Dartmouth College HANOVER • NEW HAMPSHIRE • 03755-3529
Office of the Provost • *6004 Parkhurst Hall, Rm. 204* • *(603) 646-3532* • *Fax (603) 646-3773*
E-mail: Kathleen.lambert@dartmouth.edu • *Website: http://www.dartmouth.edu/~sustain/*

Kathleen Lambert
Sustainability Manager

March 23, 2009

To whom it may concern:

On behalf of Dartmouth College, we are pleased to submit the enclosed proposal to the New Hampshire Greenhouse Gas Emissions Reduction Fund. We are requesting $300,000 for a Campus Energy and Sustainability Management system to achieve and estimated 10 to 15 percent reduction in our total greenhouse gas emissions improved building energy performance, innovative campus smart grid technology, and energy feedback systems.

If you have any questions, please do not hesitate to contact us.

Sincerely,

Kathleen Lambert
Sustainability Manager
603-646-3532
Kathy.Lambert@dartmouth.edu

New Hampshire Greenhouse Gas Reduction Fund
Campus Energy and Sustainability Management System
Dartmouth College

1. PROPOSAL COVER PAGE

1.1 Program Title
Implementation of a Campus Energy and Sustainability Management System

1.2 Program Type
The Campus Energy and Sustainability Management (CESM) system will reduce energy use and associated greenhouse gas emissions at Dartmouth College by using a web-based interface to track, report, and optimize building energy performance. The project supports items 5, 7, 8, 10 and 11 in the Public Utilities Commissions Request for Proposals issued February 23, 2009.

1.3 Program Summary
The Campus Energy and Sustainability Management system will reduce greenhouse gas emissions at the College by tackling the most energy-intensive activities on campus -- the heating, cooling, ventilation and lighting of existing buildings. The system uses innovative technologies for campus-wide energy system data aggregation and web-based system performance dashboards to:

- Provide a practical and highly-functional tool for Dartmouth facilities operations personnel to perform "continuous commissioning" of building energy systems and ensure that systems remain in optimum operating efficiency over their anticipated life – including during periods of peak electric load in the state.
- Provide an enhanced data collection and exploration system for cross-disciplinary research aimed at promoting individual behavioral change and campus-wide conservation using real-time building energy feedback data.

1.4 Low-Income Residential Customer Qualification
This project is not designed to serve low income residential customers.

1.5 Identification of Applicant Organization
Dartmouth College, Hanover, NH 03755. Dartmouth is a private, non-profit, liberal arts institution founded in 1769.

1.6 Identification of Subcontractors and Partners
Subcontractors - We plan on subcontracting to the firm of Interval Data Systems of Waltham, MA or IncuityCEM of Mission Viejo, CA, a division of Rockwell Automation to establish the data historian and web-based system-software portions of this project.

Partners - We will partner with the following internal (Dartmouth College) resources for the remaining portion of the project:

- Facilities Operations and Management department (FO&M) to automate our extensive existing utility metering network and to develop a continuous commissioning program for our building energy systems.
- Dartmouth Sustainability Initiative of the Provost's Office to link the system with a campus energy awareness and conservation campaign as well as distill lessons, develop a case study and share results with others.
- Computer Science, Sociology, and Engineering Departments to link the Campus Energy and Sustainability Management system with existing research programs related to computerized real-time energy feedback, digital social networking tools, and behavioral change research.

1.7 Authorized Negotiators

Stephen R. Shadford, P.E., LEED AP
Energy Engineer
Dartmouth College
Facilities Operations and Management
Engineering and Utilities
Phone: 603-646-9794
Stephen.r.shadford@dartmouth.edu

Kathy Fallon Lambert, M.S.
Sustainability Manager
Dartmouth College
Office of the Provost
63 South Main Street, Room 316
Phone: 603-646-3532
kathy.lambert@dartmouth.edu

William Ploog, Ph.D.
Associate Director
Office of Sponsored Projects
Dartmouth College
11 Rope Ferry Rd. #6210
Hanover, NH 03755-1404
(603) 646-3682
fax 603-646-3670

1.8 Projected Energy Savings (see Attachment 1)

We estimate that the proposed program will produce an energy savings of 15% of current campus energy usage. For Dartmouth, this amounts to approximately 9,000 mWH and 750,000 gallons of #6 fuel oil annually. The savings stream will come on line over a 2-year period, after which the full 15% savings would be maintained by use of the system on an annual basis. We estimate that 5% of the savings will be achieved through leveraging from energy-use feedback to the campus community, social learning techniques and behavior changes resulting from use of the system to display energy and sustainability indicators. It is estimated that the life of the proposed measure will be approximately 10 years before having to update or refresh the computer hardware and software portions of the system. Savings over the measure life are expected to be approximately 90,000 mWH and 7 MM Gallons of #6 fuel oil.

1.9 Projected Greenhouse Gas Emissions Reductions (see Attachment 1A)

We have estimated greenhouse gas savings resulting from implementation of the system over the assumed 10 year measure life of the system of 106,428 metric tons of carbon dioxide equivalent (MTCE) with a savings of 11,506 MTCE per year at full capacity. Dartmouth currently co-generates approximately 40% of it electrical use via steam turbine generators, while purchasing the remainder. We have, therefore, deducted emissions from the co-generated 40% portion of the electrical consumption from the electrical GHG emissions calculations as the emissions for the co-generated electricity essentially come from burning #6 fuel oil in our boilers to make steam for the turbines. These emissions are effectively accounted for in the emissions reductions for #6 fuel oil.

1.10 Length of Program (see Attachments 1A and 6)

We anticipate that it will take approximately 1 year to install the Campus Energy and Sustainability Management system and an additional year to fully employ the features of the system, verify savings, and report results. It is assumed that the hardware and main system software upon which the system will operate will have a life of approximately 10 years at which point underlying computing hardware and software will need to be renewed. The metering infrastructure and overall program, however, is designed to operate indefinitely. The measure life, therefore, is estimated to be 10 years. The target time period for which funding is sought is June 2009 through June 2011.

1.11 Total Program Costs (see Attachment 1A)

The estimated total program cost for 10 years is approximately $3 million. The two-year project budget for purchase and installation is approximately $1 million.

1.12 Funds Requested (see Attachment 2)

We request $330,936 from the Greenhouse Gas Emissions Reduction Fund. This is equal to 33% of the 2-year project costs or approximately 10% of the cost of measure over its life. The funds will be used to cover a portion of the direct purchase and installation costs of the Campus Energy and Sustainability Management system. The target time period for which funding is sought is June 2009 through June 2011.

2. EXECUTIVE SUMMARY

2.1 Introduction

In September 2009 Dartmouth College committed to reducing its greenhouse gas emissions by 30% below 2005 levels. To achieve this goal, we are developing a series of greenhouse gas reduction strategies, with an initial focus on campus buildings. Building energy use currently accounts for approximately 80% of Dartmouth’s estimated greenhouse gas emissions. By optimizing building energy use and employing real-time energy feedback to promote behavioral change with a Campus Energy and Sustainability Management system, we expect to reduce greenhouse gas emissions by 10 to 15 percent for a total reduction of 8,800 to 11,500 metric tons per year (in carbon dioxide equivalents).

As part of the overall greenhouse gas reduction strategy, Dartmouth College is committed to making significant capital improvements over the next several years in its existing buildings and building energy systems with the intent of reducing energy consumption and greenhouse gas emissions. In order to maximize the effects of these improvements and to ensure persistence of savings, we propose to implement a software-based Campus Energy and Sustainability Management System. This tool will allow Dartmouth to improve its energy infrastructure while providing an accurate, continuous near-real-time view of the performance of the systems.

In addition to the benefits of this system for continuous building commissioning, it provides a means for gathering and using building-specific real-time energy data to promote individual occupant and organizational behavior change. Occupant behavior and energy use is particularly important in buildings with large plug load demand such as campus offices, dormitories and laboratories. The interrelationship between behavior, energy, and climate change is currently receiving significant focus due to the great potential for achieving this leveraging effect. One of the organizations focusing on this topic is the American Council for an Energy Efficient Economy (ACEEE) supported by several major utility and energy regulatory agencies. The Campus Energy and Sustainability Management system at Dartmouth College will be an ideal tool to highlight, track, and experiment with these interrelationships.

