President's Task Force on Climate Change

Final Report

March 2009

The Johns Hopkins University
Benjamin F. Hobbs, Chair

JOHNS HOPKINS
UNIVERSITY

President's Task Force on Climate Change

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Letter from the Chair

February 27, 2009

President Ronald J. Daniels
Johns Hopkins University
Office of the President
242 Garland Hall
3400 N. Charles Street
Baltimore, Maryland 21218

Re: Submission of Final Report of President's Task Force on Climate Change

Dear President Daniels,

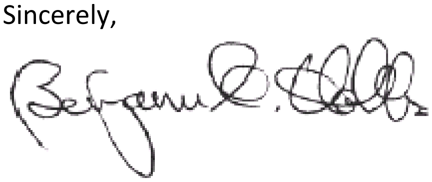
I am pleased to present our Final Report. The Task Force members, together with members of the three Working Groups, have put together an inspiring set of recommendations and thorough supporting analyses. The report is not only a product of their hard work, but also of the students who provided the leadership and ideas that lead to the establishment of the Task Force. I would like to especially acknowledge the essential contributions of the Working Group chairs (Larry Kilduff, Fred Puddester, and Prof. Darryn Waugh) and the staff of the JHU Sustainability Initiative, lead by Davis Bookhart.

Implementation of the report's recommendations will contribute to making Johns Hopkins a leader in sustainability research and education, while drastically lessening our emissions of greenhouse gases over the next decade and a half.

Moreover, these recommendations will free up significant resources to devote to the University's core missions by slashing our energy bills. The need for these resources in the present financial climate makes it all the more imperative to do what we can to lower energy costs. The energy efficiency investments we propose here will pay for themselves quickly. Appropriate financing approaches could result in positive cash flows from the very beginning, resulting in an improvement in our short-term as well as long-term financial picture. This is not a free lunch; it is a lunch we are paid to eat.

I look forward to working with you and the Hopkins community on implementing these recommendations over the coming years.

Sincerely,



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List of Terms and Abbreviations

BTU	British Thermal Units
CHP	Combined Heat and Power (see Co-Gen)
CO_2	Carbon Dioxide
Co-Gen	Cogeneration is where both heat and power are utilized in a single process.
GHG	Greenhouse Gas
GSF	Gross square feet
Offset	An arrangement where one party reduces carbon emissions on behalf of another.
MTCDE	Metric Ton of Carbon Dioxide
MW	Megawatt
MWh	Megawatt Hour
REC	Renewable Energy Credit
SO_2	Sulfur Dioxide
Solar PV	Solar Photovoltaic systems convert sunlight directly into electricity.
Solar thermal	Solar thermal systems convert sunlight into thermal energy (heat).
VAV	Variable Air Volume

Johns Hopkins University Abbreviations

APL	Applied Physics Laboratory
CBS	Carey Business School
ED	School of Education
JHSPH	Bloomberg School of Public Health
KSAS	Krieger School of Arts and Sciences
PEA	Peabody Institute
SAIS	School of Advanced International Studies
SOM	School of Medicine
SON	School of Nursing
WSE	Whiting School of Engineering
UA	University Administration

President’s Task Force on Climate Change

1.0 Executive Summary

1.1 Overview

On July 23, 2007, President William R. Brody announced the formation of the President’s Task Force on Climate Change (Task Force) to address the need to reduce greenhouse gas emissions at Johns Hopkins University, within the Baltimore area, and globally. Recognizing that universities must play a central role in meeting the challenge of climate change, President Brody defined three overarching goals for the Task Force:

1. Develop a Comprehensive Climate Strategic Plan for addressing the emissions of greenhouse gases that derive from University operations. The plan should cover a broad collection of technical measures, behavioral incentives, and innovative approaches to reducing carbon emissions on the Johns Hopkins campuses. To accomplish this goal, the Task Force created the *Tactics and Strategies Working Group*.
2. Spur creativity, innovation, and new avenues of scholarship by reexamining various aspects of climate change from a multi-disciplinary and collaborative research perspective, and translate that perspective into educational achievement. To accomplish this goal, the Task Force created the *Innovation and Research Working Group*.
3. Develop and nurture strong relationships with State, City and community groups within the Baltimore region, and explore collaborative ways to attain our respective goals, transfer knowledge, and share successes. To accomplish this goal, the Task Force created the *Community Partnerships Working Group*.

The Task Force focused on the principle of “reducing, with the vision of carbon neutrality, the emissions of greenhouse gases derived from university operations.” The Task Force focused on goals and actions that could be accomplished in the medium term (2025). The Task Force recognized that a “vision” of carbon neutrality paralleled a vision of a truly sustainable university where all resources consumed were continuously recycled or regenerated. This led to two conclusions: first, the university could not realistically reach this state within the next 15 years, but could make clear progress towards it. Second, the Task Force acknowledged that a vision of carbon neutrality should not be achieved by primary reliance on purchasing offsets or other means of transferring the responsibility for emissions reductions to others. Rather, actions, particularly in the medium term, should produce real, local carbon reductions.

In the rest of this Executive Summary, we highlight some of the recommendations; the body of this report details all the recommendations. The rest of the report is structured into three parts, each reporting the analyses and results of one of the Working Group deliberations.

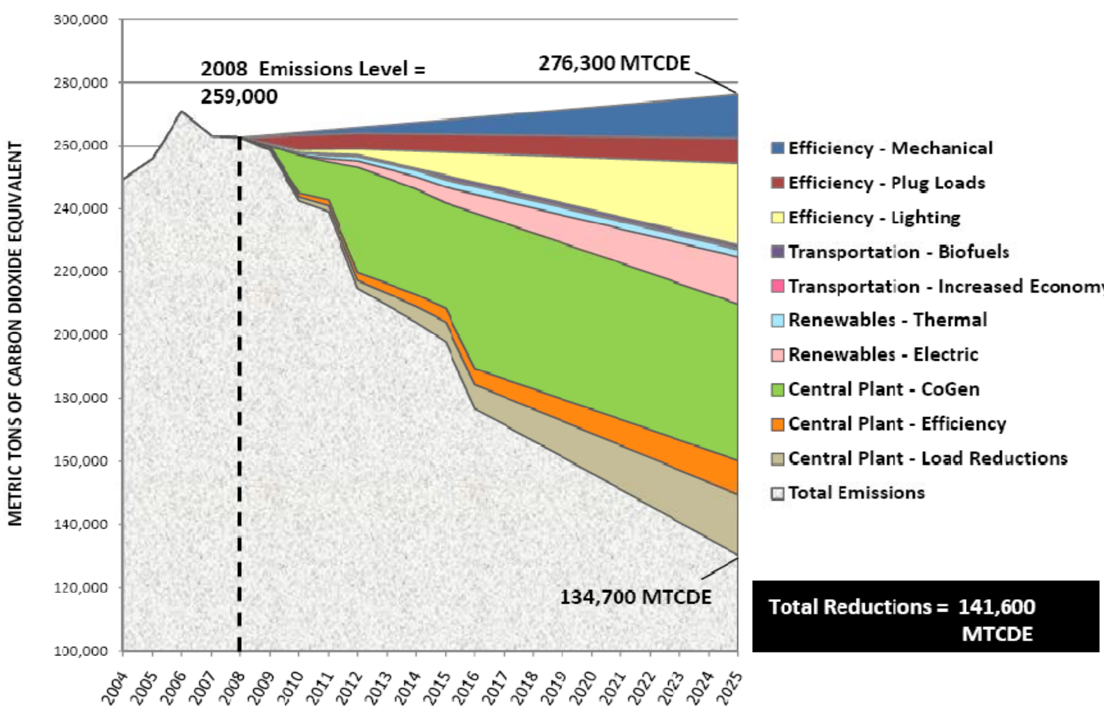
1.2 Summary of Recommendations

The three working groups developed reports that include 35 recommendations for action. The Task Force agreed that the recommendations should form the basis for actions that allow for flexibility, incorporation of new technologies and financial stewardship. In the context of carbon reductions, the strategies are consistent with known technologies and proven options that are either cost effective today, or are very likely to be so within the next five to ten years. For research and scholarship, the strategies set a course of action that will generate high value for the university. For bolstering community synergies, the strategies are designed to leverage larger pools of funds through partnerships and increased student and staff participation in the community.

Recommendations include (in no order of priority):

1. **Reduce university emissions by 51% by 2025.** Based on currently available technologies as well as emerging technologies that are expected to be cost effective within the next ten years, JHU can reduce greenhouse gases by approximately 141,600 Metric Tons of Carbon Dioxide Equivalent (MTCDE) by 2025.

Figure 1.1: Reductions by Source



2. **Implement cogeneration opportunities** on the Homewood and East Baltimore campuses, and conduct feasibility studies to determine the effectiveness of additional cogeneration opportunities at the East Baltimore and Bayview campuses.

3. **Implement all "high opportunity" energy conservation measures** defined by conceptual engineering studies within the framework of University financial plans.
4. **Address the growing energy needs of computing and data management** by "virtualizing" servers, separating mission critical operating environments from non-mission critical applications, migrating existing servers to the Mt Washington Data Center, and making use of energy saving software.
5. **Develop a financial, environmental, and carbon-evaluation matrix** to evaluate projects, including net financial indices, life cycle cost, amount of carbon reduction, educational opportunities, contributions to community partnerships, and public relations value for evaluating medium to low opportunity options for energy efficiency and renewable supplies.
6. **Create a university-wide umbrella research and education organization ("Institute")**, with a full-time director, administrative support, and internal oversight committee. The Institute will provide a single point of contact, increase the visibility of JHU internationally, and coordinate curricular and research activities related to climate change and sustainability.
7. **Integrate the Institute's activities** with efforts to reduce the JHU carbon footprint, engage in collaborative projects with the community, and participate in public outreach.
8. **Create a community-based learning working group** to promote sustainability related projects. The group will (1) work with departments to identify faculty interested in community projects, (2) develop a clearinghouse of projects working with the City and community groups, (3) set up a directory of environmental groups for students to access for internships and other opportunities and (4) work with development offices to network with interested alumni in this arena.

1.3 Implementation

The Task Force recognizes that this process of examining the university's carbon footprint and evaluating feasible options will be a process that will and should continue. By choosing a reduction target at 2025, the Task Force assumes that similar exercises will take place over the next years to develop implementation plans, evaluate progress, adjust the goals and priorities, and develop the next phases of reduction goals.

To ensure that the recommendations of this Task Force are implemented and that the university retains focus on addressing climate change over the long-term, this report should be viewed as a "living document" that continually evolves by setting in place an ongoing process in which updates are implemented and planned projects are highlighted.

2.0 Tactics and Strategies Working Group

2.1 Overview

The Tactics and Strategies Working Group (WG) is one of three Working Groups under the President's Task Force on Climate Change charged to develop viable technical measures, ways to influence behavioral change, and innovative approaches to reducing carbon emissions on the Johns Hopkins University campuses (Members listed in Appendix A). Over the course of ten monthly meetings, the Working Group examined a variety of topics ranging from the operations of existing buildings, criteria that influences the design of new buildings, financing of efficiency measures, renewable resources, and transportation options in order to determine the extent to which measures adopted could positively impact greenhouse gas (GHG) reductions. The WG assessed existing and new technologies and evaluated timeframes within which some of the more promising technologies will become available. This report is the culmination of those discussions and evaluations.

2008 Emissions at a Glance: in Metric Tons of Carbon Dioxide Equivalent (MTCDE)

Homewood	***99,700***
E. Baltimore	***98,600***
APL	***52,500***
Peabody	***5,600***
Washington DC	***2,600***
Total	***259,000***

Based on an evaluation of the current greenhouse gas inventory, projected growth of the campuses, and opportunities for reductions, this chapter also details recommendations and a proposed plan with specific targets and timetables for GHG reductions. All of the findings and recommendations of this chapter represent the consensus of the members of the working group and have been approved by the Task Force. The Working Group recognizes that in this difficult economic environment it may not be possible to advance all of the recommendations immediately. However, the group agreed that the recommendations should reflect the best views for moving forward with the understanding that some measures may need to be delayed.

This chapter begins with an overview of university greenhouse gas emissions (Section 2.2) and continues with a depiction of reduction opportunities (Section 2.3) and the role of green power and offsets in evaluating reductions (Section 2.4). The chapter concludes with an analysis of reasonable reductions targets (Section 2.5) and recommendations for reaching those targets (Section 2.6).

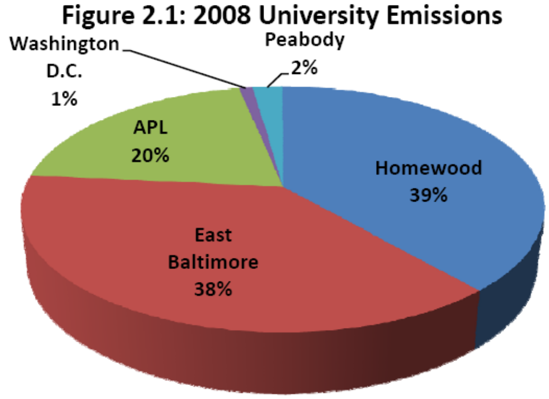
2.2 Greenhouse Gas Inventory

Over the past two years, the Sustainability Committee has collected and compiled utility and usage data to determine the overall greenhouse gas inventory (also referred to as the carbon footprint) for the University. This inventory accounts for emissions of all six greenhouse gases specified by the Kyoto Protocol: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Each gas varies in its contribution to global warming, a fact reflected by its global warming potential (GWP). The GWP compares a given mass of a greenhouse gas to the same mass of carbon dioxide, thus allowing the conversion of all the greenhouse gases into a carbon dioxide equivalent (CDE). The results of the greenhouse gas inventory are consequently reported in terms of Metric Tonnes of Carbon Dioxide Equivalent (MTCDE).

