Here are some **GENERAL TIPS** for being more sustainable:

☀ **Recycle!** Ithaca and Cornell have the following recycling guidelines:

YES: Bottles, cans, #1 and #2 plastics, #5 containers (yogurts), and paper milk and juice cartons

NO: Containers that have a wider mouth than base (except #5 plastics)

Paper & Cardboard: Paper can be recycled in the blue receptacles in your residence hall and around campus. Cardboard must be put in designated containers.

Batteries: Dead batteries are collected for recycling at Robert Purcell Community Center (1st floor); or start your own battery recycling program by contacting the University Grounds Recycling Department at (607) 254-1666 or recycle@cornell.edu.

Computers: Contact the University Grounds Recycling Department at (607) 254-1666 or recycle@cornell.edu for information about recycling your computer.

☀ **Go paperless with your banking.** Even if you have an online account, you still may get statements in the mail. So change your settings online, or call the bank and ask to have them changed.

☀ **Use a travel mug for your coffee.** If you purchase a cup of coffee every day in a disposable mug, you contribute about 23 pounds of waste per year – a significant amount.

Check out one of Cornell Dining's travel mugs, available at coffee shops and cafes across campus. Bring any re-usable mug to Cornell Dining's a la carte or convenience stores and get a large drip coffee, hot tea, or hot cocoa for the price of a small!



☀ **Bring your own canvas or cloth bag while shopping.** Carry items bought at the Cornell Store, etc. in your backpack or school bag – or bring along your own plastic bag.

☀ **Report maintenance problems.** A leaky window or a radiator that won't shut off can waste energy, as well as make you uncomfortable. You can request repairs for these and other maintenance problems by going to the Campus Life website at housing.cornell.edu. Select "Facilities Work Order Requests" from the menu on the left and enter the requested information.

Keep reading for more easy tips!

Computers

The US Department of Energy says:

AWAY FOR 20 MINUTES: Turn your **monitor** off!

AWAY FOR TWO HOURS: Turn your **computer** off!

Screen savers do NOT save energy. Take a minute to turn on Power-Saving Features *and...*

On your PC:

1. Open "Display" under your Windows Control Panel
2. Select the "Screen Saver" tab at the top of the "Display Properties" window
3. Select the "Power..." button at the bottom of the "Screen Saver" tab
4. Suggested settings: Turn off monitor: *After 15 mins.* Turn off hard disks: *After 15 mins.* System standby: *Never.*

On your MAC:

1. Click on the Apple in the top left corner and select "System preferences"
2. Select the "Energy Saver" icon in the "Hardware" section
3. Suggested Settings: Put the computer to sleep when it is inactive for: *Never.* Put the display to sleep when it is inactive for: *15 mins.* Check "put the hard disk(s) to sleep" when possible.



- ➔ **When your computer is in "sleep" mode it uses 70% less energy.**
- ➔ **There are approximately 10,000 student-owned computers on campus.**
- ➔ **Activating your computer's power management modes can save up to \$75 in electricity each year.**

Resource for Power Save Feature instructions:

<http://computing.fs.cornell.edu/Sustainable/FSSustainableComputingGuide.pdf>

All of Cornell Dining's FreshTake Grab-n-Go containers and labels are compostable!



Food

➔ **Compost leftover food, paper waste, and other compostable items at the following dining units:** Mandible, Ivy Room, Martha's, Moosewood at Anabel Taylor, Synapsis, Mattin's, and Trillium.

Cornell Farm Services composts about 6 tons of food each week from all of Cornell's dining halls (both pre- and post-consumer compost)!

- ✓ Cornell has its own student-run organic farm, Dilmun Hill. Email dilmunhill@cornell.edu to get involved, or to be put on their listserve.
- ✓ Cornell Dining has gone trayless in Risley Dining and in all five West Campus dining rooms, which saves thousands of gallons of water, plus discourages food waste due to people taking more food than they consume.



- ✓ Cornell Dining purchases more than 33% of its produce locally or regionally, cutting down on fossil fuel use from transportation.
- ✓ Plans are underway to begin converting all of Cornell Dining's waste vegetable oil into bio-diesel to use in campus vehicles!



Laundry

- ➔ **Use lower temperature settings:** Use warm or cold water for the wash cycle, and only cold for rinses. Washing clothes in cold water saves 90% in energy use compared with using hot water. If all American households switched to cold cycles, we could save the energy equivalent of 100,000 barrels of oil a day.
Hot water is only needed for greasy stain removal, and otherwise can fade your clothing faster. Washing in cold will preserve that favorite sweatshirt!
- ➔ **Load the washing machine to capacity when possible.** Washing one large load will take less energy than washing two loads on a low or medium setting.
- ➔ **Don't add wet items to a dryer load that is already partially dried.** Take clothes out when they are still slightly damp to reduce the need for ironing – another big energy user.