2.2 About the Campus Energy and Sustainability Management System

We will work with a software vendor to tailor a web-based Campus Energy and Sustainability Management system for the Dartmouth College Campus. The resulting system will:

1. track the actual energy use of all major buildings on campus in real time
2. identify problems that lead to wasted energy as they occur
3. allow engineers to take immediate corrective action to avoid unnecessary energy use and greenhouse gas emissions
4. bring building energy use in line with expected performance on a daily (as opposed to semi-annual) basis
5. provide data for real-time energy feedback systems
6. serve as a tool for evaluating the impact of behavioral change and programs.

A similar campus energy management system has been implemented at Rice University and an example from that system illustrates how real-time data and reports on building performance can be used to optimize energy use in time-sensitive manner. The attached screen shot (Attachment 3) shows actual building energy for cooling use vs. predicted energy use forecasted by the energy management system. The graph shows a spike in the blue line where energy has been wasted due to poor cooling system controls. By having a system in place that will generate alarms when buildings exceed predicted energy use, we expect to find and remedy the causes and reduce our energy consumption by approximately 10%.

The most flexible Campus Energy and Sustainability Management systems are based on web-services models, enabling connectivity to a variety of energy systems and viewing of system reports and indicators by a wide variety of stakeholders. At Dartmouth, stakeholders would include facilities operations managers, sustainability managers, central heating plant managers, executive financial managers, engineering, computer science and sociology academic communities, and building end-user communities. Other stakeholders might include peer New Hampshire higher education institutions who would benefit from viewing data, system performance and sustainability metrics, and behavior-leveraged additive effects, all made possible via the web-services model. We would also envision sharing data and performance results with other collaborators working on the interrelationship between behavior, energy and climate change. We anticipate an additional savings of 5% through collaborative activities with academic and building end-use communities.

As part of the project we will take advantage of our education and research assets to track the effectiveness of the system, monitor results, distill lessons and disseminate a case study for other colleges, universities, secondary schools, private corporations, as well as non-profits and municipalities that own and manage multiple buildings. We feel that this will be an effective leveraging tool for the New Hampshire GHG Emissions Reduction Fund and its mission.

2.3 Implementation

Dartmouth intends to implement the Campus Energy and Sustainability Management system through a phased approach, starting with the buildings that have the highest energy intensity (see Attachment 4). Over time, the full array of approximately 250 building energy meters will be tied in to the system. For the full build-out, we envision using the system to track additional indicators of sustainability which impact our overall carbon footprint and greenhouse gas emissions. These could include transportation, recycling, composting and fertilizer use (see Attachment 5). We will also explore the potential to tie the system in with Dartmouth's Environmental Health and Safety management system which is currently used to track compliance with environmental regulations.

2.4 Connections to Research at Dartmouth

Several researchers are Dartmouth are working on developing and understanding the impact of real-time energy feedback displays and social networking tools on building occupant choices. Lorie Loeb in the Computer Sciences Department has developed a system for dormitories on campus. This system, known as Green Lite Dartmouth (greenlite.dartmouth.edu), shows animations of a polar bear in various levels of happiness or distress depending on the building's energy use. Chris Levey in the Thayer School of Engineering has developed another system, used in an academic building that shows gauges depicting green, yellow, and red depending on current resource use in the building. In both cases, the concept is to provide real-time information feedback to building occupants to influence their behavior. Existing research on college campuses suggests that such systems can produce substantial reductions in energy use through changes that reduce plug load, hot water, and lighting (e.g., Petersen et al. 2007)[1]. We are already working with these researchers to test the impact of the dormitory feedback system during an upcoming campus energy conservation campaign by comparing the percent change in energy use for buildings with and without real-time feedback displays.

Once the Campus Energy and Sustainability Management system is in place, we expect to work further with these research teams to combine daily building energy use with real-time feedback displays to maximize conservation. Using energy data from the Campus Energy and Sustainability Management system, we will establish building energy and greenhouse gas reduction targets for each building. We will work with academic departments and researchers to

---

[1] Petersen, J.E., V. Shunturov, K. Janda, G. Platt and K. Weinberger. 2007. Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives. International Journal of Sustainability in Higher Education. 8(1):16-33.

determine the best way to share these energy goals with building occupants using the feedback displays. Once the goals are established and communicated with building occupants, we will provide data on the impacts of energy use, tips for conservation, as well as specific information on what the building occupants can do to help achieve the building energy targets. The beauty of this system is that we can then use the Campus Energy and Sustainability Management system to quantify the impact of coupling feedback displays with goal-setting measures and conservation information.

Also, we will connect with social scientist Denise Anthony who uses surveys and behavioral research to better understand the motivations or barriers to change. By working with a sociologist interested in the role of social-networking tools, we hope to combine the Campus Energy and Sustainability Management system with a rigorous understanding of the potential use and impact of virtual communities engaged in energy conservation through Facebook groups and other networking tools. We will then use this information to inform future campus campaigns.

2.5 Synthesizing Results, Education and Outreach

Throughout the project we will capture information about the project's successes and challenges and develop a series of outreach materials to share with stakeholders at Dartmouth (senior administrators, facilities managers, students, staff and faculty), at peer institutions (college, universities and other institutions with large campuses), and at state agencies (PUC and DES officials). We will synthesize information on the actual versus expected costs and benefits, case studies from specific campus buildings, and the results of combining the building energy management system with feedback and occupant information. We will distill the results into a webpage, written case studies, a white paper suitable for publication in a peer-reviewed journal, walking tour (real and virtual), and presentation materials. We will share the information through a Dartmouth webpage with data and a virtual walking tour, distribution of hard-copies of the publication to interested stakeholders identified by the state (similar to the white paper series produced by the New York State Energy Research and Development Authority – NYSERDA), and conference presentations. The goal of this part of the project is to promote the use of local smart-grid and innovative technologies to accelerate greenhouse gas reductions from the building sector at the state level and beyond.

3. PROPOSED WORK SCOPE AND SCHEDULE

In order to realize the maximum value of a Campus Energy Management system as quickly as possible we will implement the system in four phases over a 2-year period (see Attachment 6).

Phase 1 - Easily Connectible High-Energy-Intensity Buildings

In Phase 1 we will connect approximately 20 to 25 of our highest energy using facilities to the system. It is anticipated that these can be connected over an approximately 3 month period. The selected software vendor will be responsible for establishing the central data-historian database, connecting to building energy meters and building management systems, and polling and storing essential data points. Once these points are established, the data will be checked against the source data to verify that it is the same. Building baseline energy performance will be established and building energy scorecards will be created. Also during this period, training will take place in use of the system for energy fault-detection.

Dartmouth Facilities Operations & Management personnel will be responsible for automating the existing metering infrastructure during the same time period that the software vendor is setting up the system software.

Phase 1 Tasks will include:

- Automate meters for Phase 1 buildings
- Connect to BMS systems (data historian)
- Link live weather feeds and 24-hour energy projections by meter
- Implement analytical tools for mining energy savings (retrocommissioning)
- Develop real-time energy alarms (Actual use vs. Projected use)
- Propose initial Sustainability Indicators
- Test web-Publishing of User-Created Excel Spreadsheets

Phase 2 - Remaining High-Energy-Intensity and All Other Buildings

Phase 2 buildings will include the remaining high-energy-intensity facilities such as Burke Chemistry and Moore Psychology, and then all of the remaining facilities. Phase 2 will also include automation of all remaining energy meters. Burke and Moore will be done in Phase 2 because they will undergo some BMS updates to allow connectivity to the Campus Energy and Sustainability System. Overall time frame for Phase 2 implementation is anticipated to be 9 months.

Phase 2 Tasks will include:

- Automate additional buildings meters
- Connect additional buildings to BMS system
- Connect to Boiler Plant for real-time efficiency monitoring
- Add more Sustainability Indicators
- Develop Building Performance Metrics (Actual vs. Design)

Project Management and Quality Assurance (Phase 1 & 2): The College Energy Engineer, Steve Shadford, will be responsible for project oversight and quality assurance of the Phase 1 & 2 portions of the project.

Phase 3 – Feedback, Behavioral Change, and Education & Outreach

In Phase 3 we will tie the building energy data in with existing new energy feedback displays in campus dormitories, academic buildings and student centers. Researchers will be using these systems to evaluate social leaning and behavior modification. We will also develop outreach materials to summarize our findings and share them with internal and external stakeholders.