2.2.1 Sources

Greenhouse gas emissions derive from a variety of sources. However, the main greenhouse gas – representing over 99% of all emissions – is CO_2, resulting from the combustion of non-renewable fossil fuels. Within the university setting, these emissions are largely concentrated in energy services such as heating and cooling buildings, lighting, electronics – sometimes referred to as "plug loads," – and transportation. A number of refrigerants are also sources of greenhouse gases, and if released accidently or from leaking equipment, their global warming potential is significantly higher than other greenhouse gases like carbon dioxide. Although the amount of released refrigerants is very low, the inventory includes them.

Figure 2.1: 2008 University Emissions



Emissions counted in the Johns Hopkins University inventory come from "direct" sources (i.e., fuels that we use on campus and over which we have direct control) and "indirect" sources, (i.e., electricity that is generated at facilities outside of our control, but the consumption of the electricity remains in our control). Most GHG protocols also identify a third scope of indirect emissions that are outside the university's control, but may be influenced by university policies or actions. These emissions – such as employee commuting, work-related air travel, and solid waste disposal – remain outside of the university's inventory, but demonstrate areas of opportunity for university actions that could encourage and promote positive behaviors that would benefit the larger community.

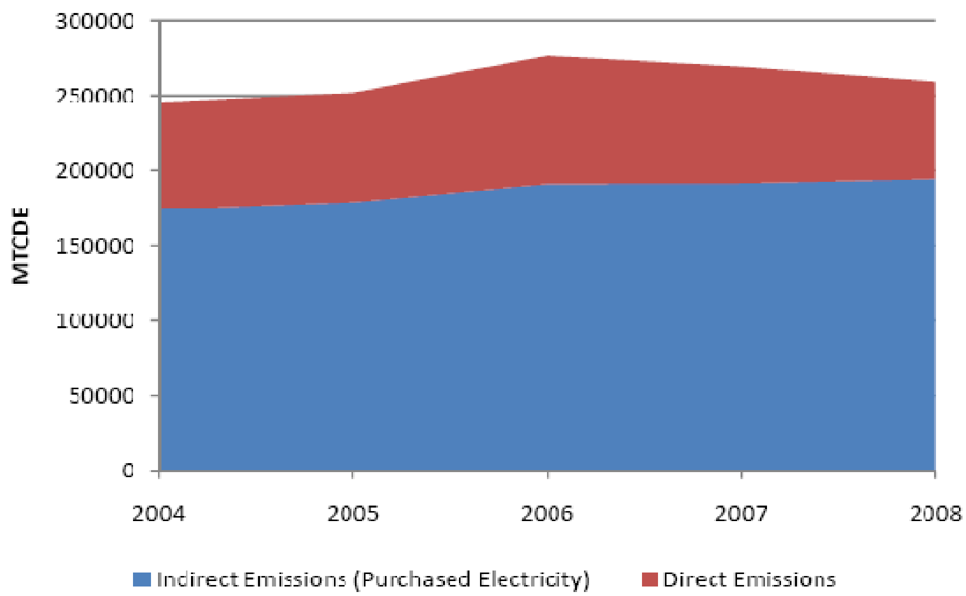
2.2.2 Emissions

The total amount of greenhouse gases emitted in 2008 was 259,000 MTCDE. The two significant groupings of emissions were from the Homewood[1] and East Baltimore campuses, reflecting their size and research intensity. Of the university total, 99,700 MTCDE came from the Homewood campus, 98,600 MTCDE from the East Baltimore campus (excluding JHH), 52,500 MTCDE from the Applied Physics Laboratory, and the remaining 8,200 MTCDE result from operations at the remaining sites, including the Peabody Institute, the School for Advanced International Studies in Washington, DC.

[1] The Homewood campus category includes all of the buildings in the traditional Homewood campus, University buildings in Charles Village, the Eastern building on 33rd St., the Mt Washington Campus, the Downtown Center, the Evergreen House, and the Montgomery County campus.

Figure 2.2 depicts the combined University-wide emissions from fiscal year 2004 to 2008. Emissions are broken into two categories: direct emissions and indirect emissions. Direct emissions derive from activities where the university has complete control over the fuels or the emitting sources. The direct emissions category includes the consumption of natural gas for heating, diesel fuel for shuttle buses, gasoline for motor pool fleet, and the release of refrigerants from cooling systems. Indirect emissions are mainly electricity purchases where the emissions factors at the regional level based on the overall portfolio of fuels used to generate electricity for the regional grid.[2] While the university has control over electricity consumption, the university does not have control over how purchased electricity is generated.

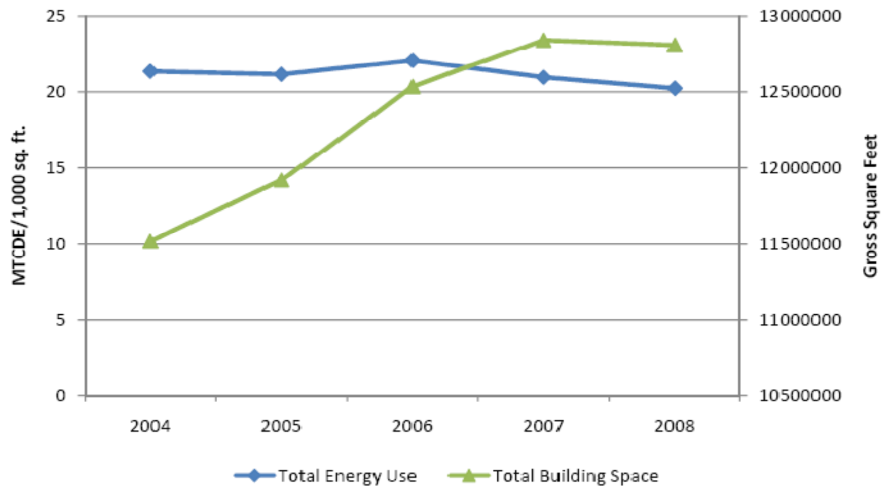
Figure 2.2: 2004-2008 University-wide Emissions by Source



Indirect emissions from purchased electricity dominate the University's greenhouse gas emissions profile, and have grown from 71% of total emissions in 2004 to 75% of total emissions in 2008. This is due to a number of factors, including increased plug loads, more intensive computing resources, and an increased need for summer cooling and dehumidification. Direct emissions from on-campus stationary sources, the other primary source of emissions, mostly reflect campus heating and domestic hot water operations, but also include a modest amount of fuels used for back-up generators and grounds equipment. The share of on-campus stationary sources remained steady at around 27% of total emissions from 2004 to 2006, dropping to 24% in 2007 and 2008. The transportation functions of the university, while growing, remain a very small piece of the overall GHG emissions profile at less than 1%.

[2] E-Grid data available at http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

Figure 2.3: 2004-2008 University-wide Emissions Density



All university campuses have been actively involved in reducing energy consumption during the past five years. The effectiveness of these actions is clear and overall emissions of the university has actually decreased recently, while the intensity (in tons per unit floor area) has fallen by more than 6% in the last two years. The growth in emissions from 2004 to 2008 was 13,000 MTCDE or about 5%, which demonstrates vast improvement in energy and emissions management, and is especially impressive for two reasons: (1) as noted above, the university is using more electricity, and electricity has a higher carbon footprint than natural gas, and (2) the overall size of the university has grown by nearly 10 percent (1.25 million square feet) over the past five years. Seen another way, the emissions density – the amount of emissions per square footage of building space – has shown a steady decline, going from 21.25 MTCDE/1,000 ft^2 in 2004 to 20.13 MTCDE/1,000 ft^2 in 2008, as demonstrated in Figure 2.3.

2.2.3 Greenhouse Gas Potential

The data suggests that electric consumption is both the largest overall contributor as well as largest emitter per unit of energy. Compared to energy "sources," like oil or natural gas, electricity has a unitary emission factor that is roughly two to three-times higher (see Table 2.1). The largest consumers of electricity on the JHU campuses are laboratory buildings, computing/data centers and chilled water plants for air conditioning. Natural gas is the cleanest of the fossil fuels, but remains a major greenhouse gas contributor because of the volume consumed. Diesel fuel used in transportation shuttle bus fleets has high carbon content, but can be blended with renewable fuels like biodiesel to help reduce the emissions impacts.

Table 2.1: Greenhouse Gases

UNITARY EMISSION FACTORS		
FUEL SOURCE	HIGHER HEATING VALUE	CARBON DIOXIDE (LB/10^6 BTU)
ELECTRIC	3,413 BTU / KWH	352.0
NATURAL GAS	100,000 BTU /THM	117.0
DISTILLATE OIL	138,000 BTU / GAL	168.0
GASOLINE	123,400 BTU / GAL	155.5

2.3 Opportunities for GHG Reductions

The Working Group examined all facets of campus operations and determined that the most compelling opportunities for greenhouse gas reductions are available in five areas: power plants, existing buildings, new construction, data centers and computing, and behavioral changes. More details on these areas are included in Appendices D.1 through D.5.

2.3.1 Power Plants

Large power plants and smaller district heating and cooling plants, in which steam and chilled water are generated and distributed, offer the greatest potential for GHG reductions since they are the major consumers of fossil fuels and electricity. The advantage of central power plants is that they are controlled and operated centrally, so major and even minor changes in fuel input or efficiency can have large campus-wide gains. The opportunity for efficiency – and further GHG reductions – is even greater where CHP (combined heat and power, co-generation) systems can be deployed.

The WG confirmed that viable and financially attractive opportunities exist to design and install CHP systems on the Homewood and East Baltimore campuses, with further potential at the Bayview Campus. On the Homewood campus, the opportunity to install a gas turbine that will generate 4.6 MW of electricity while capturing waste heat for use in steam production is being implemented and will be operational by April 2010. The efficiency gains will lower GHG by over 12,000 metric tons annually, about 5% of total university emissions. On the East Baltimore campus design efforts are well along to install two gas turbines with a capacity of 15.0 MW to serve the University and Hospital that will lower GHG by 44,000 metric tons and where 50% of the reduction, 22,000 metric tons, would be credited to JHU since approximately 50% of the steam and chilled water distributed serves the School of Medicine, the Bloomberg School of Public Health, the School of Nursing and other University affiliates. There is also an opportunity to expand cogeneration at this site by an additional 7.5 MW in the following decade.

2.3.2 Existing Buildings

With over 200 large and small buildings located throughout the Baltimore-Washington region, energy consumption in existing buildings accounts for 95% of all GHG emissions for the university. The WG determined that new and old buildings alike offer a wide variety of energy conservation measures that can be implemented that will contribute to GHG reduction goals. New buildings, even those that benefit from energy efficient designs and modern equipment, consume significantly more energy than older buildings because of their sheer size, the intensity and variety of activities, density of occupancy, numbers of fume exhaust hoods and numbers of air changes.

The WG compiled extensive data at the building level and ranked buildings from highest to lowest performing buildings from an energy perspective. Further refinement of the data highlighted a number of buildings that appear to be high ranking candidates for immediate attention to include more extensive energy audits and feasibility studies to more specifically define the scope, cost and benefit of conservation measures. Lab buildings contribute the highest levels of energy consumption and GHG emissions – in some cases by a factor of four over other academic and administrative buildings – making them the highest priority for continuous examination for efficiency opportunities. Based on highest potential for GHG reductions, the WG selected 10 buildings, collectively representing 1,832,000 gross square feet of building space, to evaluate for conservation upgrades.

Measures studied in candidate buildings included:

- Potential for Variable Air Volume (VAV) retrofits.
- Application of frequency Drive Generators on higher HP motors.
- Fume hood exhaust management in Laboratory Buildings.
- Reducing numbers of air changes while meeting code and safety requirements.
- Application of air-to-air heat recovery wheels.
- Re-commissioning buildings whose controls have "drifted."

A full list of buildings, the measures that would be appropriate for each, the costs and savings are detailed in Appendix D.2.

Once the candidate buildings have been brought up to a higher energy performance level, the WG recommends that measures be taken to provide continuous commissioning over time to monitor the performance of the systems so that they remain at peak performance levels.

The WG agreed that similar building energy audits be compiled at regular intervals (e.g., every five years) to capture the next grouping of high ranking candidate buildings for retrofits or upgrades. This is especially important in light of the rapid development of new technologies. The WG also agreed that outside the 10 candidate buildings there are smaller measures that can be implemented in much of the remaining building stock. Upgrades include lighting retrofits, occupancy sensors and developing product lists to address equipment "plug loads."