Refrigerators

- ➔ **Share a mini-fridge with a roommate, or use the refrigerator in your building's communal kitchen.** And if you aren't using it, unplug it! Appliances still draw energy when plugged in, even if they're not in use.
- ➔ **Be sure that your refrigerator is sealing properly.** Close the door on a dollar bill. If you can pull the bill out easily, the seal needs to be fixed.
- ➔ **Keep the refrigerator between 35 and 38 degrees Fahrenheit** and the freezer at 0 degrees Fahrenheit.

Light Bulbs

One of the easiest ways to reduce energy use is by turning off lights when not in use, and by choosing energy-efficient light bulbs.



Conventional Light Bulbs

Incandescent light bulbs are very inefficient – only 10-15% of the electricity used to operate them goes to produce light. The remaining 85-90% is lost as heat. Incandescent bulbs are also fragile and have a short life.



Halogen Lights

These lights are not only inefficient and expensive to replace, but they pose a serious fire hazard. If you want to use a torchiere lamp, buy a compact fluorescent bulb for it instead.



Compact Fluorescent Lights (CFLs)

CFLs are bulbs that provide the same amount of light as incandescents, but are able to do so using a lot less energy. On average, CFL's consume 75% less energy and can last up to 10 times longer than traditional light bulbs. While these bulbs do have a higher initial cost, they still will save more than \$20 in avoided energy consumption over three years.

Transportation

Having a car on campus is expensive, and because parking is so limited, you would likely keep your car parked in a lot far from your residence and classes.

Most Cornell students walk, take the bus, or ride their bikes... which is healthier for us, and healthier for the environment!

TCAT buses

TCAT (Tompkins Consolidated Area Transit) buses run regularly through campus, and are a great way to get to classes... especially in the winter.

Visit www.tcatbus.com and check the website's TCAT trip planner for times and routes. Best of all, new Cornell students receive automatic, no-fee OmniRide privileges for their first academic year, allowing unlimited access to all TCAT buses in Tompkins County. (TCAT is free for ALL students after 6:00pm and on weekends in Tompkins County.)

Ithaca Carshare

Cornell's Transportation Office provides free Ithaca Carshare memberships to all students who wish to join, and who are eligible. Cars can be found at three convenient locations on campus. Visit www.ithacacarshare.org for information.



Biking on campus

Biking on campus is safe and easy, thanks to a system of marked and easy-to-follow bike paths. Check out Cornell's Bike Map at www.bike.cornell.edu/oncampus.html.



Coming soon: Keep your eyes open for a bike-share program at Cornell. The student-run Big Red Bikes program has been working on implementing this for the past year!



Water

➔ **Fill a reusable water bottle with tap water (or Brita-filtered water!) instead of buying bottled water.** If just one in every 20 gym-goer picked up this habit, the United States would reduce plastic waste by almost 30 million pounds each year.



Also, EPA tap water health regulations are much stricter than FDA bottled water regulations. *Bottled water is no healthier than tap water!*

PICTURE THIS: To visualize the average energy cost associated with bottled water (making the plastic, processing and filling the bottle, transporting the bottle to market, and then dealing with the waste) it would be like filling up a quarter of every bottle with oil. (Source: http://seattlepi.nwsource.com/local/312412_botwaterweb.html)

➔ **Keep showers short!** About 75% of the water used in most homes can be traced to the bathroom.

A **two-minute** reduction in your daily shower time can save more than ten gallons of water. By reducing the time we spend in the shower by **one minute** each, residents of Cornell and surrounding communities could save over 100,000 gallons of water per day. *Try timing yourself in the shower, and see if you can improve!*

PS: Wasting water also wastes electricity. The process of cleaning, supplying, and heating water is the largest use of electricity in many cities.



Climate Action

*Since 2008,
Cornell has
reduced
GHG
emissions by
nearly 30%*

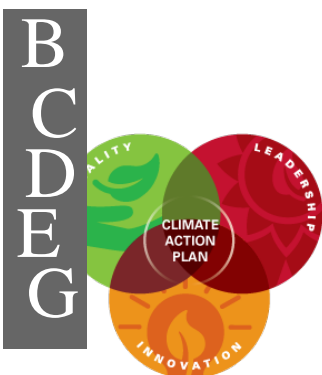
Initiative

Climate Action Plan

Cornell's award-winning plan
to create a low-carbon
future...