Phase 3 Tasks will include:

- Connect energy data from dormitories into the energy feedback display system
- Add additional feedback displays to buildings on campus
- Through separate research-funding, evaluate the impact of feedback and connected social networking tools on occupant behavior

- Conduct outreach to students, staff and faculty about recommended conservation measures, use feedback systems to share information on the impact of those changes on building energy use.
- Develop case studies in areas where occupant behavior accounts for a relatively high proportion of total building energy use – such as laboratories and dormitories.
- Share findings with state officials and colleagues through campus tours, a white paper, and conference presentations.

Project Management and Quality Assurance (Phase 3): The College Sustainability Manager, Kathy Lambert, will take the lead on this portion of the project, working with the Energy Engineer (Steve Shadford), and academic collaborators (Lorie Loeb, Chris Levy, and Denise Anthony).

Phase 4 – System Monitoring, Verification and Reporting

In Phase 4 we will report on the results of continuous monitoring and verification efforts. Specifically, we will:

- ensure that the meter automation program provides accurate results
- establish a rigorous program to verify the polled data from the BMS systems
- set target energy reductions on a building-by-building basis once building energy baseline performance has been established
- monitor the financial expenditures and performance of the program
- use the system to assess the effectiveness of behavior change campaigns and social learning experiments
- share the results of our measurement and verification program in an annual summary report.

Project Management (Phase 4): During the course of the first program year, it is anticipated that the Energy Engineer (Steve Shadford) will dedicate approximately 1/2 of his time to these tasks.

4. PROJECT BENEFITS

4.1 Greenhouse House Gas Emissions Reductions (see Attachment 1)

The Campus Energy Management project is expected to reduce total annual greenhouse gas emissions at Dartmouth College by approximately 11,506 metric tons per year (in carbon dioxide equivalents) from the following fuel sources:

No. 6 Fuel oil	8,844 metric tons
Purchased electricity	2,662 metric tons

4.2 Cost-effectiveness (see Attachment 7)

We used the benefit cost calculator provided by the PUC to calculate the benefit-cost ratios based on the full 10-year life of the system using the projected 10-year costs. The results are summarized below and the spreadsheets are included as part of Attachment 7.

Benefit-cost Category	Based on 10-year Costs
Full Program Cost	5.8
GHGER Fund Costs	57.6
Full - $60/ton value	7.4
GHGER - $60/ton value	73.6

4.3 Reduce New Hampshire's Peak Load

The Campus Energy Management system will provide Dartmouth with a much more sophisticated approach to demand response than we are currently able to achieve. The Campus Energy Management system will have connectivity to the Building Management Control Systems in each building on campus. Through building-level metering and connectivity to energy systems, we will be able to automatically shut non-essential systems down, turn lighting systems down or off, raise setpoints in office, classroom and indoor sports venue areas, lower speeds of fan and other HVAC equipment. Using the 24-hour forward load projection capabilities we will also be able to anticipate high demand days and implement capacitive strategies such as pre-cooling of spaces to give us greater carry-through capability and load shifting strategies such as enabling absorption chillers to become lead chillers rather than electric drive chillers during demand response periods. We anticipate that the Campus Energy and Sustainability Management system will give us the capability to reduce our peak electric demand by an additional 500-1,000 kW beyond current reduction measures.

4.4 Market Transformation

By developing this project as a case study, distilling the lesson and sharing our findings with others who manage groups of buildings; we hope to accelerate the adoption of cost-effective smart grids technology and building intelligence systems. While this technology already exists, it is under-utilized in the Northeast markets and lacks regional case studies that will advocate for a holistic, sustainable approach to building management. By closely monitoring our system and tracking our results in terms of both energy savings and greenhouse gas reductions, then disseminating the results through publications, campus tours, and conference presentations we believe we can have a discernible impact on the use of building systems technologies at college, universities, and secondary schools in the state.

4.5 Innovative Technologies

Through this project, we will help deploy smart grid technology in a campus environment using the following approaches:

- Web-based software platform
- Ability to link live data to spreadsheet models and self-publish to the web
- Wireless metering and data transfer technology
- 24-hour forward load projections (meter-by-meter & building-by-building) based upon local weather data feeds via the Internet
- Energy feedback and compelling animated displays produced by academic programs for social learning and behavior modification

4.6 Economic Development

We anticipate that this program will have a modest impact on economic development in both direct and indirect ways.

Direct Job Creation and Preservation

Description (type)	Number (FTE)	Duration
Meter automation	0.75	1 year
Building commissioning	1.5	10 years+
System administration	0.5	10 years+

Indirect economic benefits:

- We will be using a US-based software vendor for the project.
- There will likely be additional labor supported for building system repairs which is difficult to estimate.

4.7 Energy Cost-Savings

We used the benefit-cost calculator provided by the PUC to estimate avoided costs for the program. Based on a 10-year life of measure, the projected 10-year costs of the project, and the assumptions embedded in the spreadsheet for energy costs and avoided greenhouse gas emissions, we project a total avoided energy cost-savings of $24,342,220 (see summary below).

Avoided Cost Category	Savings
Electricity supply	$6,669.134
Heating oil	$12,400,463
Electric avoided CO2 costs	$1,066,401
Non-electric avoided CO2 costs	$4,206,222
TOTAL	$24,342,220

4.8 Promote Collaboration and Information

The Dartmouth Campus Energy and Sustainability Management system will promote collaboration with three groups:

- on-campus stakeholders
- peer institutions
- New Hampshire state officials at the PUC and DES

As discussed above, this project will engage campus stakeholders in reducing campus energy use and greenhouse gas emissions. Through our outreach efforts, we will also share information with peer institutions. Finally, through detailed a monitoring and verification program we expect to provide rigorous evaluation data to the PUC and to NHDES which we hope would be useful to them in future program investment decision-making.

5. MEASUREMENT AND VERFICIATION

The Campus Energy and Sustainability Management System is inherently self-verifying as the load profile projections and month-to-month energy-use comparisons are based upon actual metered data. Dartmouth has greater than 250 meters currently in place monitoring electricity, condensate and chilled water consumption of its individual buildings. By automating these meters under this program and using the data sets collected continually by the system, we will establish building load baselines and will then be able to track the effectiveness of the Campus Energy and Sustainability System as an energy reduction tool. Furthermore, with the Campus Energy and Sustainability Management System in place, we will be able to assess the effectiveness of behavior change campaigns and social learning experiments in a similar manner, determining the additional leverage that these techniques enable. We will set targets for each building and measure performance against these targets. We will share the results of our measurement and verification program in an annual summary report.

6. BUDGET

A line-item budget for the Campus Energy Management and Sustainability Management System is attached (see Attachment 2). The budget follows the progression of system installation, setup, configuration and use as an energy fault detection system for our operations personnel, and finally as a means to explore and develop additional savings strategies via energy feedback, social learning and behavior change.

7. APPLICANT QUALIFICATIONS

Stephen Shadford – Energy Engineer (Attachment 8)

Steve Shadford is a graduate of the University of Hartford School of Engineering, and is a registered Professional Engineer and LEED Accredited Professional. He has served clients in the building energy systems field for over 35 years. For the five years prior to coming to Dartmouth, Mr. Shadford established an energy and commissioning services division at the consulting firm of vanZelm, Heywood and Shadford, Inc., in Farmington, CT. For the previous 18 years, Mr. Shadford was President and CEO of Mira Systems, Inc., a building automation systems firm serving corporate and institutional clients from New York City to Boston. Mr. Shadford brings to this project his passion for creating energy efficient building systems. In his current position as Dartmouth's Energy Engineer, he works collaboratively with internal institutional clients, leveraging human and technical assets towards meeting the College's efficiency and sustainability goals.

Kathy Fallon Lambert – Sustainability Manager (Attachment 9)

Kathy Lambert is a graduate of Dartmouth College (BA) and the Yale School of Forestry and Environmental Studies (MS). She has 15 years experience in the field of the environmental impacts of electricity generation from coal-fired power plants. Specifically, as the Executive Director of the Hubbard Brook Research Foundation she co-authored a series of papers on acidic deposition and mercury hotspots in New Hampshire and the region. She brings to this project a unique understanding of the benefits of reducing energy consumption, the important connection between site-specific "experiments" such as this and public policy, and methods of distilling technical information for others through publications and case studies.