2.3.3 New Construction and Renovations

The WG recruited members of Design and Construction units from four Divisions, Homewood, The School of Medicine, The Bloomberg School of Public Health and the Applied Physics Lab, to staff a sub-group.[3] The focus of their effort was to develop a set of "Design Guidelines" that would be universally employed as the basis to select the energy efficiency measures that would become the "basis of design" (BOD) before consulting architects and engineers begin actual design work. Use of these guidelines as the BOD will ensure that all viable opportunities will be discussed and evaluated early in the design process. Some measures identified will be simple and low cost while others thought to be more costly will be evaluated on the basis of life-cycle cost where both financial and GHG reductions will be factors to guide final decisions. The product of this sub-group's efforts is found in Appendix D.1.

For both new construction and renovations, the US Green Building Council's LEED[4] green building rating system is being utilized in a number of buildings on all campuses. While the structure of LEED does not require a high level of energy performance, it does reward good energy performance.

[3] The Sustainable Building Subgroup included: Larry Kilduff, Homewood; Craig Goodwin, School of Medicine; Glenn Carey, Applied Physics Lab; David Kempner, School of Public Health; John Schaefer, Health and Safety; Jennifer Dawson, Homewood; and Davis Bookhart, Sustainability Initiative.

[4] Leadership in Energy and Environmental Design. See www.usgbc.org.

2.3.4 Data Centers and Computing

Rapidly growing computing needs for all areas of university operations and research have resulted in measureable increases in energy consumption – in both electricity and cooling – and have become a large driver of GHG emissions. Server rooms supporting dedicated needs are growing at a rapid rate. This growth requires that dedicated cooling and back-up power be installed, resulting in increased capital costs; growing power consumption; increasing operations and maintenance costs; and allocation of space that might be better used for program needs.

The WG recognized that development of near and long term strategies for the placement and operation of data centers for administrative and academic/research computing is essential to the overall GHG reduction strategies.[5] Some strategies include:

- "Virtualizing" servers to maximize their utilization and reduce numbers. Virtualization for Windows and Linux operating environments has been the single most significant technology advancement impacting power and overall cost savings for all data centers over the past several years. Server virtualization allows customers to consolidate many physical servers onto one physical server running multiple virtual servers and has been successfully deployed at 15:1 or 20:1 ratios resulting in significant savings.

- Dividing data centers into "mission critical" and non mission critical operating environments so that they employ differing criteria and energy requirements. At this time, nearly all centers have elaborate layers of redundancy and stand-by power requirements. Separating those centers that are non mission critical could reduce or eliminate some of the energy intensive redundant features for those applications.

- Developing plans to migrate existing servers to the Mt Washington Data Center. New data center designs, such as high Delta-T HVAC systems, can improve cooling efficiency by 25-30%. Larger cooling plenums and maximum airflow allow these units to cool air at a higher rate than standard HVAC equipment. These data center efficiency measures are some of the best in contemporary data center design, and represent significant improvements in economies of scale over smaller distributed server rooms scattered across the campuses.

- Potentially operating newer servers at higher temperatures. Due to their higher temperature tolerance, server rooms and data centers would be able to reduce their need for cooling. Widespread testing is in progress to evaluate other relevant factors such as the effect of humidity and long-term hardware reliability. This is a strategy we will continue to pursue, particularly at the larger data center locations.

- Evaluating the feasibility of "thin client" networking to reduce workstation requirements. Thin client networking refers to a system by which the main computing and system requirements are hosted on a server accessed by work station terminals.

[5] Strategies identified by IT@Hopkins through the white paper, "Green Initiatives." Credit goes to Eric Colliflower, Jim Ferrens, Steve Sears, Bob Romero, and Mike McCarty.

- Implementing new software that can be deployed throughout the enterprise to put desk-top computers into the "hibernate" mode in off hours. The NightWatchman product from 1E offers a solution to centrally manage the power-down of PCs in large networks. This capability could be used to conserve power on over 25,000 PCs across the Johns Hopkins enterprise by automatically putting PCs into a suspended or hibernated state so that machines can safely be powered down with no loss of data. This software is being piloted in the JH@ Eastern facility at the present time and if results are as expected, this software will be deployed throughout the enterprise. Early analyses suggest that this simple and low cost measure by itself represents a GHG reduction of approximately 7,000 metric tons annually enterprise-wide.

2.3.5 Behavior Change

The WG recognized that even with technological upgrades and the implementation of conservation measures, the continuous engagement of campus populations is essential to reduce behavioral impacts on emissions.[6] This engagement can come in a number of forms, but at its simplest levels it must accomplish two objectives: reward positive behavior (i.e., those behaviors that help meet GHG reduction goals) and discourage behaviors that do not.

In some cases, certain negative behaviors may decrease as a consequence of conservation measures. For example, occupancy sensors for lighting eliminate the responsibility on building occupants to turn off lights when they leave rooms. Improving the thermal comfort inside buildings through more efficient systems and building envelope improvements may reduce the number of occupants who use energy inefficient space heaters near their work stations.

Similarly, positive behaviors may be supported and nurtured through a strong emphasis on GHG reduction goals combined with a visible effort of university leadership to emphasize the goals as a collaborative effort. The WG established that the concept of "social norms" is an essential element in changing personal behaviors to meet the larger goals of the institution. Social norms refer to "the rules that a group uses for appropriate and inappropriate values, beliefs, attitudes and behaviors," and can include a variety of incentives and disincentives. The shaping of social norms is often directed by leaders and liaisons in each community; in our case, these would be members of the senior administration, deans, department chairs and representatives. Strong and consistent reinforcement from the Administration and at the Divisional level is essential in reinforcing positive behavior change.

Rewards need be scaled and tailored to each target group or individual, and need to evolve over time. For example, a non-monetary public acknowledgement may be a positive reward for certain behaviors, whereas coffee cards or other consumable goods may be more effective for others. Studies show that the "threat of loss" will often elicit more effective behavior changes than a positive incentive, although the threat of loss must be tangible and direct. Threats of loss are more effective when coupled with intermittent reinforcement of the behavior through rewards. However, a strategy to produce positive behaviors based on the threat of loss may undercut some of the other goals, such as developing a strong sense of community and cooperation and commitment to common goals as an institution.

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[6] Additional work on behavior change research was conducted by the Behavior Change subgroup, including Jessica Vahrenkamp, Leana Houser, Steve Shapiro, Maria Elena Figueroa, Susan Larson, and Davis Bookhart.

Immediate feedback is a powerful motivator. The "Prius effect," where a driver can see the real-time gas consumption while driving, has been shown to increase the kind of driving patterns that reduce gas consumption. This effect is relevant for energy consumption in buildings as well where real time energy data is displayed for building occupants to see or access.

Reduction targets, coupled with rewards for meeting the targets and local leadership to help reinforce the behaviors, would seem to offer the best combination to influence and change behaviors. Two examples of behavior efforts on the Homewood campus are Recyclemania, a competition to increase the amount of recycled materials diverted from waste the waste stream, and Saving Energy Extreme: Inter-dorm Tournament (SEX:iT), an inter-dorm energy reducing competition.

2.3.6 Collaboration with Peers

The Ivy+Sustainability Working Group (IPS) was formed in the Spring, 2007, as a natural alignment of sustainability programs within the peer group of the Ivy Plus institutions.[7] Members of the IPS have identified a series of shared goals – from reducing greenhouse gases to increasing environmental stewardship – and look to leverage our institutions' established record of cooperation and shared scholarship to help meet those goals. The overarching objective of the IPS is to maximize cross-institutional collaboration in ways that positively impact each institution's sustainability efforts. Members of the IPS collaboratively drafted the following vision:

> We recognize that with an issue as complex as climate change, a vast number of areas demand attention and exploration—more than any one university can address individually. From this point forward, the Ivy Plus institutions have a unique opportunity to work directly and collaboratively to make a significant contribution to solving the global challenges of climate change through research innovations, using each of our campuses as a microcosm in which to test our technological, social and economic strategies. Through the guidance and vision of the Ivy Plus presidents, we look to bond our institutions together in ways that leverage each of our particular institutional strengths while demonstrating a force of leadership on this paramount effort both nationally and globally.

The entire group has now met three times and the sustainability officers join a monthly conference call to share ideas and strategies on GHG reductions. The group has identified a number of areas for collaborative research and analysis, including energy conservation in laboratory buildings, benchmarking progress, and research on emerging technologies.

2.4 Role of Renewables, Green Power, and Offsets

In developing strategies for addressing greenhouse gases, there are essentially two viable areas of concentration: reducing the amount of energy consumed, and producing energy in a way that does not produce GHG emissions. As noted in section 2.2.2, the majority of university GHG emissions are derived

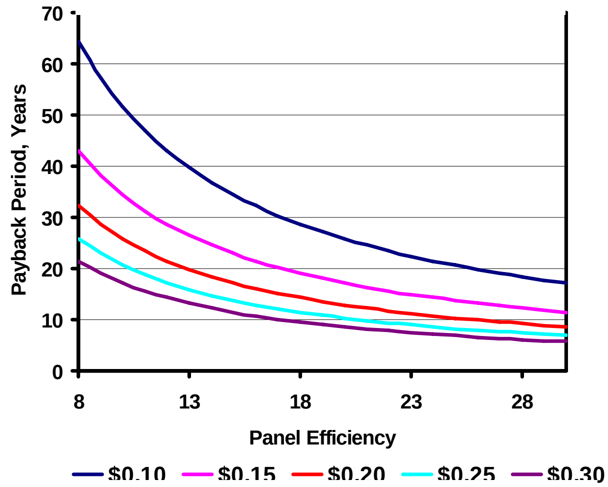
[7] The Ivy Plus Sustainability working group comprises the chief sustainability officers from: Brown, Chicago, Columbia, Cornell, Dartmouth, Duke, Harvard, MIT, Penn, Princeton, Stanford, Yale, and Johns Hopkins.

through our consumption of grid-purchased electricity. Therefore, the two options are to eliminate – through conservation measures – or displace by substituting low- or zero-emitting resources.

2.4.1 On-site Renewable Power

As a complement to energy conservation measures, the installation of onsite renewable technologies can reduce the amount of GHG emitting resources (mainly electricity and natural gas) purchased by the university. Currently few renewable energy applications are cost effective. Those that do lend themselves to campus settings are often space-intensive and inefficient. While not feasible now, some technologies such as solar photovoltaics (PV) continue to improve in both panel efficiency and costs per watt (see figure 2.4). In addition, state incentives, such as the Maryland "solar carve-out" in the State's Renewable Portfolio Standard may have the effect of cutting these costs in half within the next few years. Combined with federal incentives, rapid improvements in production efficiencies, and creative financing options, it is possible that JHU could find attractive opportunities in the near future. Efforts should continue to monitor solar technology advances for improved applications / efficiencies that may become more financially attractive in the next three to five years.

Figure 2.4: Efficiency and Cost Potential for Solar PV



Source: Harry Charles, APL, presentation to T&S Working Group August 7, 2008

One technology that is closer to cost effectiveness at this time is solar thermal for domestic hot water. Using rooftop collectors, solar energy is absorbed and transferred to hot water tanks in buildings. This may be especially attractive for buildings, such as residence halls, with significant hot water loads. This opportunity should be investigated in the near future for demonstration purposes and, if successful, wider adoption.

Where architecture is not a limiting factor, small rooftop or parapet wind turbines may be able to take advantage of thermal drafts and wind currents to produce modest amounts of electricity to buildings. These models are moderately cost effective, and would likely be more advantageous as symbolic representations of positive efforts versus significant contributions to GHG reduction goals.

For on campus combustion technologies, there are an increasing number of renewable or low GHG forming fuels coming to the market. Once thoroughly tested and accepted as safe and effective, these fuels may be acceptable alternatives to fossil fuels used in campus generators, industrial boilers, or heating equipment. Some of these, such as second or third generation biofuels, are in the research and development phase, and are likely three to five years away from serious consideration for large scale use.

Geothermal is not often considered a renewable resource since it is typically utilized as an assisting technology (i.e., it helps water source heat pumps operate more efficiently). Geothermal technologies take advantage of relatively constant temperatures within the earth's crust to moderate heating and cooling needs, and recent developments in "deep bore hole" techniques indicate that these technologies may be beneficial on large buildings or even quad-sized applications.

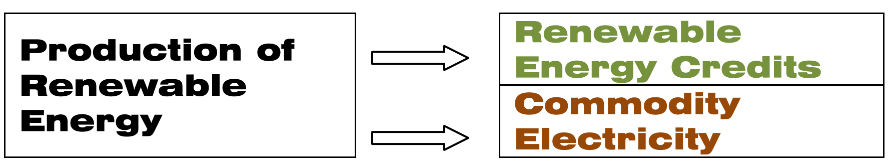
Considering the current limitations of renewable technologies, and given the large energy demands of university buildings, it is not likely that in the medium-term (10-20 years) renewable resources would be able to significantly displace grid-purchased electricity and GHG emitting fuels on the JHU campuses. However, the WG does anticipate a measurable contribution from renewable resources.

2.4.2 Green Power

Recognizing that on-site renewables may not be ready to make significant contributions to GHG reductions over the next decade, the WG evaluated the purchase of green power as an alternative option. Most electricity providers offer a retail "green power" package to customers in which a certain percentage of the electricity provided is certified as renewable energy.[8] Certified renewable power carries a premium, where costs vary depending on the amount purchased, the location of the renewable resource, and the type of renewable resource.