Related Initiatives

[Climate Change
Information Portal](#)
[Climate Focus Team](#)
[Greenhouse Gas
Emissions Inventory](#)
[Mission-Linked
Carbon Offsets](#)
[KyotoNOW](#)
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Resources

- [Climate Action Plan
Acceleration
Working Group
June 2014
Report\(pdf\)](#)
- [CAP 2013 Update
& Roadmap 2014-
2015 \(pdf\)](#)
- [CAP 2011 Update
\(pdf\)](#)
- [CAP 2011 Executive
Summary \(pdf\)](#)
- [CAP 2009 and
Basis](#)

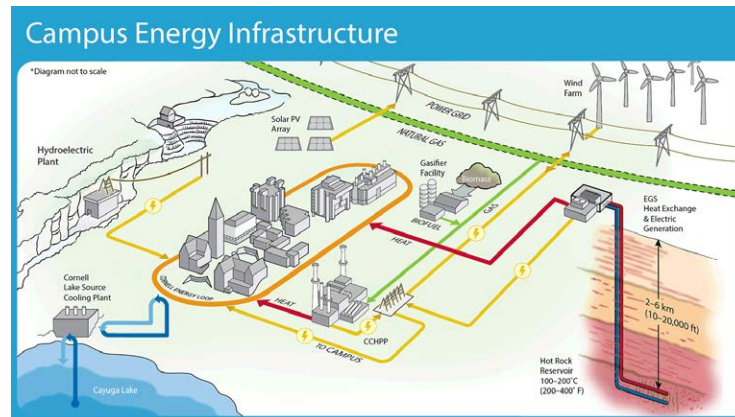
**The Climate Action Plan (CAP) is Cornell's
overarching plan to move to a low-carbon
future.** The original CAP was developed in 2009
by Cornell faculty, students, and staff with funding
from the state energy authority, NYSERDA. The
plan is intended to enhance the university's core



Documentation
(pdf)

- **President Skorton on Future Climate Action - 2013**
(video)
- **President Skorton on Climate Commitment - 2007**
(video)

mission of education, research, and outreach, while cutting net carbon emissions to zero. Since 2008, we have initiated broad actions to green our campus and have reduced gross emissions by more than 30%, and by nearly 50% since 1990. These collective actions are significant steps forward and have established Cornell as a national leader among universities that have committed to carbon neutrality.



It's imperative. Here's what the evidence is telling us: the climate of our planet is warming at an alarming rate and human activities are the cause. How to reverse this trend poses an immense challenge, and the imperative to change our course is here, now. As one of the world's leading universities, Cornell University has a pivotal role to play. We have a responsibility both to reduce our contribution to climate change and to generate solutions to address the mounting impacts on our planet.

We must take action. For 150 years Cornellians have taken on the world's issues as our direct challenges. We are committed to find new solutions to complex problems. What has kept Cornell at the forefront of the sustainability movement is our institution-wide commitment to focus our collective strengths in education, research, and public engagement toward one of humanity's greatest challenges – climate change. We put this commitment into action every day, in

ways large and small.

We're at a crossroads. We have made great progress, but to move ahead we need to change the way we do things. Early successes were achieved through projects that yielded a return on capital investment. Current economic realities, including cheap natural gas and the absence of a price penalty for carbon emissions, mean that further significant progress will be more difficult and will require making key actions institutional priorities to benefit Cornell's academic mission and achieve carbon neutrality. Working collectively is the answer.

We can achieve our goal. Cornell's updated Climate Action Plan prioritizes the steps toward campus climate neutrality. Academic and operational innovation are essential to our success. As we work together to create a living laboratory for climate smart behaviors, education, and research, we are engaging the Cornell community in constructive conversations about how best to move forward. These conversations involve faculty across disciplines, students across colleges, staff across campus, and university leadership. The plan incorporates input from key project leaders, as well as ideas and contributions from students, faculty, and staff. There are ways for everyone to get involved.

It takes teamwork. Cornell's Climate Action Plan Roadmap 2014-2015 presents the comprehensive set of 62 actions endorsed by each of the ten PSCC Focus Teams, including one action being spearheaded by the Campus Sustainability Office. Actions are listed according to the focus team that is responsible for following up and tracking progress. **Learn more about each action using the icons below.**



News

Videos

Events

Actions

*In Staving Off
Climate Change,
Social Landscape*

*Professor
Discusses
Causes and*

*Senior Group is
Guiding Cornell's
Climate Actions*

Adjusts

Women, people of color, children, the elderly, workers, immigrants, communities of color will all be affected disproportionately by the impacts of climate change...

Implications of Climate Change in Seminar

Around 10 gigatons of carbon were released into the atmosphere this year, making 2015 the warmest on record...

This new group will set climate-action direction and prioritize initiatives...

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	People	Discover Research		How We Rank	
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	Transportation	Smackdown			
	Waste	Explore Your			
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