Collaborators

Lorie Loeb – Co-director and founder of the Digital Arts Minor and Research Associate Professor in the Computer Science Department at Dartmouth College. She has worked with students to develop a real-time energy metering project which uses animated sequences to encourage people to change behaviors around energy use. She holds a BA from NYU in film and animation and a graduate degree from Hunter College. She has received two Emmy awards for her work and the Cine Golden Eagle Award. http://www.tellemotion.com/index.html and greenlite.dartmouth.edu)

Christopher Levey – Associate Professor of Engineering and Director of Instructional Labs. Chris holds a BA from Carleton College and Ph.D. in physics from the University of Wisconsin-Madison. As chair of the engineering school's Energy Indicators Working Group, he has been responsible for increasing awareness among engineering students of energy issues in our laboratory and classroom building. We have implemented large real-time graphical displays of paper and energy use, including building-wide electric use and targeted sub-meters. As Director of Instructional Labs, he has also encouraged student engineering projects on energy awareness related devices.

Denise Anthony – Chair of the Department of Sociology and Director of the Institute for Security, Technology and Society. Denise holds a BA from Indiana University and a Ph.D. in sociology from the University of Connecticut. She is currently working on research to understand how information feedback and social networking can promote behavioral change. Specifically, she is working with Lorie Loeb to apply these concepts to energy use through the Dartmouth Green Lite feedback system.

8. ADDITIONAL INFORMATION
Not applicable.

9. LETTERS OF COMMITMENT
We are currently still evaluating two potential software vendors. Both have submitted full proposal to Dartmouth College and have expressed keen interest in the project. Given the size and detail of these documents, we have not attached them to this application but they are available upon request.

10. ATTACHMENTS
Attachment 1 - Annual Energy and GHG Savings
Attachment 1A - Timeline of Costs and Benefits during Measure Life
Attachment 2 - Budget Spreadsheet
Attachment 3 - Screenshot Example – Cooling System Energy Fault Detection
Attachment 4 - Phase 1 System Build-Out Diagram
Attachment 5 - Full Build-Out Diagram
Attachment 6 - Proposed Work Schedule
Attachment 7 - NH GHGER Fund Benefit-Cost Spreadsheet
Attachment 8 - Resume for S. Shadford
Attachment 9 - Resume for K. Lambert

- ATTACHMENT 1 -

ANNUAL ENERGY AND GHG SAVINGS

(See Attachment 1A for Timeline of Savings Over the Life of the Measure

	Purchased Electric mWH	Self-Generated Electric (Co-Gen) mWH	#6 Fuel Oil Gallons			
CURRENT CAMPUS ENERGY CONSUMPTION >	**36,000**	24,000	**5,000,000**			
	Purchased Electric (MT/mWH)	**Self-Generated Electric (MT/mWH)**	**#6 Fuel Oil (#/gal)**	**#6 Fuel Oil (MT/Gal)**		
CO2 EMISSIONS FACTORS (From NH GHGER Fund RFP Document)	0.493	Incl in Fuel Oil Use	26	0.01179138		
SAVINGS ESTIMATES						
% Saved via Continuous Commissioning >>	10%					
Energy Feedback, Social Learning, & Behavior >>	5%					
TOTAL ESTIMATED SAVINGS %	**15%**					
	Purchased Electric (mWH Reduced) **	Self-Generated (Co-Gen) Electric (mWH Reduced) *	#6 Fuel Oil(Gallons Reduced)	GHG Reductions in Metric Tons (Electric) **	GHG Reductions in Metric Tons (#6 Fuel Oil)	Total Annual GHG Reductions (MT Co2e)
ENERGY AND GHG REDUCTIONS ACHIEVED VIA CAMPUS ENERGY & SUSTAINABILITY MANAGEMENT SYSTEM	5,400	3,600	750,000	**2,662**	**8,844**	**11,506**

* Emissions for the self-generated (co-generated) electricity essentially come from burning #6 fuel oil in our boilers to make steam for the turbine-generators. These emissions, therefore, are effectively accounted for in the emissions reductions for #6 fuel oil and are not included in these emissions reductions calculations.

** Only emissions from purchased electricity are used in calculating electrical GHG reductions.

- ATTACHMENT 1A -

TIMELINE OF COSTS AND BENEFITS OVER THE MEASURE LIFE
(PROGRAM LIFE IS INDEFINITE)

ANNUAL COSTS AND BENEFITS

	Measure Life Assumed to be 10 Years										
Annual Costs	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	**Cumulative Cost**
Dartmouth's System Setup	595,620										**$595,620**
Dartmouth's In Kind Labor (Facilities Op's 3% Escal. Yrs 2-10)	192,500	156,000	160,680	165,500	170,465	175,579	180,847	186,272	191,860	197,616	**$1,777,321**
Dartmouth's In Kind Labor (Leveraging Programs)	50,000	55,000									**$105,000**
NH GHGER Funding (2/3 in Year 1 and 1/3 in Year 2)	**(220,624)**	**(110,312)**									**(330,936)**
Annual System Maintenance Fee (3% escalation)	0	54,000	55,620	57,289	59,007	60,777	62,601	64,479	66,413	68,406	**$548,592**
Totals	**617,496**	**154,688**	**216,300**	**222,789**	**229,473**	**236,357**	**243,448**	**250,751**	**258,274**	**266,022**	
										Total Cumulative Cost	**$2,695,597**

	Measure Life Assumed to be 10 Years											
Annual Benefits	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	**Cumulative Benefit**	
GHG Reductions (Purchased Electrical Reductions) MTCO2e	1,331	1,997	2,662	2,662	2,662	2,662	2,662	2,662	2,662	2,662	**24,625**	
GHG Reductions (#6 Fuel Oil Reductions) MTCO2e	4,422	6,633	8,844	8,844	8,844	8,844	8,844	8,844	8,844	8,844	**81,803**	
Totals	**5,753**	**8,629**	**11,506**	**11,506**	**11,506**	**11,506**	**11,506**	**11,506**	**11,506**	**11,506**	**106,428**	MTCO2e

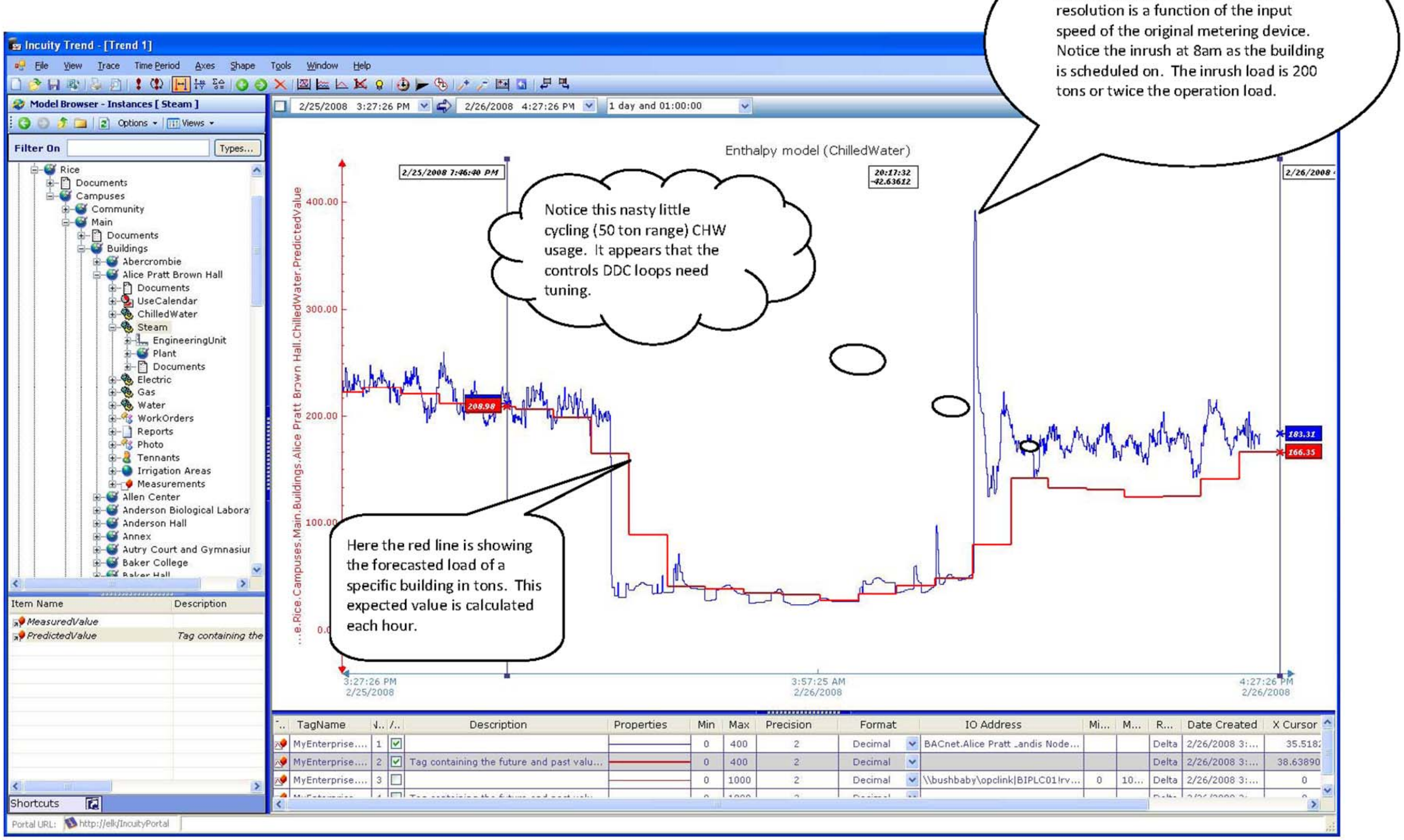
Note: Year 1 &2 benefits ramp up as system comes on line and leveraging programs come into effect