Since electrons from renewables are indistinguishable from electrons from dirtier forms of generation once they enter the regional grid, Renewable Energy Credits (RECs) were developed to track and verify the production of green power. Through an independent third party verification program, each MW of renewable electricity can be certified as a REC and stripped away from the electricity commodity so it can be traded as a separate product, as seen in Figure 2.5. By definition, RECs do not represent the actual commodity of electricity; rather they represent "all of the environmental attributes or benefits of a specific quantity of renewable generation."[9] Simply, a REC is a certificate that proves that 1 MWH of electricity has been generated.

Figure 2.5: Where Renewable Energy Credits Come From



In the green power market, RECs allow renewable electricity generators to "unbundle" the green aspects of the power they produce from the power itself so that they can sell both products separately. This has given rise to a market for certified green power; on the voluntary market, consumers can purchase RECs directly or they can purchase them through their electricity provider as a "certified green power" product. As described by Constellation New Energy: "In a typical 'green power purchase' an electricity consumer pays for generic electricity from the 'grid,' and also separately purchases RECs from

[8] Certified renewable power may come from sun, wind, earth, and water, and renewable energy fuels include solar, landfill biomass, wind and geothermal. See Constellation New Energy, www.newenergy.com.

[9] From www.green-e.org.

one or several renewable energy facilities in an amount that match all or a portion of the actual electricity purchased."[10]

If such purchases are made, it is critical to ensure that the purchased RECs are not used by other power providers to meet Maryland or other states' renewable portfolio requirements. Through legislation such as the Maryland Renewable Portfolio Standards, power providers are required to purchase RECs.[11]

It is also important to point out that several states, including Maryland, now cap the CO_2 emissions of its power plants.[12] Federal legislation that would impose such a cap nationally is likely to be passed in the near future. If emissions are capped, then producing more renewable electricity in the market will not lower emissions in the short run, as power producers will simply trade permits so that the total emissions still falls within the cap. Only if JHU were to buy carbon allowances and retire them would regional CO_2 emissions from electricity actually decrease. However, in the long run, the production of onsite renewable energy – as well as energy efficiency measures – will allow the emissions caps to be adjusted downward more aggressively.[13]

At this time, RECs do not carry a guarantee of GHG emissions reductions, nor are they tested for "additionality" — the likelihood that the project would not have happened in the absence of the REC payment. Some members of the WG posited that if RECs could pass the additionality criteria and there was certainty that RECs had a clear and measureable GHG reduction effect, then such purchases might be more attractive.

2.4.3 Carbon Offsets

A carbon offset is an emission reduction credit that counterbalances the purchaser's greenhouse gas emissions by funding an off-site greenhouse gas reduction project. If the project tests positively for "additionality," the transaction results in a net of zero additional GHG being introduced into the atmosphere. Carbon offsets are measured in metric tons of carbon dioxide equivalent (MTCDE) and can

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[10] From Constellation New Energy website, www.newenergy.com, accessed 12/11/08.

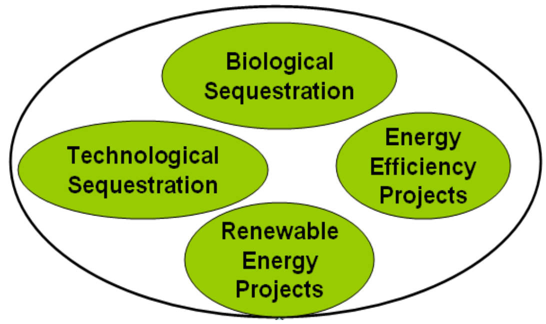
[11] Maryland and several other states have adopted "renewable Portfolio Standards" (RPS) in which sellers of power must include a certain minimum percentage of renewable energy in their mix of power sources. Federal RPS legislation is a possibility in the near future. For instance, if a RPS of 10% is imposed, a seller of electricity must self-generate renewable energy and/or buy RECs amounting to one-tenth of its total sales. If a seller turns around and resells credits to consumers that it also uses to meet the RPS, the consumer is buying RECs that would have been generated anyway, and no additional renewable energy would actually be produced as a result of that consumer purchase.

[12] Maryland is a member of the Regional Greenhouse Gas Initiative, www.rggi.org, which is a group of several northeastern states that have imposed caps upon the carbon emissions of its power plants. A tradable permits scheme allows plants whose emissions exceed their allocation of allowance to buy excess allowances from other plants or an auction.

[13] A reduction in energy demand would contribute to a lowering of emissions allowance prices which would contribute to a political dynamic in which a lower cost of achieving a cap would encourage USEPA or Congress to tighten that cap and lower total emissions. There is good reason to expect that this dynamic would be a reality, given the precedent of the Title IV SO_2 trading program and the SIP Call NO_x trading program, both of which experienced lower than expected prices of emissions allowances which encouraged USEPA to propose tightening the caps (under their "Clean Air Interstate Rule").

be indexed to electricity-related emissions. Figure 2.6 shows four common types of carbon offset projects.

Figure 2.6: Types of Carbon Offsets



The Gold Standard[14] is an international carbon offset protocol that was developed in response to the concerns that emission reduction projects were not making a real contribution to mitigating CO_2 levels. The standard applies to Kyoto-based as well as voluntary offsets. Forty-four national and international non-governmental organizations (NGOs) endorse the Gold Standard as the preferred certification for carbon offsets. The Gold Standard accepts only renewable energy and energy efficiency projects, due to concerns regarding the permanence of biological sequestration projects. Currently, Gold Standard offsets cost $18-20 per MTCDE. Gold Standard carbon offsets are vigorously audited for additionality and are the highest quality offset currently available on the voluntary market.

Table 2.2: Comparison of RECs and Offsets

	Green-e RECs	Gold Standard Carbon Offsets
Unit of measure:	MWh	MTCDE
Represents:	Positive attributes associated with a renewable source	GHG reduction
Recognized by:	Voluntary Framework	Voluntary and Kyoto-Based Frameworks
Additionality:	Not tested for additionality	Tested for additionality
Cost:	Depending on the renewable source and the region of the country where the power is generated, $6 to $10 per MTCDE (expected to rise in mandatory regulatory framework).	$18-20 per MTCDE

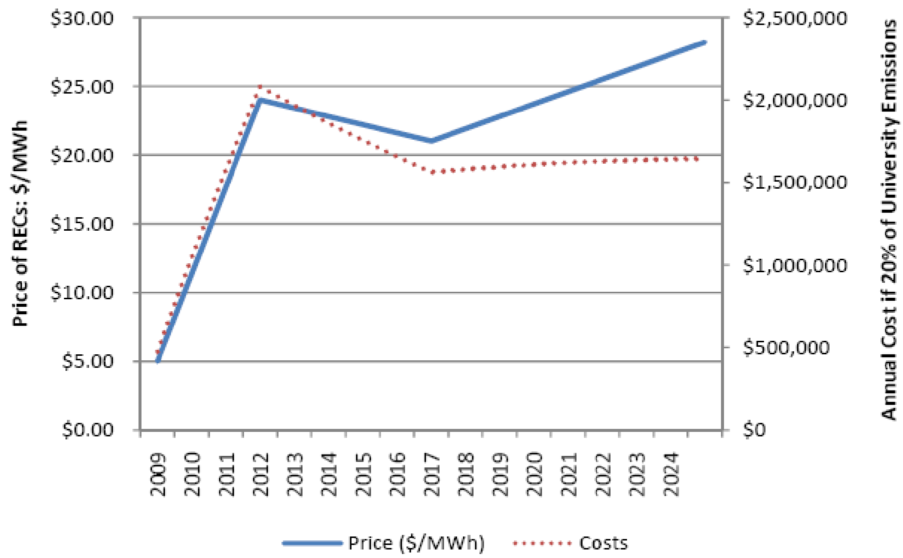
2.4.4 Purchase versus Investment

The WG discussed the value of purchasing RECs or offsets as part of the overall GHG reduction strategy. In the absence of federal legislation, there is some uncertainty over the estimated prices of RECs in the next decades and beyond. However, over the past few years a number of climate change bills have been introduced. Each has been accompanied by research on the potential impacts of REC prices under different legislative scenarios. The future REC prices in Figure 2.7 are based on analyses by the Department of Energy's Energy Information Administration, which considered 4 possible cases for the implementation of a nationwide renewable portfolio standard.[15] Estimates are provided for the price of a 1 MWh renewable energy credit in years 2010 and 2020 and extrapolated through 2025.

[14] www.cdmgoldstandard.org

[15] Energy Information Administration, "Impacts of a 10-Percent Renewable Portfolio Standard," at http://www.eia.doe.gov/oiaf/servicerpt/rps/pdf/sroiaf(2002)03.pdf, accessed on 12/1/08.

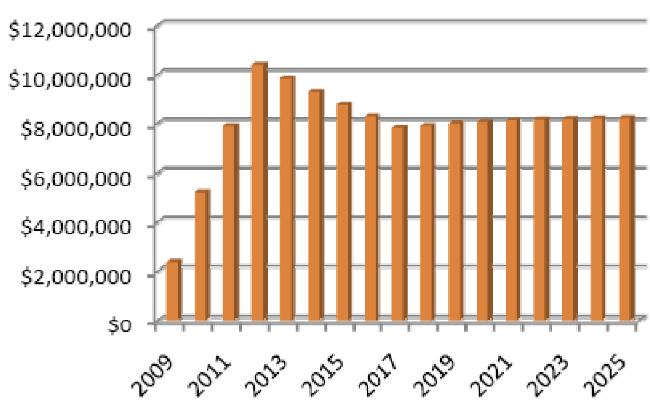
Figure 2.7: Cost of RECs Over Time



As a starting point, the WG evaluated the costs of purchasing green power (either buying RECs directly or indirectly as part of a certified green power purchase agreement with a retail power supplier) to cover 20% of the overall GHG emissions for the university.[16] In the Mid-Atlantic region, each REC represents the equivalent of 0.545 tons of CO_2, so in 2009, 20% of the university's carbon footprint would equal roughly 95,000 RECs.[17]

While the price for the RECs increases over time, the amount purchased would decrease due to overall conservation efforts. Figure 2.7 shows that the costs would start at roughly $475,000 in 2009 and rise to $2,000,000 in 2012. Afterward the increase in REC prices would be roughly offset by the decrease in purchases. Through 2025, the overall investment would represent the equivalent of 698,000 tons of CO_2 at a cost of $26,900,000.

Figure 2.8: Costs for Offsetting 100% of GHG by Year



In the context of "carbon neutrality," where the total volume of emissions were offset by purchases of RECs or other instruments, the costs would average roughly $9 million annually through 2025, as seen in Figure 2.8. Over the 15 year timeframe, the cummulative costs would be $135,000,000.

An alternative assessed by the WG was to use the REC price as a proxy for internal

[16] Assumptions and data tables included in Appendix E.

[17] As pointed out in footnote Y, *supra*, under a mandatory CO_2 cap, purchasing RECs will not lower CO_2 emissions unless those purchases are accompanied by a purchase and retirement of carbon allowances.

investments instead of REC purchases. Assuming a five year payback for investments, the total value of energy savings (based on investments of $26,900,000) at year 2025 would be $26,000,000, or 97% of the overall investment pool. However, if the savings are counted through their entire useful life, then the overall savings would be $37,700,000, an 140% improvement over the initial investment.

One of the arguments for purchasing RECs or other offsets is that on a dollar per pound of carbon reduction, RECs are the most cost effective. Over a one year period, this is true. For 2009, the university could not invest in projects that would reduce CO_2 at the cost of $9.00 per ton. However, the WG noted that the CO_2 savings, similar to the cost savings, also accrue over time, so an investment in conservation will avoid the release of CO_2 over many years afterwards as well as produce the acccompanying recurring savings. Even if the costs of CO_2 reductions at the university are greater than the purchase of RECs by a factor of four, the total amount of CO_2 avoided over time will be greater than the amount represented by the purchase of RECs (see Table 2.3).

Table 2.3: Comparing REC purchases Versus Internal Investments

If at Year 2025, Stop Purchases or Investments	Total Purchases of RECs	GHG Reductions Represented by REC Purchase	If Invested, Total Savings	If Invested, Total GHG Reductions
	$26,900,000	698,000 MTCDE	$37,700,000	768,000 MTCDE

An alternative to purchasing RECs is to purchase and retire CO_2 emissions allowances from the state-based cap-and-trade systems now in existence (such as the Regional Greenhouse Gas Initiative, which Maryland belongs to), or from any future federal system.[18] We do not recommend purchase of RGGI or other state allowances of this time because of concerns over "leakage," and the cost and availability of federal allowances is highly uncertain.[19] However, JHU should monitor the development of CO_2 markets and consider whether purchase of CO_2 allowances might be more cost-effective than buying RECs or offsets.

2.5 Targets and Objectives

Based on currently available technologies as well as emerging technologies that are expected to be cost effective within the next ten years, the WG estimated that the university could reduce GHG emissions by 141,600 MTCDE by 2025. This figure is based on the following assumptions:

- For the next five years, the energy reduction strategies are based on well-known technologies and approaches with proven results. Many of these measures will need a

[18] Purchases of European Emissions Trading System (ETS) certificates is also a possibility.