- ATTACHMENT 2 -

Budget for Campus Energy and Sustainability Management System

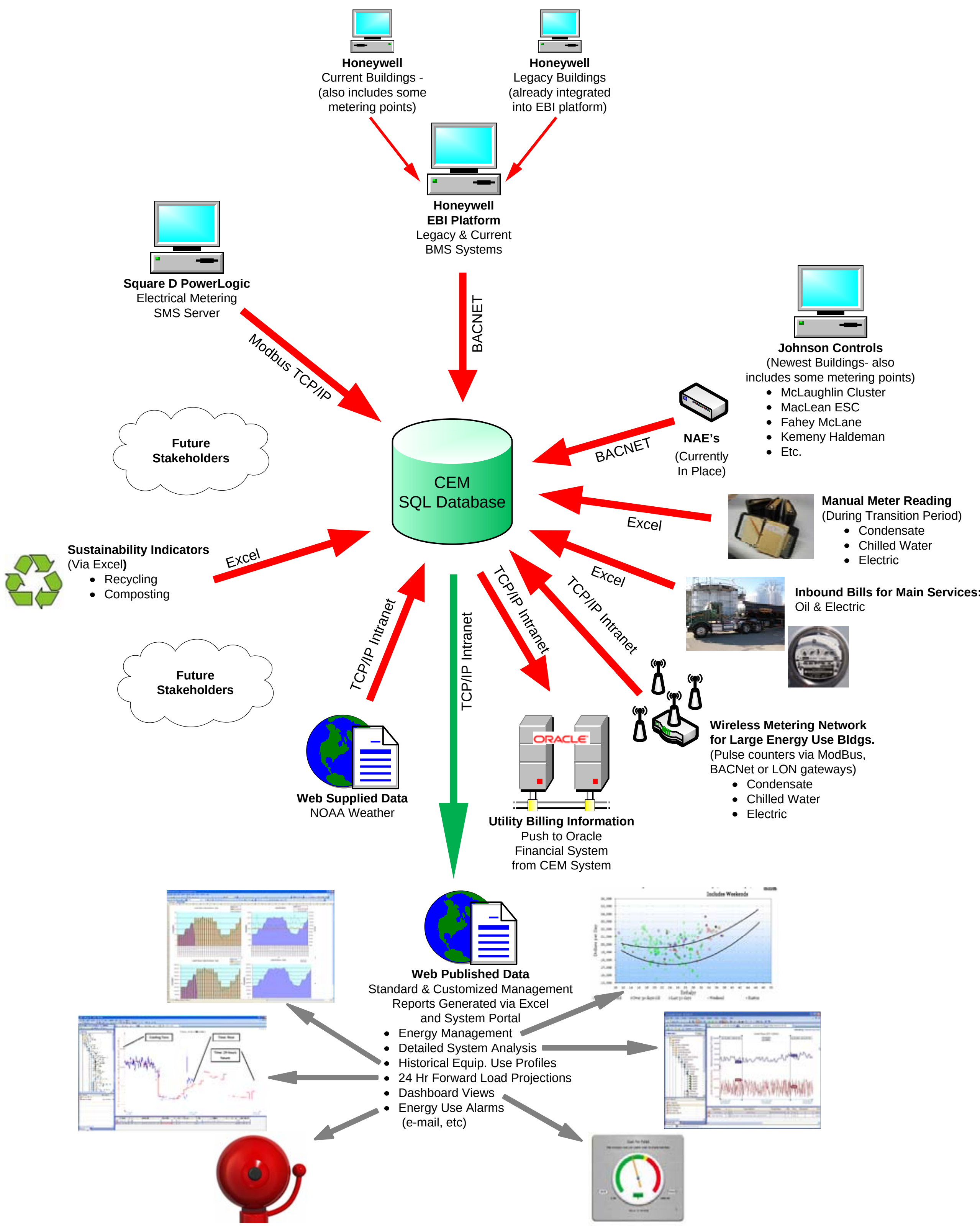
		Cost ($)
YEAR 1 COSTS		
Installation, Setup and Commissioning of Hardware and Software		
1. Server Hardware & Software		25,000
2. System Software & Vendor Configuration Services		300,000
3. Vendor Travel and Expenses		10,000
4. Meter Automation Hardware		133,700
5. Meter Automation Labor (Dartmouth Electrical & Electronics Shops)		70,500
6. Upgrades for Connectivity		60,000
7. Project Management Labor (Dartmouth Energy Engineer)		70,000
	Subtotal	**$669,200**
8. Contingency	10%	66,920
	Total Installation, Setup and Verification of Hardware and Software	**$736,120**
Labor Using System to Achieve Savings via Continuous Commissioning Process		
9. Continuous Commissioning Labor Using System (Dartmouth Facilities Operations & Management)		52,000
	Continuous Commissioning Labor	**$52,000**
Labor Using System to Leverage Additional Savings via Feedback, Social Learning and Behavior		
10. Social Learning, Individual & Organizational Behavior Collaborative Projects w/Academic Dept's.		45,000
11. Communication and outreach (Dartmouth Sustainability Manager)		5,000
	Academic Project Labor	**$50,000**
	YEAR 1 SUBTOTAL	**$838,120**
YEAR 2 COSTS		
System Maintenance		
12. System Maintenance Fee		54,000
Labor Using System to Achieve Savings via Continuous Commissioning Process		
13. Continuous Commissioning Labor (Dartmouth Facilities Operations & Management)		156,000
Labor Using System to Leverage Additional Savings via Feedback, Social Learning and Behavior		
14. Social Learning, Individual & Organizational Behavior Collaborative Projects w/Academic Dept's.		45,000
15. Communication and outreach (Dartmouth Sustainability Manager)		10,000
	YEAR 2 SUBTOTAL	**$265,000**
	TOTAL PROJECT COST (YEAR 1 + YEAR 2)	**$1,103,120**
	MATCHING FUNDS REQUESTED FROM NH GHGER FUND (30%)	**$330,936**
	DARTMOUTH IN-KIND (Labor Items 5,7,9,10,11,13,14,15)	**$453,500**
	DARTMOUTH MATCHING FUNDS	**$318,684**