[19] "Leakage" occurs when a reduction in emissions in a region subject to an emissions cap is partially or completely offset by emissions increases in other regions. This can arise if, for instance, an emissions target is met in Maryland simply by importing more power (perhaps coal-generated) from another state. The degree of leakage in regional systems such as RGGI is in dispute.

financial commitment, but the savings in utility costs will offset the initial investments in a reasonable time frame. In the long run, this would improve the financial position of the university, reducing expenditures on energy and increasing resources available for the JHU's core missions. It should be possible to finance these in such a manner that positive cash flows result in all or most years.

- For the following five years, emissions reductions are based on emerging technologies that are currently showing promise and a clear path of progress down a cost curve. Examples of these technologies are LED lighting, solar water heating, solar photovoltaics, and heat recovery systems. The WG was comfortable with the estimate that these technologies would be commercially viable and cost effective within this time frame.
- For the final five years, the WG estimated that the current and emerging technologies would continue to contribute to the emissions reductions targets at the same rates.

Reductions at a Glance

Business as usual emissions	**276,300**
Potential reductions	**141,600**
Emissions at year 2025	**134,700**
Total emissions reductions	***51%***

The overall emissions reduction target of 51% by 2025 was created by evaluating the contributions of four main categories of opportunities: (1) Efficiency gains in buildings that reduce electrical loads, (2) Reductions in transportation-related emissions, (3) Increased contribution of on-site renewables as a means of reducing fossil fuels, and (4) Efficiency gains at campus central power plants.[20]

2.5.1 Growth Assumptions

The projected growth of all campuses, based upon known development plans on each of the university campuses is approximately 550,000 gross square feet (GSF), representing a significant slowing of growth compared to the previous 15 years. Based on present energy consumption patterns, the anticipated growth in buildings would translate to a 0.7% annual increase in GHG emissions if operations continued in a "business as usual" scenario.

2.5.2 Emissions Reductions Assumptions

As indicated in the GHG Inventory (Appendix B), electricity is the largest category of energy usage on the campuses. Since over 50% of the regional electricity generation portfolio comes from coal, electricity also produces more greenhouse gases than other sources of energy. To address this, the state of Maryland has mandated that 20% of electricity in the state be generated by renewable resources by 2021 and has joined the Regional Greenhouse Gas Initiative (RGGI). However, since there is no guarantee that the renewables will displace coal, the WG decided that it is too early to know whether statewide actions will influence the regional electricity mix in ways that affect the university's GHG footprint. Thus, the emissions forecasts shown earlier in this chapter are based on a fixed 0.545 tons/MWh assumption of emissions. If average emissions rates decrease – through a reduction of coal,

[20] Details of the reductions assumptions are listed in Appendix C.

increase in renewable, or other combinations – then the decreases in emissions would be even greater than the 51% year 2025 reduction target.

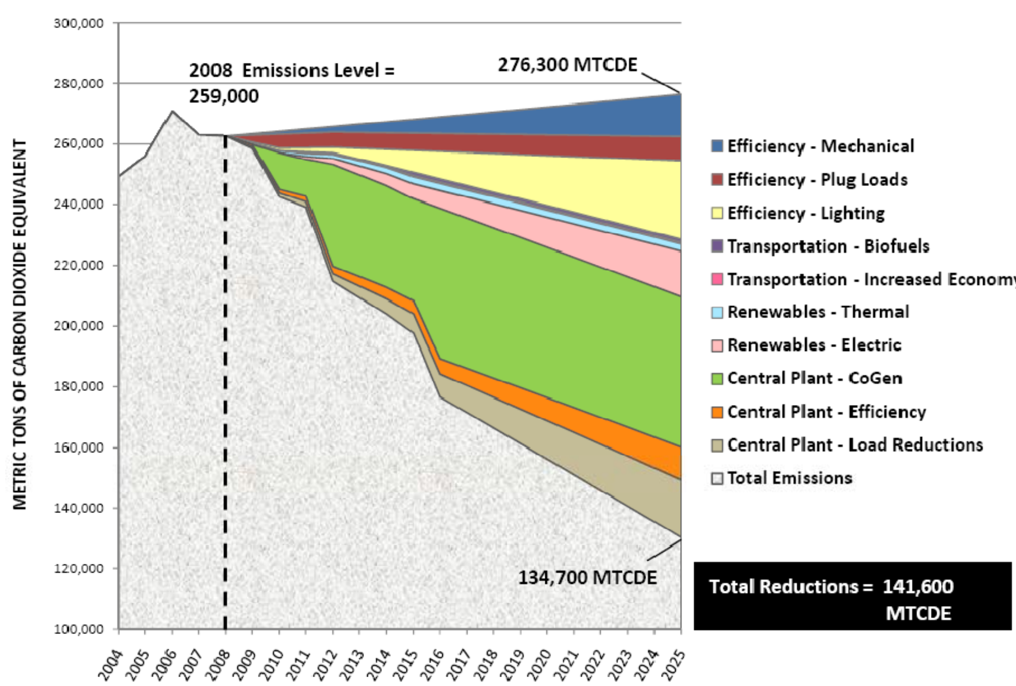
The largest reduction opportunity will be the installation of cogeneration facilities at the Homewood and East Baltimore campuses. The combination of facilities will reduce GHG emissions by nearly 34,000 MTCDE in the next five years with an opportunity to reduce another 11,000 MTCDE in the following five years by expanding these facilities in East Baltimore.

Solid state lighting (LEDs) represents a significant opportunity to reduce energy, not just in lighting, but also in mechanical systems. Since heat is a by-product of lighting, more efficient lighting could reduce air conditioning needs by up to 33%. In addition, the reduced loads would allow for smaller sized equipment in existing spaces generating additional savings. Finally, the reduced load would have a multiplier effect in the central plants.

2.5.3 Wedge Analysis

As mentioned above, reduction goals through 2025 represent an overall GHG emissions reduction of 51% from 2008 levels. Two co-generation projects – one on the Homewood campus and one on the East Baltimore campus – represent the largest single source of this reduction. However, there is no "silver bullet" that will account for all of the emissions over time. Rather, the analysis suggests that there are a number of avenues for reductions within the four main categories of campus emissions. For example, within the category of Efficiency Gains in Buildings, it is clear that there are significant opportunities for reductions in lighting loads, mechanical equipment, personal computing, and more efficient appliances.

Figure 2.9: Reductions by Source



2.5.4 Impact of Federal Legislation on Assumptions

With the recent change in administration, there is a greater chance that carbon dioxide emissions will become regulated and controlled. Legislation could take the form of carbon taxes, a “cap and trade” market mechanism, or indirectly through higher efficiency standards or more restrictions on certain goods and products. The WG recognized that a monetary value on carbon would increase the financial viability of energy reduction activities. However, since it is still too early to know what kind GHG legislation will pass, the WG decided to err on the side of a conservative analysis and not include federal legislation assumptions or their impact on reduction projects.

2.6 List of Recommendations

1. **Reduce university emissions by 51% by 2025.** Based on currently available technologies as well as emerging technologies that are expected to be cost effective within the next ten years, JHU can reduce greenhouse gases by approximately 141,600 Metric Tons of Carbon Dioxide Equivalent (MTCDE) by 2025.
2. **Implement cogeneration opportunities** on the Homewood and East Baltimore campuses, and conduct feasibility studies to determine the effectiveness of additional cogeneration opportunities at the East Baltimore and Bayview campuses.
3. **Implement all “high opportunity” energy conservation measures** defined by conceptual engineering studies within the framework of University financial plans.
4. **Address the growing energy needs of computing and data management** by “virtualizing” servers, separating mission critical operating environments from non-mission critical applications, migrating existing servers to the Mt Washington Data Center, and making use of energy saving software.
5. **Develop a financial, environmental, and carbon-evaluation matrix** to evaluate projects, including net financial indices, life cycle cost, amount of carbon reduction, educational opportunities, contributions to community partnerships, and public relations value for evaluating medium to low opportunity options for energy efficiency and renewable supplies.
6. **Evaluate different commissioning, recommissioning, and continuous commissioning options** for existing buildings and test methods to identify best practices. Implement a “green building audit” program to identify and address conservation upgrades that can be undertaken on a continuous basis.
7. **Use the newly developed Design Guidelines** on every renovation, retrofit and new building project at all times and uniformly throughout all Design and Construction departments.
8. **Gather more information on geothermal technologies**, especially “deep bore hole” geothermal, for possible applications at single buildings or closed loop quad-sized applications.
9. **Demonstrate leadership** – especially among members of the senior administration, deans, department chairs and committee representatives – to provide strong, consistent, and active reinforcement of the university’s GHG goals and conservation efforts.
10. **Create a set of reachable building reduction targets** that can be influenced by occupants.

11. **Install real-time meters** in all residence halls and connect the utility data to web based interactive kiosks that provides education and awareness about sustainability and energy consumption.
12. **Implement an internal marketing campaign** to increase awareness of GHG reduction goals through e-mail messages, posters, recruiting building reps to carry messages among their co-occupants.
13. **Undertake a transportation study** that will assess the benefits of combining the various transportation offices and shuttle services under one administrative structure.
14. **Increase the use of biodiesel** in shuttles to the highest acceptable levels.
15. **Prioritize the acquisition of GHG reducing equipment and vehicles** when shuttle buses and contracts are up for renewal and/or replacement,.
16. **Promote alternative commuting options**, including carpooling, biking, public transportation, and walking.
17. **Install a "demonstration" renewable energy project** within the next five years on each of the large campuses so that students and employees can see a visible representation and reminder of GHG reduction efforts.
18. **Each Division should try to link and document programmatic plans** beyond the normal 5-year cycle and correlate this information with the present state of their physical plan (i.e. Buildings) and IT infrastructure.
19. **Apply a minimum of LEED Silver criteria to all new building and major renovations**. The WG understands that these criteria will be encouraged by the University's Trustees Committee on Buildings and Grounds as standard practice.

3.0 Innovation and Research Working Group

3.1 Overview

The Innovation and Research Working Group was formed to examine ways that Johns Hopkins University (JHU) could leverage its academic and research strengths to make significant, unique contributions to solving the challenges associated with climate change. Although not well known, there is a wide range of climate-related research activities and expertise across JHU. However, these activities are limited by a lack of coordination and resources, and the whole is not presently greater than the sum of the parts. The Working Group recommends that a university-wide umbrella organization be established that co-ordinates and encourages innovative research and teaching that addresses, in an interdisciplinary manner, critical issues related to climate change, health impacts, energy challenges, policy, and sustainability. By establishing integrated approaches that cut across disciplines and divisions, JHU will be able to make significant contributions in these crucial areas. Furthermore, the formation of an umbrella-institute will provide a single point of contact for JHU, dramatically increase the visibility of JHU in climate change and sustainability, and will be critical for attracting top students, recruiting and retaining faculty, and obtaining funding.

It is suggested that initially the Institute focus on research in (i) Climate Observations and Modeling, (ii) Human Health Impacts, (iii) Sustainable Energy Supply, and (iv) Policy and Decision-Making. JHU has strengths and unique capabilities in each of these areas, and this combination of focus areas will differentiate the Institute from those at other universities. It is also recommended that the research and education activities within the proposed Institute be integrated with efforts to reduce the JHU carbon footprint and with collaborative sustainability activities with the surrounding community.

3.2 Introduction

Assessing and responding to climate change is arguably the greatest human challenge of our time. There is a strong scientific consensus that the climate is changing and that over the next century, we will see continued increases in surface temperatures, melting of ice, rising of sea levels, and more climate extremes. The human health impacts of these changes are wide-ranging and likely to be of considerable magnitude. These include the direct effects of heat, increased vector-borne diseases, increased pulmonary and cardiovascular diseases, as well as increasing risks related to altered patterns of food production, water shortages, environmental refugees, and social unrest. At the same time, there is growing recognition that many of the world's most easily accessible energy sources are reaching their maximum production levels. This has profound implications for climate change, as well as food production, manufacturing, transportation networks, and the built environment. For a sustainable future, we must develop solutions to climate change, energy needs, and our current built environment as an integrated whole. Thus, there is an urgent need to improve our description of the problems, enhance our understanding of causal relations and the leading drivers of these problems, and develop and evaluate technical and policy solutions.

The Innovation and Research Working Group (Appendix A) was formed to examine ways that Johns Hopkins University (JHU) could leverage its academic and research strengths to make significant, unique contributions to solving the challenges associated with climate change (see Appendix B for original charge to the working group). This report summarizes the results of the Working Group's efforts.

We first present (in Section 3.3) the Working Group's overall vision for research and education in climate change and sustainability. The existing research and teaching resources within JHU, including their strengths and weaknesses, are then discussed (Sections 3.4 and 3.6, respectively). Proposed activities, in the short and long term, to realize the Working Group's vision are presented in Section 3.7, and the Working Group's recommendations are summarized in the final section.