- ATTACHMENT 3 -
EXAMPLE
Cooling System Energy Fault-Detection

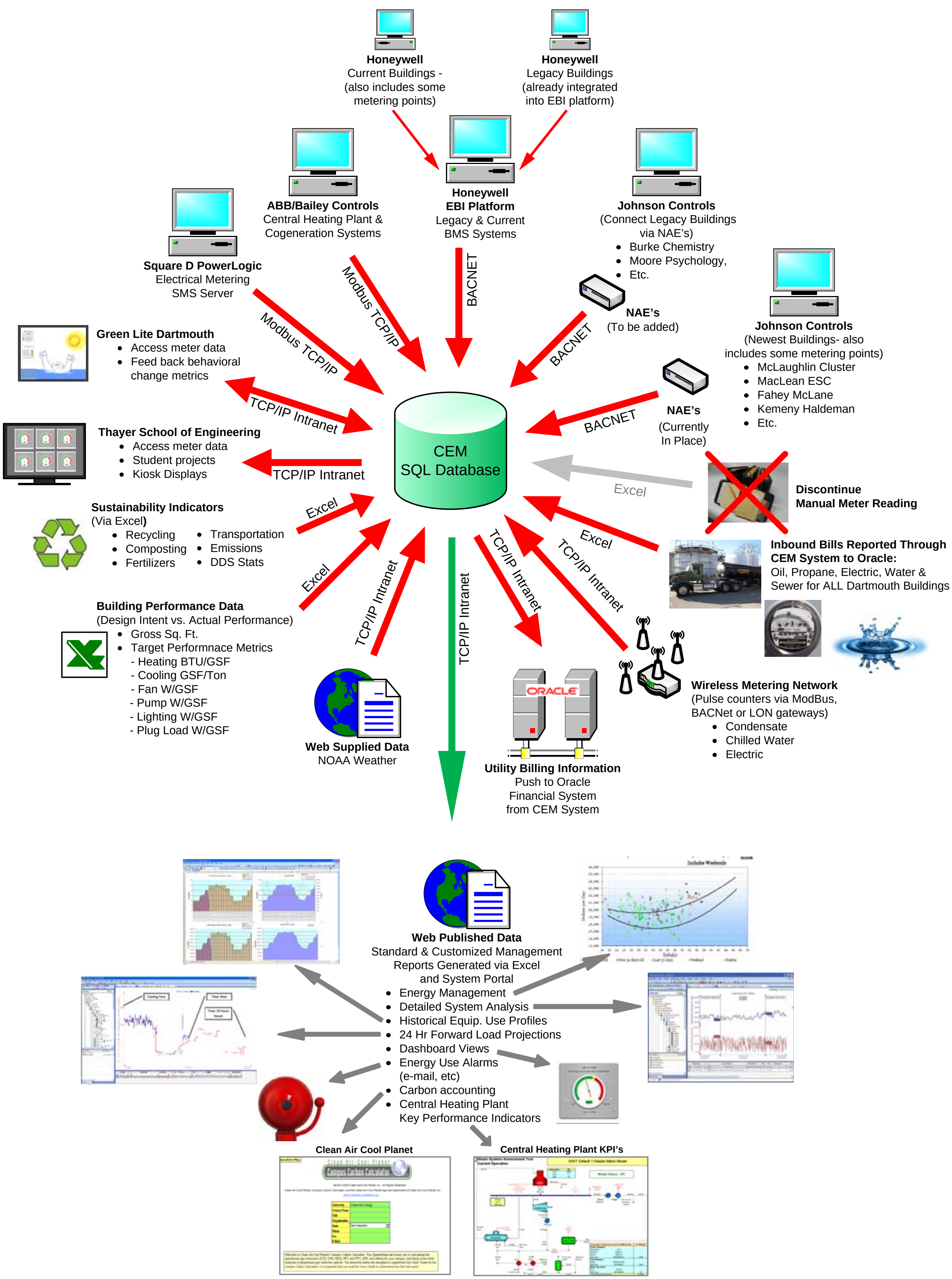


The following is a typical building level report. This one is set to show the cooling load.
This happens to be data coming from a Siemens Apogee system using BACnet.
This graph was set to show the past 24 hours of performance.

- ATTACHMENT 4 -
CAMPUS ENERGY AND SUSTAINABILITY SYSTEM
PHASE 1 BUILD-OUT

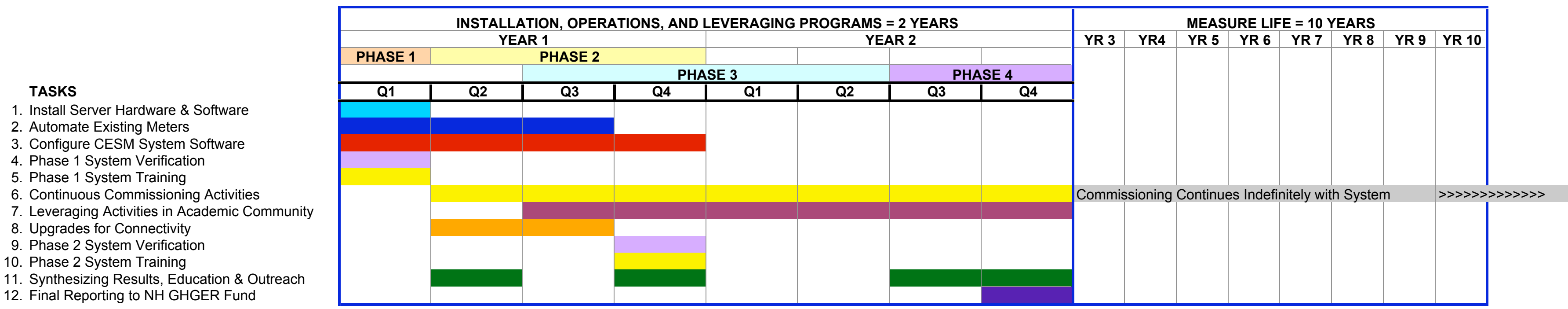


- ATTACHMENT 5 -
CAMPUS ENERGY AND SUSTAINABILITY SYSTEM
FULL BUILD-OUT



- ATTACHMENT 6 -

PROPOSED WORK SCHEDULE



NH Greenhouse Gas Emissions Reduction Fund (GHGERF) 3/09 RFP Cost Effectiveness Analysis r. 3/20

This worksheet uses default Total Resource Cost (TRC) Test values to calculate Benefit-Cost Ratios for proposed programs.

NOTE: Use of this spreadsheet is not required, but is encouraged to the extent applicable and possible, as cost-effectiveness is an important factor in selecting proposals to be funded, as is the extent that they are realistically proposed. Please submit with your proposal the electronic file and a printed copy of the 1st page of each worksheet completed.

Instructions: Enter relevant values in yellow highlighted cells. Then watch for results in green highlighted cells.

NOTE: If you have more than one type of program, meaure type or measure life, you can complete a separate Measure Group tab (worksheet) for each one.

Line #	**Assumptions**			
		Name of Applicant or Proposal:	Dartmouth College	
1	Program Type	**Select** residential, commercial or industrial:	commercial	
2	Principal Type of Measures	**Select** type of program or measures:	Other - C/I	
3	Average Measure Life (weighted by CO2 savings)	**Enter** average life** of measures in group here:	10	years; depends = Range of measure life based on measure type
4	Assumed Load Reduction Factor*	See **Note near bottom of page for more measure life info.	0.000276	
5	Assumed Summer Annual Demand Coincidence*	See *Note below (right of lines 22-25) and FN 9 of the RFP.	100%	
6	Nominal Annual Discount Rate		5.000%	
7	Annual Inflation Rate		2.700%	

	Program Costs			% of Total
8	Non-GHGER Funds (from applicant, participants and other sources)		$ 2,965,597	90%
9	GHGER Funds (amount requested in this proposal)		$ 330,936	10%
10	**Total Program Costs**	(sum lines 8 and 9)	$ 3,296,533	

Distribution of Electric Savings by % within each time period over the course of a calendar year. (Default normal distribution shown.)

Line #	%	Period
66	27%	Winter Peak (6am-10pm, M-F except holidays, Jan.- May, Oct. - Dec.)
67	39%	Winter Off-Peak (10pm-6am, M-F, all day Sat., Sun. & holidays, Jan.-May, Oct.-Dec.)
68	14%	Summer Peak (6am-10pm, M-F except holidays, June-Sept.)
69	20%	Summer Off-Peak (10pm-6am, M-F, all day Sat., Sun & holidays, June-Sept.)
	100%	= Total (Holidays are New Year's, Memorial, 7/4, Labor, Thanksgiving & Christmas.)

Line #	***Estimated Annual Energy Savings (or increased Use as a negative #)***		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
11	**Annual kWh Savings (kWh)**	*See *Note below right (@ lines 23-26)*	5,400,000	5400000	5400000	5400000	5400000	5400000	5400000	5400000	5400000	5400000
12	kW demand Savings-Summer Coincident	(line 11*line4*line5)	1,490.4	1,490.4	1,490.4	1,490.4	1,490.4	1,490.4	1,490.4	1,490.4	1,490.4	1,490.4
13	**Annual Natural Gas Savings (MMBTU)**		-	-	-	-	-	-	-	-	-	-
14	**Annual Propane Savings (MMBTU)**	Conversions from gallons and other	-	-	-	-	-	-	-	-	-	-
15	**Annual Heating Oil Savings (MMBTU)**	units to MMBTU are available at:	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500
16	**Annual Kerosene Savings (MMBTU)**	www.think-energy.net/energy_units.htm	-	-	-	-	-	-	-	-	-	-
17	**Annual Coal Savings (MMBTU)**		-	-	-	-	-	-	-	-	-	-
18	**Annual Wood Savings (MMBTU)**		-	-	-	-	-	-	-	-	-	-
19	**Annual Water Savings (Gallons)**		-	-	-	-	-	-	-	-	-	-
20	**Net value of Operations & Maintenance Savings or (increased Costs) in $.**		-	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
21	Electric CO2 Savings (short tons)	((line 11*CO2/kWh)/2000, from GHG Reductions tab)	2,934.9	2934.9	2934.9	2934.9	2934.9	2934.9	2934.9	2934.9	2934.9	2934.9
22	Other Fuel CO2 Savings (short tons)	((lines 13-17*CO2/mmBTU)/2000)	9,078.8	9078.8	9078.8	9078.8	9078.8	9078.8	9078.8	9078.8	9078.8	9078.8

23	**Benefit/Cost Ratio for Full Program Costs, reg. TRC**	(line 43 / line 10)	**5.78**
24	**B/C ratio with GHGER Fund Costs only, reg. TRC**	(line 43 / line 9)	**57.62**
25	**B/C ratio, Full Progam Cost, $60/ton CO2 value**	(line 46 / line 10)	**7.38**
26	**B/C ratio, GHGERF share only, $60/ton CO2 value**	(line 46 / line 9)	**73.56**

** NOTE: For simplicity sake assume full annual savings starting in 2010. KW demand savings can be estimated by mutlipling kWh savings by the "Load Reduction Factor" and "Annual Demand Coincidence" for "Summer" that most closely matches the proposed program measures from the Measure Type & Load Reduction Factor Lookup Table found under the Lookup Table Tab and referenced in footnote 9 in the RFP. This occurs automatically by default when you select type of program or measures.*

Output Table on Value of Program Benefits

NPV= Net Present Value

Line #	**Avoided Electric Supply Costs**	**Calculations**	**NPV**	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
27	Winter Peak	(line 11 * line 66)		$165,086	162,501	169,416	165,955	175,144	177,099	186,265	196,428	197,216	201,784
28	Winter Off-Peak	(line 11 * line 67)		$176,219	174,793	182,236	173,911	180,224	185,604	194,105	206,637	210,394	211,000
29	Summer Peak	(line 11 * line 68)		$83,925	85,081	91,720	89,693	93,150	96,979	102,127	108,784	108,639	114,792
30	Summer Off Peak	(line 11 * line 69)		$84,880	84,216	89,745	87,367	91,865	93,144	100,195	103,055	106,745	108,720
31	Avoided kWh Costs $	(sum lines 27-30)	$4,289,561	$510,109	506,591	533,117	516,926	540,382	552,825	582,691	614,904	622,995	636,295
32	Avoided kW demand -Summer Coincident Costs $	(line 12* line 51)	$2,379,573	$181,030	$266,521	$295,791	$317,002	$325,561	$334,351	$343,379	$352,650	$362,171	$371,950
33	Total Avoided Electric Supply Costs	(sum lines 31 and 32)	$6,669,134										
	Avoided Non-Electric Supply Costs												
34	Avoided Natural Gas Costs $	(line 13*(line 52 or 53))	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
35	Avoided Propane Costs $	(line 14* line 54)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
36	Avoided Heating Oil Costs $	(15*(55 or ave(56 and 57) or 58))	$12,400,463	$1,538,868	$1,532,611	$1,528,987	$1,522,080	$1,542,229	$1,591,037	$1,641,404	$1,701,064	$1,763,242	$1,827,031
37	Avoided Kerosene Costs $	(line 16* line 59)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
38	Avoided Coal Costs $	(line 18* line 60)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
39	Avoided Wood Costs $	(line 17* line 61)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
40	Avoided Water Costs $	(line 20* line 62)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
41	Avoided (or Increased)) O&M Costs	same as line 20	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
42	Total Avoided Non-Electric Supply Costs	(sum lines 34-41)	$12,400,463										
43	**Total Program Benefits w/o Avoided CO2 Costs**	lines 33+42+43 from other measure tabs	$19,069,597										
44	Electric Additonal Avoided CO2 Costs @ $60/ton	(line 21* line 65)	$1,066,401	$169,138	$168,669	$148,330	$142,167	$136,003	$129,840	$123,677	$117,513	$111,350	$105,187
45	Non-electric Avoided CO2 Costs @ $60/ton	(line 22* line 63)	$4,206,222	$544,725	$544,725	$544,725	$544,725	$544,725	$544,725	$544,725	$544,725	$544,725	$544,725
46	**Total Program Benefits w/ Avoided CO2 Costs**	33+42+44+45+46 from other measure tabs	$24,342,220										

PROFESSIONAL EXPERIENCE RESUME

Stephen R. Shadford, P.E.

EDUCATION
University of Hartford, West Hartford, CT,., B.S.M.E. - 1975

REGISTRATION
Registered Professional Engineer, Connecticut

ACCREDITATION
LEED Accredited Professional

PROFESSIONAL SOCIETIES
American Society of Heating, Refrigerating and Air Conditioning Engineers
Association of Energy Engineers
US Green Building Council - USGBC
American Solar Energy Society
Building Commissioning Association

PROFESSIONAL EXPERIENCE

January 2008 to Present

Dartmouth College, Hanover, NH, - Campus Energy Engineer for Facilities Operations and Management department. Responsible for managing a $12.5 MM conservation and efficiency improvement program for building HVAC and control systems, energy metering systems, steam distribution systems, lighting systems, process systems, and building envelopes.

May 2007 to December 2007

New World Energy Services, LLC, Canton, CT - Managing Member, responsible for establishment of the firm and performing a variety of energy-related services, including strategic energy planning, energy studies, commissioning of USGBC LEED™ projects, and retrocommissioning.

April 2002 to April 2007

vanZelm, Heywood & Shadford, Inc., Farmington, CT - Senior Associate and Director of Energy and Commissioning Services. Responsible for establishing and growing a commissioning services division of the firm. Later responsible for growing an energy planning and analysis group and a retro-commissioning group. Participated in Connecticut's first utility-sponsored pilot retro-commissioning project. Conducted a successful large-scale retrocommissioning project at the 1.4 mm square foot trading operation of UBS in Stamford, CT. Managed a large-scale strategic energy conservation planning project at St. Francis Medical Center in Hartford, CT. Conducted a number of speaking engagements for professional societies to promote conservation and efficiency, and the field of retrocommissioning.

September 1997 to October 1999

Yesco-Mira Systems, Farmington, CT - Vice President and General Manager of control systems division of Yankee Energy Services Company, a wholly owned unregulated division of Yankee Gas. Continued full management responsibilities after selling Mira Systems, Inc., to Yankee in 1997. Managed a staff of 20 control system engineers, programmers, field technicians and office administrators. Managed growth in volume from $2mm per year to $5mm per year during a 2-year period. Collaborated with other YESCo division vice presidents and management staff on business planning, marketing and policy decisions.April 1983 to September 1997

Mira Systems, Inc., Farmington, CT - President and owner of building automation system contracting firm. Built the firm from a staff of 1 to 18 over a 14-year period. The firm specialized in DDC control of HVAC, chiller plant, boiler plant, and security systems. Mira Systems, Inc. served large corporate, institutional, and utility clients, including General Electric, NBC, Pfizer, Southern New England Telephone Company, and The Hartford. During the 14 years of ownership, developed extensive engineering, hands- on, and project management experience in all areas of building controls, start-up, commissioning, and training for facility operations personnel. Sold business in September, 1997 to Yankee Energy Services Company, an unregulated division of Yankee Gas.

April 1981 to March 1983

Saren Engineering, Inc., Farmington, CT - Partner in the firm of Saren Engineering, Inc., Responsible for energy studies at numerous private colleges and universities, as well as design and general contracting for energy retrofit projects.

March 1979 to March 1981

Energy Watch, Inc., West Simsbury, CT - President and owner of energy consulting firm. Responsible for extensive energy conservation studies and design work for Yale University. The project was a 2 year fast-track study/implementation program to upgrade the mechanical and control systems of the university. Studied approximately 20 buildings in the medical school, science area and central portion of campus. Implemented recommendations in a fast-track manner with university-sanctioned contractors.