3.3 The Vision

The first question that arises when considering research and education in climate change, energy, and sustainability is whether JHU should invest resources in this area. The Working Group feels very strongly that, given the national and international importance of these issues, a world-class university such as JHU needs to focus on identifying and understanding the problems, finding solutions, and training the next generation of problem-solvers. In fact, it could be argued that JHU could not remain a top university if it does not play a leading role in this vital area. As discussed below, there is a wide range of relevant expertise with JHU and, given leadership and resources, JHU can make significant and unique contributions to these important issues. Furthermore, while significant resources will be required for successful and sustained research and education activities, there are extremely good prospects for obtaining long-term funding from a wide range of sources.

For JHU to make significant contributions to finding solutions to the challenges associated with climate change, the Working Group proposes that a university-wide, umbrella organization be established that co-ordinates and facilitates research and teaching activities related to climate change, health impacts, energy challenges, policy, and sustainability. For brevity, we shall refer to this organization as the "Institute."

By establishing integrated approaches that cut across disciplines and divisions, JHU will be able to make significant and unique contributions in these crucial areas. The formation of an Institute will also dramatically increase the visibility of JHU in climate change and sustainability. This increased visibility will be critical for attracting top students, recruiting and retaining faculty, and obtaining funding (from federal agencies and private individuals/foundations). Without such an Institute, JHU is currently at a competitive disadvantage in all these areas.

The research and education activities within the proposed Institute should not be considered in isolation from other considerations of the Climate Change Task Force. We advocate a broad approach, where researching and teaching activities are integrated with changing the University's "culture" regarding sustainability issues, and where we as a University reach out and work with the surrounding local and regional community, in both educational and collaborative sustainability activities.

3.4 Research

3.4.1 Existing Resources

Although it is not widely appreciated within the JHU community, there exists a wide range of climate-related research activities and expertise across the campus. These activities cover most, if not all, schools and divisions. Below we have grouped activities into three broad focus areas, rather than by schools or divisions. The three focus areas ("Climate Change Science", "Health Consequences", and "Sustainability") are inherently interrelated and cross school and divisional boundaries. Research in each of these areas is described below (and key faculty are listed in Appendix H).

3.4.2 Climate Change Science

A key requirement for developing strategies to reduce the magnitude and impact of global climate change is an improved understanding of the climate system and ability to predict future changes. In particular, improving and quantifying the trustworthiness of climate projections is becoming more crucial than ever. JHU has extensive expertise in modeling and observations relevant for understanding and predicting the climate system. The department of Earth and Planetary Sciences (EPS) in the School of Arts and Sciences (KSAS) has a new "Global Change Science" initiative, which includes several new faculty hires (Zaitchik, Passey, Levin) to complement the existing expertise in climate science (e.g., Waugh, Haine, Arking). There is a unique combined expertise in the School of Engineering (WSE) and KSAS in multi-scale geophysical fluid flow and transport modeling, science-based parameterizations, and data-intensive computing that is well suited to climate change science (e.g. faculty in the Center for Environmental and Applied Fluid Mechanics (CEAFM) and the Institute for Data-Intensive Engineering and Science (IDIES). There is also expertise in KSAS and WSE in studying the local environment (e.g., Chesapeake Bay) and climate, including the use of cutting edge technology (e.g., Ball, Brush, and Szlavecz). Furthermore, this expertise at Homewood could be enhanced with stronger linkages with the modeling expertise at APL to develop global Earth System modeling capabilities, with connection to air quality, water availability, and health impacts. APL also provides the capability to define, design, build and operate space missions to make key observations of Earth's atmosphere, oceans, and cryosphere (e.g., Yee, Monaldo, Del Castillo). The role JHU plays in making and analyzing space-borne observations of the climate system would be greatly enhanced with the formation of a "Johns Hopkins Space Studies Institute," and a proposal exploring the possibility of such an institute was funded by the Provost office's *Framework for the Future* program.

3.4.3 Health Consequences

The projected impacts of climate change on human health are many, diverse, and wide-ranging in magnitude. There is a need for a better understanding of, and ability to forecast, the impact of climate change on human health, as well as need for the development and assessment of potential adaptation and mitigation strategies. Extensive expertise and research programs exist within the JHSPH and the School of Medicine (SOM) in these areas. One area of active research is the impact of global change on water supply and sanitation, and this research is a component of the "*Global Water"* initiative (Schwab, Ball) funded under the Provost Office's Framework for the Future program. Another area of active research is global climate change and its association with infectious diseases. Several groups are engaged in laboratory and field research to forecast patterns of infection, and epidemiologic studies of disease impacts (e.g., Glass, Gilman, Checkley). There are also several groups studying the impact of changes in temperature, ozone, and particulate matter on health, mortality and morbidity (e.g., Breysee, Dominici). Many faculty at JHSPH are skilled in the qualitative research methods necessary to understand the decisions that people make in their lives regarding food, water, transportation, housing, and energy use, how these will be impacted by climate change and emerging energy challenges, and how behaviors can be changed to solve these problems. Active collaborations are taking place between WSE and JHSPH involving air quality, water sanitation, and system analysis, and between the School of Advanced International Studies (SAIS) and JHSPH involving global health and foreign policy.

3.4.4 Sustainability

The development of a sustainable future requires consideration not only of renewable energy sources, but also of land and water use, food production and distribution, as well as questions relating to population levels and distributions, the dynamics of wealth generation and distribution, and social and environmental justice. Attaining sustainability will require the development of efficient renewable energy sources and new technology, consideration of the built environment and transportation, significant behavioral changes, and ongoing analysis of the social, economic and policy implications of any changes. Expertise and activities exist within JHU covering each of these areas.

Energy and Technology: Several groups within WSE, KSAS, and APL are exploring fundamental science and engineering of new, renewable, energy technologies. For example, research into efficient enzymatic reduction of cellulosic plant biomass into fuels, and into increasing the photosynthetic capture of CO_2 by plants is being performed within the "*Bioenergy*" initiative (Barrick, Garcia-Moreno) funded by the Provost Office's Framework for the Future Program. There are also faculty with research activities in "materials for energy" (e.g., Erlebacher, Katz, Reich, Charles), wind energy (Menevau), and design of "green" infrastructure (Schafer). Furthermore, the systems group in the Department of Geography and Environmental Engineering (DoGEE) is working to make the electrical grid more efficient and resilient and less polluting in response to changing resource availability, heightened environmental expectations, and natural disasters (Guikema, Hobbs, Norman).

Built Environment and Transportation: The built environment and transportation networks present a key challenge for sustainability in the face of climate change. There is a need for research in land use, urban and community planning/ design, green architecture, and transportation networks within the context of sustainability. There are several ongoing projects at the SPH on the influence of the built environment on health (Schwartz), but it is possible that one outcome of this initiative will be the recognition that JHU must develop additional expertise in the above areas.

Individual and Social Behavioral change: Several groups in JHSPH and WSE are conducting research into the human behavioral changes, at the individual, local, national, and international levels, needed to avert climate change or reduce its impacts, and the policies needed to motivate these changes. This includes research to understand attitudes and policy strategies relevant to the management of natural resources, "after peak oil", sustainable agricultural practices, and diet (e.g., high meat consumption) as well as economic incentives for behavioral change (e.g., Lawrence, Neff, Norman).

Economics and policy: Policies addressing sustainability must be adaptive and integrated from the outset, incorporating updated monitoring information and models of changes in weather, habitat, and social impacts. JHU faculty have significant experience in comparing and evaluating national and international policies aimed at managing both traditional air pollutants as well as greenhouse gases, ozone-depleting substances, and other pollutants (Ellis, Hobbs, Norman). Active research programs exist in adaptive environmental management (Hobbs, Wilcock) that could be used to evaluate and design alternative policies addressing sustainability and health impact assessments and adaptation. There is also expertise in the International Energy & Environment program at SAIS in the design of international agreements to address adaptation and mitigation of climate change and the impacts of energy use on the environment (Kohl). [21] Faculty at JHSPH also work on valuing policy impacts to human life, quality of life, and health, which will be crucial to evaluating the large-scale, long-term policy changes that the climate crisis suggests are needed (Frick).

3.4.5 Existing or Proposed Research Centers

There are several existing inter-school and campus centers within JHU that contribute expertise in climate change and sustainability, including:

- Center for Environmental and Applied Fluid Mechanics
- Institute for Data-Intensive Engineering and Science
- Center for Global Health
- Center for a Livable Future

Also, as mentioned above, the Provost Office's Framework for the Future program has recently funded proposals for the creation of the several new programs/initiatives that include components of climate change and sustainability:

- Bioenergy Initiative
- Global Water Program
- Space Sciences Studies Institute

Furthermore, the Carey Business School (CBS) plans to launch research centers on "Technological entrepreneurship and innovation" (by 2009) and "Enterprise sustainability and twenty first century business practices" (by 2010). Both centers will include research efforts related to sustainability (e.g. sustainable business practice and transfer of new technologies).

While the above centers and programs contain components that are relevant for climate change and sustainability, they cover only some of the relevant research done at Hopkins, and there is also only limited coordination between the programs.

[21] SAIS is presently undertaking a search for the head of its Energy and the Environment program; such a hire would provide additional leadership in this area.

3.5 Potential Partners

The close proximity of JHU to government laboratories, regulatory agencies, and policy makers provides the potential to expand JHU activities. These collaborations could differentiate the JHU Institute from those at most other universities.

One example is the NASA Goddard Space Flight Center (GSFC). Collaborations already exist between KSAS (Departments of Earth and Planetary Sciences and Physics and Astronomy) and APL with NASA GSFC, and a Homewood-APL-GSFC partnership in Earth system modeling and observations would provide many unique advantages, and would be extremely competitive for future formation of NASA Earth Science institutes and satellite missions. Such an activity could also be a component of the proposed *JHU Space Studies Institute*.

Another example is Resources for the Future (RFF), a Washington DC nonprofit organization whose mission is to improve environmental and natural resource policymaking. Again, there are existing collaborations between JHU (e.g., SAIS, WSE) and RFF, and increasing these linkages would expand and enhance the systems and policy-making research done within the Institute.

There are many other potential partners, most with existing interactions, including USDA Beltsville Agricultural Research Center, Smithsonian Environmental Research Center, The Joint Global Change Research Institute (a partnership between DOE's Pacific Northwest National Laboratory and the University of Maryland), and The Craig Venter Institute.

3.5.1 Leveraging Strengths and Weaknesses through Partnerships

As discussed above, there is a wide range of climate-related research activity and expertise across JHU, with activities in most schools and divisions. However, there is a need for much better coordination and communication between different and even disparate activities, schools, and campuses, and there are only a few examples of the truly interdisciplinary research required for finding climate change solutions. The Provost office's *Framework for the Future* program has recently funded proposals for the creation of the several new initiatives that will increase cross-division interactions. While this is an important beginning, these new initiatives address only a few aspects of the broad climate change – the sustainability problem and, in general, do not involve interdisciplinary research. Larger undertakings will be required to make JHU a leader in this area

Another issue is the coverage of different research areas. Although there is a wide range of activities, the depth of expertise is not uniform between research areas. JHU is strong with unique expertise or capabilities in some areas but is weak or poorly represented in other areas. An important decision that needs to be made is in which areas will new resources have the most impact. This could include a combination of building on existing areas where JHU has some expertise and putting resources in areas that are needed for interdisciplinary climate change and sustainability research.

One area where JHU is strong (with an international reputation) is public health. As discussed in Section 3.4.3, there are numerous activities examining the impacts of climate change on human health at the JHSPH and SOM, and there are also examples of active collaborative and interdisciplinary research with other schools (e.g., the new Global Water initiative). There is also potential for more extensive collaborations that bring together other activities and schools. In particular, the research involving observations (APL, KSAS), modeling (KSAS, APL), and policy and economic options (WSE, SAIS) could be combined with public health research (JHSPH, SOM) to perform integrated, end-to-end studies of the impact of climate change on water supply, air pollution, and infectious diseases. This is one area where JHU can make unique and significant contributions to critical issues related to climate change.

Another strength includes the JHU Applied Physics Laboratory (APL). As described in Section 3.4.2, APL provides capability to define, design, build and operate space missions to make key observations of Earth's climate. This is unique among our peer universities, and by combining this with the analysis of remote-sensed data in other schools (KSAS, WSE, and JHSPH) could position JHU as the leader in obtaining and analyzing space-borne observations of the climate system. Furthermore, there is extensive modeling expertise at APL that could be combined with expertise at other schools to develop capabilities for modeling the climate system, impacts of climate change, and adaptation strategies. The proximity of NASA GSFC also provides an opportunity for unique activities in Earth system modeling and observations.

Another possible focus area is policy and decision-making. Although the numbers involved in this area are smaller than those above (and possibly sub-critical at the moment), there are activities in WSE and SAIS that could be enhanced (see Section 3.4.4). Furthermore, the close proximity of JHU, in particular, SAIS, to regulatory agencies and policy makers provides a unique JHU advantage in this area of research. Additional new faculty in key areas and closer interactions between the different schools (in particular SAIS and Homewood schools) could lead to JHU being a leader in climate policy and decision-making.

Another critical issue in sustainability is the development and use of efficient renewable energy sources. Although JHU does not have a reputation in this area, as discussed in Section 3.4.4, there are several groups at JHU exploring the fundamental science and engineering of new, renewable energy technologies, as well as groups examining systems and policy aspects of energy supply. Additionally, the engineering and technology capabilities at APL offer the potential for JHU to develop and assess the practical applications of new technologies that would provide support to the physical initiative recommended by the Tactics and Strategies (T&S) Working Group.