May 1972 to February 1979

Coordinated Systems, Inc., West Hartford, CT - General manager of energy consulting and general contracting firm specializing in HVAC and control system operational analysis and improvements. Responsible for managing a staff of 8 energy engineers in analysis, pricing, design and implementation of energy conservation projects. Served corporate, institutional and utility clients including SNET, The Hartford, Hartford Hospital, Wesleyan University, and Yale University.

KATHLEEN FALLON LAMBERT
Sustainability Manager
Dartmouth College
Hinman Box 6011
Hanover, NH 03755
Tel. 603-646-3532
Email: Kathy.lambert@dartmouth.edu

EDUCATION

Yale University School of Forestry and Environmental Studies, New Haven, CT
1992 M.F.S.
Dartmouth College, Hanover, NH
1990 A.B.
Harvard University Summer Science Program, Cambridge, MA
1985 Women in Science program.

PROFESSIONAL HISTORY

Dartmouth College Sustainability Manager
2008 – present

- Work with facilities and operations staff to develop sustainability indicators and strategies to reduce the College's ecological footprint.
- Work with senior administration to develop sustainability policies and practices.
- Develop communications materials to increase campus awareness and engagement in sustainability programs.
- Support student efforts and organizations on campus related to sustainability.

Ecologic: Analysis & Communications - Woodstock, Vermont
2004 – 2008

- Founder of environmental consulting firm focused on distilling and translating scientific research for policy makers and the public.
- Consulting services include policy analysis, science writing, research synthesis, media communications and public outreach.

Hubbard Brook Research Foundation - Hanover, New Hampshire
1996 – 2007, Executive Director/Consultant

- Directed the operation, management and development of the Hubbard Brook Research Foundation, including its dormitory and laboratory near the Hubbard Brook Experimental Forest.
- Designed and implemented Science Links a program to increase public awareness of the Hubbard Brook Ecosystem Study, its scientific resources, societal implications of the research and the value of long-term ecological research generally.

- Coordinated first Science Links project on acid rain and nitrogen pollution that resulted in extensive world-wide media coverage and political attention.
- Played a lead role in the creation of the Northeast Ecosystem Research Cooperative.
- Increased annual operating budget from $70,000 to $500,000 over five years through grant writing and fundraising.
- Secured over $3 million in Federal appropriations to benefit the Hubbard Brook Experimental Forest.

Vermont Department of Environmental Conservation – Waterbury, Vermont
1994 – 1996, Hydrologist
- Developed and worked with legislature to implement new legislation governing water withdrawals for snowmaking.
- Prepared terms and conditions comments to the Federal Energy Regulatory Commission on dam relicensing applications and Federal Environmental Impact Statements.
- Developed a water use Needs and Alternatives Analysis now required for ski areas.

Appalachian Mountain Club – Pinkham Notch, New Hampshire
1992 – 1994, Hydrologist
- Developed technical case for Federal Energy Regulatory Commission dam relicensing interventions on the Androscoggin, Deerfield, Kennebec, and Penobscot Rivers.
- Conducted instream flow analyses to evaluate and develop New Hampshire instream flow rules for the state's Rivers Management and Protection Program.

GRANTS AND AWARDS
2008 Morgan Family Foundation Grant – PI, Dartmouth College
1999 U.S. EPA Environmental Merit Award
1997 Leopold Schepp Scholar Award
1996-97 Switzer Environmental Leadership Grant
1992 Switzer Environmental Leadership Grant
1991 Switzer Environmental Fellowship
1991 Leopold Schepp Graduate Fellowship
1991 Carpenter/Sperry Research Grant
1990 Andrew W. Mellon Research Grant
1988 Dartmouth College Rockefeller Public Affairs Grant

VOLUNTEER SERVICE
- Mascoma Watershed Association – Bear Pond Protection project leader
- Wellborn Ecology Fund of the New Hampshire Charitable Foundation – advisor
- Alumni representative to Dartmouth College Director of Outdoor Programs search
- Vermont Rivers Council – founding board member
-

SELECT PUBLICATIONS
Driscoll, C.T., K.F. Lambert, Y-J Han, C.T. Driscoll, N.C. Kamman, M.W. Goodale, K.F. Lambert, T.M. Holsen, C.Y. Chen, T.A. Clair, and T. Butler. 2007. Mercury Matters: Linking

Mercury Science with Public Policy in the Northeastern United States. Hubbard Brook Research Foundation. Science Links Publication, vol. 1, no. 3.

Driscoll, C.T., Y-J. Han, C. Chen, D. Evers, K.F. Lambert, T. Holsen, N. Kamman, and R. Munson. 2007. Mercury Contamination in Remote Forest and Aquatic Ecosystems in the Northeastern U.S.: Sources, Transformations and Management Options. BioScience. 57(1):17-28.

Evers, D.C., Y-J Han, C.T. Driscoll, N.C. Kamman, M.W. Goodale, K.F. Lambert, T.M. Holsen, C.Y. Chen, T.A. Clair, and T. Butler. 2007. Biological Mercury Hotspots in the Northeastern U.S. and Southeastern Canada. BioScience. 57(1):29-43.

Lambert, K.F. 2006. Report on the Multi-Agency Critical Loads Workshop. For the U.S. Environmental Protection Agency. Under contract with ICF International. 66 pages.

Driscoll, C. T., K. F. Lambert, and L. Chen. 2005. Acidic deposition: Sources and effects. In M. G.Anderson (ed.), Encyclopedia of Hydrological Sciences. John Wiley & Sons, Ltd., Chichester, England, p. 1441-1457.

Driscoll, C. T., K. F. Lambert, and L. Chen. 2005. Acidic deposition: Sources and ecological effects. In G. R. Visgilio and D. M. Whitelaw (eds.) Acid in the Environment: Lessons Learned and Future Prospects. Springer Science + Business Media, Inc.

Driscoll, C.T., D. Whitall, J. Aber, E. Boyer, M. Castro, C. Cronan, C. Goodale, P. Groffman, C. Hopkinson, K.F. Lambert, G. Lawrence, and S. Ollinger. 2003. Nitrogen Pollution in the Northeastern United States: Sources, Effects, and Management Options. BioScience. 53(4): 357-374.

Driscoll, C.T., D. Whitall, J. Aber, E. Boyer, M. Castro, C. Cronan, C. Goodale, P. Groffman, C. Hopkinson, K.F. Lambert, G. Lawrence, and S. Ollinger. 2003. Nitrogen Pollution: from the Sources to the Sea. Hubbard Brook Research Foundation. Science Links Publication vol. 1, no. 2.

Driscoll, C.T., D. Whitall, J. Aber, E. Boyer, M. Castro, C. Cronan, C. Goodale, P. Groffman, C. Hopkinson, K.F. Lambert, G. Lawrence, and S. Ollinger. 2003. Nitrogen Pollution: Sources and Consequences in the U.S. Northeast. Environment. 45(7):8-22.

Driscoll, C.T., G.B. Lawrence, A.J. Bulger, T.J. Butler, C.S. Cronan, C. Eagar, K.F. Lambert, G.E. Likens, J.L. Stoddard and K.C. Weathers. 2001. Acidic Deposition in the Northeastern United States.: Sources and Inputs, Ecosystem Effects, and Management Strategies. BioScience. 51(3):180-198.

Driscoll, C.T., G.B. Lawrence, A.J. Bulger, T.J. Butler, C.S. Cronan, C. Eagar, K.F. Lambert, G.E. Likens, J.L. Stoddard and K.C. Weathers. 2001. Acid Rain Revisited: advances in scientific understanding since the passage of the 1970 and 1990 Clean Air Act Amendments. Hubbard Brook Research Foundation. Science Links Publication. Vol.1, no.1.

Likens, G.E. and K.F. Lambert. 1998. The importance of long-term data in addressing regional environmental issues. Northeastern Naturalist 5(2):127-136.

Lambert, K.F. 1998. Ecosystem Science: understanding nature's complexity--guiding society's problem-solving. A summary of the 1997 Cary Conference. Institute of Ecosystem Studies. Millbrook, NY.

Lambert, K.F. 1998. Instream flow uses, values and policies in the Upper Connecticut River Watershed. A Report to the Connecticut River Joint Commissions and U.S. Environmental Protection Agency.