While JHU has strengths in the above areas, there are several key areas where there are limited research activities in some areas. Examples include research into the built environment (land use, urban planning, and transportation), domestic environmental law and politics, and drivers of behavioral change. These are key issues for developing a sustainable future, and there should be serious consideration of expanding / investing in these areas. Consideration will also be needed regarding linking all the above areas with the expansion of the Carey Business School (in particular, with the proposed focus of sustainable business practices).

3.6 Education

3.6.1 Existing Resources

There are a large number of relevant courses and several existing educational programs at JHU that cover the various aspects of climate change and its impacts. A list of courses can be found on the Hopkins Sustainability website (http://www.sustainability.jhu.edu/courses.html). The existing (or proposed) undergraduate and graduate programs include:

- BA – Global Environmental Change and Sustainability major/minor (proposed, 2009), KSAS
- BSE – Environmental Engineering major and minor, WSE
- BE – Engineering for Sustainable Development minor (proposed, 2009), WSE
- MS – Environmental Sciences and Policy [part-time] (KSAS)
- MS - Environmental Engineering, Science and Management [part-time] (WSE)
- MSE, MS – Full-time degree programs in environmental engineering, environmental science, and environmental management and policy within WSE
- MPH - Global Sustainability and Health [concentration] (JHSPH)
- MA - International Policy [Energy, Environment and Health] - SAIS

There are also other planned programs that will or could include significant climate change, energy, or sustainability components. For example, the Business School's new Global MBA, to be launched in 2009, is focused on the themes of technology transfer, business sustainability and social responsibility. The new masters in Engineering Management (WSE) could easily include a specialization in energy. In addition to the above masters programs, there are several PhD programs that cover aspects of climate change and sustainability.

Of particular note in the above list are the two proposed undergraduate programs (major/minor in Global Environmental Change and Sustainability, and minor in Engineering for Sustainable Development). Approval of these programs is expected in Spring 2009, and these programs represent an initial step towards providing coordinated, interdisciplinary programs that will equip students to pursue careers or graduate study in fields that address challenges related to climate change and sustainability. However, as discussed below there are still gaps in the current JHU curriculum.

There are also a number of complementary programs that link students to faculty and sustainability professionals (e.g., the ECO-Reps, Sustainable Hopkins Infrastructure, and Green Idea Generator programs). Although these do not constitute formal educational programs, there is the potential to include and expand these, and similar, activities within the formal education programs.

3.6.2 Strengths and Weaknesses

As described above there are several existing educational programs, with a wide range of courses, already in place. JHU is therefore in a very strong position to build a reputation for education in the area of climate change and sustainability. However, there remain issues that need to be addressed for these educational programs to reach their potential.

The two new "sustainability" undergraduate programs have been proposed to fill current gaps in the JHU undergraduate curriculum, and are important first steps. However, these are new (and in fact not yet formally approved), and are based primarily on existing courses. To be successful, new courses (including interdisciplinary courses) will need to be added. Examples include courses on renewable energy technology, sustainable policies, and the built environment. There could also be a need for additional programs or concentrations, e.g., an undergraduate minor in sustainable energy.

There are potential issues with the needed interdisciplinary programs and courses. One issue is the funding of instructors and TAs for interdisciplinary courses. These courses might be important for the broader, inter-department (inter-school) program but be a lower priority for an individual department. Furthermore, many of these courses would be best team-taught by faculty from different disciplines (which typically means different departments and schools) or by non-Hopkins faculty with "real-world" experience. A university-wide integrated approach to teaching in climate change and sustainability, with mechanisms and funding to encourage/enhance interdisciplinary teaching, will likely be needed to address these issues.

Another issue is coordination between the existing programs. There is currently no formal coordination between the above programs, and the programs do not leverage off each other. Such coordination might identify duplication of courses, help the development of courses that contribute to multiple programs, or lead to concurrent 5-yr BA and masters programs (as exist for public health studies or international studies). Again, a university-wide integrated approach will help address this issue.

A final issue to be considered is expansion, and better integration within the formal education framework, of student internships and programs (including student-initiated) activities. Currently the JHU sustainability initiative provides some coordination of student programs and internships, but these activities could be expanded (including more involvement with the wider Baltimore community) and be formally linked to educational programs (e.g., courses requirements for internship or community placement).

3.7 The Way Forward

As described above, there exists a wide range of research and educational activities at JHU that address issues related to climate change, health impacts, energy challenges, policy, and sustainability. However, these activities are poorly coordinated, the whole is not greater than the sum of the parts, and JHU generally has low visibility in this area of research and education.

The WG believes that there is an urgent need for an umbrella organization (Institute) that will (amongst other things) coordinate and facilitate research and teaching activities. Such an Institute would

- Provide a single point of contact for climate and sustainability research and education at JHU.
- Encourage innovative research and teaching that addresses, in an interdisciplinary manner, critical issues related to climate change, health impacts, energy challenges, policy, and sustainability.
- Increase the visibility of JHU in climate change and sustainability.

- Provide the administrative infrastructure to help obtain funding from federal agencies and private individuals/foundations.
- Help attract top students, and recruit and retain faculty.

It is worth noting that virtually all of our peer institutions have similar umbrella organizations, and many have obtained significant funding from private donors (see Appendix I). Also, sustainability centers at other universities have reported that establishing leadership in climate change and sustainability has provided them an increasing edge in attracting top students.[22] A similar result would be expected if JHU created the proposed Institute.

Below we discuss the proposed research focus areas and organizational structure for the Institute. This is followed by a discussion of near-term (<3 years) activities and further consideration of what is required for a sustained, successful long-term program.

3.7.1 Focus Areas

While there should be a broad range of activities within the Institute, given limited resources the Institute will initially focus on a few research areas where JHU has a unique advantage that differentiates the JHU Institute from those at other universities. The WG proposes that these focus areas of the Institute be:

1. Climate Observations and Modeling
2. Human Health
3. Sustainable Energy Supply
4. Policy and Decision-Making.

As discussed in Section 3.4, JHU has strengths in these four areas, and the formation of an Institute with these combined foci would enable JHU to make significant contributions to understanding and solving sustainability problems. It is important to note that these areas are not independent, and combination of the four foci covers aspects important for understanding climate change and sustainability problems as well potential impacts and solutions. Coordinating activities in the above areas would pull together the unique capabilities JHU has in human health (e.g. JHSPH), climate observations (e.g., APL), and policy (e.g. SAIS), and differentiate the Institute from those at other universities.

While the working group recommends these four focus areas, the activities within the Institute should not be limited to the above areas. There needs to be consideration of opportunities to develop further focus areas, e.g., built environment, behavior change, and business practices.

3.7.2 Organizational Structure

The Institute could, at least initially, be a virtual center and not require a physical home.

[22] "A Closer Look at Applied Sustainability Centers," Aspen Institute, March 2008.

However, it would require, at a minimum, a "Director" and administrative support. The Director's office would provide a much-needed single point of contact (e.g., a place to start exploring the range of activities within the university), and coordination for climate and sustainability research and education.

The Director would be responsible for fostering and strengthening interactions; exploring collaborations with other institutes; coordination of educational programs; and identifying and targeting new funding opportunities. With regard to the latter, it would be beneficial for the Institute to have close interactions with the Office of Development and Alumnae Relations (DAR) (including perhaps a development officer within the Institute).

The Institute would also need an internal university oversight / advisory committee comprised of faculty from all schools / divisions. A key role of this committee in the first year would likely be identification of where new resources will have the most impact.

The creation of an Institute would provide a "top-down" approach, and show commitment from top administration. However, it would also be important to promote faculty ownership and to continue, and grow, "bottom-up" research centers and activities. Some existing centers are listed in Section 3.4.5, and these (and similar centers formed in the future) would be a major part of any umbrella Institute.

One potential model for the proposed Institute is the JHU Berman Institute of Bioethics. This institute has a director and administrative support, involves faculty from four schools, fosters collaborative activities in both research and teaching, and has five focus areas.

Another consideration would be to form an institute that combines the research and education activities discussed above with operations and community outreach activities. These latter activities are currently coordinated by the JHU Sustainability Initiative, and this initiative could become part of a much broader / larger Institute. This broader Institute could bring together recommendations from all three working groups, with student activities being involved in all components, i.e., student projects / internships involving research, reducing JHU's carbon footprint, and working with the community.

3.7.3 Short-term

A major challenge to achieve the goals of the Institute is increasing the interactions between researchers and students from diverse disciplines, and from different campuses (that differ not only geographically but also in "culture" and teaching calendars). Mechanisms and funding will need to be introduced at an early stage to encourage these interactions. Examples include:

- Focused "think-tank" seminar series or one-day workshops that bring together JHU faculty and students from different disciplines, schools, and divisions to share research and identify future collaborative research and funding opportunities.

- Joint appointments between key researchers from the different campuses to improve interactions and collaborations. As discussed above, in many areas closer interactions between people at different campuses would greatly enhance research capabilities. In some cases partial salary support will be needed, e.g., APL scientists and JHSPH faculty. The APL Homewood Professor is an example of a mechanism to do this, and expansion of this program (and similar programs between campuses) should be explored.

- Seed funds for new research initiatives. These funds could be used for faculty, visiting and post-doctoral scholars, and students to work on interdisciplinary and inter-department (inter-school) projects. This could include coordinated undergraduate projects (possibly in connection with the JHU Sustainability Initiative), support for graduate students (e.g., the Innovation Grants from the Center for a Livable Future), and interdisciplinary postdoctoral fellowships (e.g., the new, donor-funded, Cormack Postdoctoral Fellowship in global change based in EPS).

- Support for new course and curriculum development and for teaching of interdisciplinary courses (instructors and TAs). This should include support for team-taught courses by faculty from different departments or taught with non-Hopkins faculty.

The above activities would require only a modest level of funding, and could be implemented within the first year.

The Institute will need new faculty in targeted areas that bridge between disciplines (and Schools) or cover key areas that are underrepresented at JHU. Possible examples are discussed above (Section 3.5.1), but identifying these areas will need to be one of the foci for the first year of the Institute and its oversight committee. The recruitment and retention of top faculty would be greatly enhanced by the creation of endowed chairs, and this could be a medium-term goal of the Institute.

3.7.4 Long-term

A successful, sustained Institute would require commitment from university administration and significant resources. For example, there will be a need for faculty lines for interdisciplinary research, multiple funding sources (likely from a combination of university, federal, and private sources), and possibly a physical home (ideally in a “green” building). There are, however, extremely good prospects for the Institute to obtain long-term funding from a wide range of sources.

Government agencies now recognize the importance of global climate change and the urgent need to understand these changes and impacts, and to find solutions. As a result there are many opportunities for funding of activities within the proposed Institute, including formation of interdisciplinary “centers of excellence.” Examples of possible funding sources include the DOE Energy Frontier Research Centers and Bioenergy Research Centers, proposed NASA-funded Earth Science institutes NASA satellite missions, proposed CDC climate-related centers of excellence, EPA STAR centers, and NSF IGERT grants. Without an umbrella Institute that shows interactions between different disciplines and Schools, JHU will be at a competitive disadvantage when it comes to competing for these funds.

The formation of an umbrella Institute, together with the broad visibility of climate change, health, and sustainability challenges, is likely to make a significant draw for funding from less-traditional sources such as private donors, foundations, and corporations. For example, KSAS recently obtained separate gifts to establish a new interdisciplinary “global change” major and a new Postdoctoral Fellowship in global change. There is also potential for much larger gifts, and in the past few years numerous universities have received multi-million dollar gifts to establish large sustainability enterprises (see Appendix I). Again, the formation of a university-wide Institute and inter-School activities is likely to be a key for obtaining private funding for sustainability research and teaching.

A long term goal could be a physical home for the Institute. This building would ideally be a new building, showcasing the latest "green" technology. Several other universities house their environmental or sustainability centers in green buildings, see Appendix I.

3.8 Recommendations

1. **Form a university-wide umbrella organization ("Institute"),** with full-time director, administrative support, and internal oversight committee. The Institute will provide a single point of contact, increase the visibility of JHU, and coordinate activities related to climate change and sustainability.

2. **Implement mechanisms such as joint appointments and salary support** to encourage and enhance interactions and collaborations between the different campuses related to climate change and sustainability.

3. **Establish a fund to provide seed funds for new research initiatives** in the area of climate change and sustainability, with a focus on interdisciplinary and inter-division projects.

4. **Support new course and curriculum** development and for teaching of interdisciplinary courses related to climate change and sustainability.

5. **Set aside faculty lines for faculty in targeted areas that bridge between disciplines** (and Schools) or cover key areas that are underrepresented at JHU.

6. **The Institute's activities should be integrated with efforts to reduce the JHU carbon footprint**, engage in collaborative projects with the community, and participate in public outreach.

4.0 Community Partnerships Working Group

4.1 Overview

The Community Partnerships Working Group adopted a mission to develop and nurture strong relationships with State, City and community groups within the greater Baltimore-Washington region; to explore ways to enhance our respective goals; and to transfer knowledge, sharing successes and other means by which we can collaboratively address climate change (the membership of the working group is in Appendix A). This mission was based on the vision of President Brody, who stated: "We will extend knowledge and experience into the community, offering leadership and assistance on actions that can improve our surroundings while reducing the carbon footprint of the Baltimore area."[23]

In order to meet this mission, the Working Group (WG) proposes the development of four areas of concentration: (1) strengthening the connections between the greater Baltimore community with the help and guidance from JHU faculty and students, detailed in Section 4.2; (2) establishing a process by which innovative carbon reduction projects that leverage community and JHU participation can be evaluated and supported, detailed in Section 4.3; (3) engaging the JHU staff, recognizing that as the largest employer in Maryland, we have the potential to affect communities by positive actions through our employees, detailed in Section 4.4; and (4) strengthening the Johns Hopkins brand as a resource for policymakers in the areas of climate change, energy, and sustainability, as detailed in Section 4.5.

4.2 Learning and Sharing Opportunities

The WG determined that there is a need to find creative ways to match interested professors and departments with meaningful sustainability projects on the Hopkins campus and in the surrounding community. Each semester an average of ten undergraduate courses offered in the Krieger School of Arts and Sciences and the Whiting School of Engineering cover topics related to sustainability, with an additional ten to fifteen courses offered at the graduate level. While at the same time community-based organizations and local government agencies need specific expertise and skills that the University possesses, many of which go beyond the traditional sciences and environmental disciplines.

For example, over the summer the City of Baltimore approached JHU asking for help with a business and marketing plan for a new sustainable venture they are developing. The Sustainability Initiative was fortunate to find an appropriate Carey Business School professor who used that project as a core element in his marketing class. Ultimately the City was able to achieve its goals and the students were able to apply theoretical coursework in a real world context. This project is just one example of community-based learning, a teaching and learning model that integrates meaningful community service with traditional classroom instruction to enrich the learning experience, teach civic responsibility

[23] "A Letter from President Brody Regarding JHU's Climate Change Policy," July 23, 2007, seen at http://web.jhu.edu/announcements/faculty-staff/targetpage.html?baid=1568.

and strengthen communities. Clearly great potential exists at Hopkins for more learning opportunities like this; however, in order for them to expand and thrive into practical live models additional resources and institutional structures will need to be put in place.

No resource currently exists for students to search for courses that incorporate community-based learning experiences or for community groups to inquire about whether they are in need of student or faculty expertise. Further, there is no mechanism by which a professor can identify useful projects for a course or discover which local entities have needs that could potentially be addressed by a concentrated student effort. In addition to this resource vacuum, there is no support system in place for faculty interested in pursuing this type of pedagogical teaching model nor any institutionalized incentive program to reward faculty who choose this course of action.

4.2.1 Community-based Learning Working Group

Born out of the Provost's Framework for the Future planning process and in response to myriad appeals from undergraduates, the Center for Social Concern initiated the formation of a Community-based Learning Working Group (CBLWG). This group, composed of invested faculty; staff; students; and alumni, is charged with setting up the process by which faculty members and community organizations can partner in order enhance and expand the inclusion of valuable community service in courses and to establish guidelines for what constitutes a community service learning course at Johns Hopkins. Additionally the Center for Social Concern,[24] through this working group, intends to develop resources for faculty such as how-to-guides, workshops, mini-grants for course development, and a listing of community-based learning courses for students, similar to that of University of Pennsylvania's Netter Center for Community Partnerships.[25] This effort is currently being directed by an AmeriCorps VISTA member, hired by the Center for Social Concern this past summer for a one year term, with renewal funding for an additional two years.

4.2.2 Scaling the Efforts for Student Involvement

Members of the WG pointed out that the size and scale of potential projects will have positive impact on both the excitement level of students as well as the logistical and administrative management. For example, larger projects where students receive academic credit might help to engage students in meaningful sustainability projects while creating a partnership with the larger community. However, those projects will need more staff resources in terms of time and effort to align the interests of faculty with the community while working out the academic oversight. The size of the project may also affect the type of student who may want to participate. Large projects that are incorporated into coursework may exclude students who have a personal passion in the environment, but who are majoring in non-environmental disciplines. Members suggested that community partnership projects be evaluated through a "clearinghouse" in which projects of all scales are made accessible to students. Projects may be developed in three categories, with each project category having a different set of evaluation criteria:

[24] See http://www.jhu.edu/csc.
[25] See http://www.upenn.edu/ccp/index.php.

1) Small scale, in which individual students or student groups engage in projects that are short in duration (up to one semester), and where the community partner takes on more of the supervisory or mentoring role.
2) Medium scale, in which students or students groups engage in more developed ongoing projects, either through internships or other formal means of engagement.
3) Large scale, in which group projects are led by faculty members as part of an established course or where academic credit is granted.

One of the considerations will be to connect and integrate projects that are developed as community partnership models with similar projects that may be developed as on-campus efforts, such as those identified in the Tactics and Strategies Working Group. It will be important to create a comprehensive clearinghouse so that students have many choices of on-campus, off-campus, for credit, or volunteer opportunities.

4.2.3 Engaging our Local Peer Institutions

Universities and colleges have historically provided the impetus for change throughout the world through their leadership and innovation. The current environmental and climate challenges we face offer yet another opportunity for such leadership. As concern about the impact humans are having on the environment and our atmosphere increases across the region, many institutions of higher education are answering the call to make a serious commitment to sustainability. The Baltimore region is home to many top-notch universities and colleges and there are many opportunities to collaborate and share ideas.

An initiative that began in 2008 called B-CaUSE (Baltimore Colleges and Universities for a Sustainable Environment) is one avenue for this type of collaboration. B-CaUSE brings together university and college facilities directors, sustainability coordinators and other committed faculty and staff in the Baltimore area to network and share resources for improving campus sustainability and reducing environmental impact. The geographic proximity and operational similarity of our institutions present opportunities to leverage our influence to find solutions to the challenges we face. Additionally, because many institutions in the region specialize in one field or another, advances in research and innovation can be shared to maximize resources and hasten progress.

4.3 Project Evaluation

Achieving greenhouse gas reductions and other environmental benefits in the JHU local communities necessitates a constant stream of good ideas, implemented in a timely fashion. There will be no "silver bullet" solutions, but a large number of creative projects that combine community and JHU relationships, strengths, and intellectual resources that will have a positive – and in many cases, a quantifiable – outcome. To identify these projects, it will be important to develop a system by which creative and interesting projects that leverage community/JHU partnerships can be evaluated and promoted (examples of projects are in Appendix F).

Members of the WG reached consensus on a list of criteria by which proposed projects could be evaluated. Projects may not necessarily satisfy each of the following criteria, but the list represents the issues the WG agreed were the highest priority for making the partnerships – and greenhouse gas reduction projects – succeed.

a. How does the project reduce greenhouse gases?

b. How does the project impact Hopkins? The community? The City?

c. Is this a project that can be done independently, through an existing group or administrative structure, or does it need a new partnership arrangement?

d. How do costs of the project get addressed? If there are savings, how do they get reallocated?

e. What are possible funding sources to support the project?

f. What is the learning potential for the project? Can students be involved? Are there opportunities for professors to use this project as a learning tool in a course?

g. What are the internship (or student job) opportunities?

h. How does this project impact employees? Are the benefits accrued on campus or off?

i. Does the project have a behavior change or adaptation component? If so, how does the change in behaviors create positive environmental benefits?

This above criteria list is part of the first step in creating a framework for promoting and establishing sustainable JHU-community projects for the future. Table 4.1 outlines the steps for moving good ideas through project initiation, management and to implementation and fruition. Sample projects that have potential for meeting these criteria are listed in Appendix G.

Because similar processes exist or may be established to evaluate energy efficiency and renewable energy investment opportunities on campus, effort should be made to ensure that the criteria used to evaluate those projects and the community-based projects that are the focus of this chapter are broadly consistent.

Table 4.1: Project Criteria Evaluation Steps

Step 1: Establish the Framework	• Develop the set of criteria, transparent and highly visible. • Clarity on what JHU will offer, process, timetables • Encourage participation from groups • Coordinate with City to align priorities • Set deadlines for submissions
Step 2: Collection of Ideas	• Send out RFQ or other means of soliciting ideas and project proposals from members of the JHU or local Community • Encourage established groups and organizations to participate
Step 3: Assessment of Project Feasibility	Staff – collect and coordinate proposals for first cut assessment. Proposals may fall into three categories: 1. Send back to authors for clarification; or 2. Reject; or 3. Advance to project development teams
Step 4: Establish Project Development Team	Each project that meets the initial criteria and feasibility requirements needs 1. Project leader – should be either the person who proposed the project or appointee. 2. Project team – size depends on project, but should include members from JHU, the City, and the community The purpose of teams is to develop proposals with the level of detail and research – including finding opportunities, grant writing, and establishment of partnerships – necessary to meet final approval.
Step 5: Approval	Evaluation Committee includes members of JHU, City, and community with authority to approve projects. Committee meets quarterly and sets priorities and agenda for categories of projects. Serves as a Board of Overseers.
Step 6: Implementation	Project development team implements project, or oversees the implementation process.

4.4 Engaging Staff

As the largest private employer in the state of Maryland, JHU has an opportunity to reach tens of thousands of individuals with a positive message of resource conservation and the importance of greenhouse gas reductions. Hopkins' sizable employee base could make a large difference in the region behavior or lifestyle changes spill over to their homes and communities.

JHU has an extensive network of communications resources, as well as training, educational, and staff development opportunities for employees. These assets can be leveraged to promote resource conservation to employees.

There is evidence that suggests that employees who engage in certain behavior at work will bring lessons home. For example, if staff members are encouraged to look for energy savings opportunities on campus, and are rewarded for their efforts, it is possible they will continue those efforts in a home setting. This "learning by doing" model has the potential for benefits for both JHU and the employees. There are some initiatives under way at the university level, but more could be done to engage the JHU employees.

In addition to expanding the number and breadth of workshops and seminars,[26] the working group identified a number of new initiatives that could provide benefits to the university as well as "spill-over" benefits to the community. One example would be in the establishment of a Green Office Reps Program that would utilize peer-to-peer outreach at the departmental level to encourage more environmentally preferable behaviors in the office. The program would focus on recruiting a "rep" in each departmental or administrative office who would then be a conduit for communicating new ideas and coordinating sustainability efforts throughout the offices. While promoting "learning by doing" in the office, these reps would be helping establish behaviors that employees could take home with them to their communities.

Based on research undertaken by the Tactics and Strategies Working Group, positive incentives and reinforcement are essential to promoting affirmative behavior and behavior change that would support institutional climate change goals. Group members determined that there is an opportunity to go beyond the promotion of good environmental behaviors by fostering an atmosphere where aggressive participation and leadership are rewarded. Employees who are identified and rewarded as environmental advocates may be more likely to continue that role in the community. Group members determined that there is a role for a Green Leader award program that would recognize staff who go above and beyond to improve the sustainability of Johns Hopkins.

4.5 Role in Legislation

Over the past few years, the State of Maryland has passed bills intended to reduce energy consumption, increase the use of renewable energy resources, and encourage cleaner, more efficient vehicles. The state has also joined the Regional Greenhouse Gas Initiative (RGGI), a collaborative effort of ten Northeastern and Mid-Atlantic states with the goal of reducing GHG from the electric power industry by 10% by 2018.[27] The state of Maryland is also considering additional legislation that would reduce GHG emissions more aggressively, and the City of Baltimore is likely to adopt the state's targets. With this level of legislative activity, members of the Task Force asked the working group to consider what role the university might play in supporting or influencing climate change legislation at the local, state, or federal levels.

The group determined that there are two main areas of action for consideration; (1) reacting to existing legislation and (2) serving as a resource for policymakers. As a matter of course, the university does not typically get involved in the legislative process unless the body is considering a bill that affects the university directly or would have an impact on the university's core mission. This is a done on a

[26] During the past three years, the Sustainability Initiative has facilitated energy savings workshops and has hosted "clean car clinics" for employees.

[27] See http://www.rggi.org/home.

case-by-case basis and decisions to take action are made by the senior administration. In the event that a climate change bill is introduced that would affect the university's core mission, the president and other senior administrators could make a decision to act.

The group determined that the second option – acting as a resource for policymakers – would have a greater overall impact based on the fundamental strengths of the university. While the university does have a small government affairs arm, the university has significantly more experts, specialists, and professional practitioners who can help in the development of good policy ideas through testimony and the sharing of research and relevant data. The university is already a well known resource for health-related topics, but is not yet known for sustainability or climate change. To be a valuable resource for policymakers in these areas, the university will have to take a number of measures to build up the sustainability brand. Some of the measures discussed included:

- Develop a working list of university sustainability climate change authorities who would be willing to travel to Annapolis occasionally to provide expert testimony to the legislature and committees.
- Have the government affairs personnel contact MD state legislators and their staffs to inform them on the expertise available from the Hopkins community.
- Create a sustainability policy committee comprising JHU climate and sustainability experts who will meet twice yearly to develop a list of cutting edge issues that should be considered by policymakers. Acting as an informal policy "think tank," the committee will evaluate the current state of technologies and scientific conditions and develop a list of ideas that could be used by policymakers to draft new legislation. The committee could also assess drafts of legislation and provide comments or suggestions.

The group also considered whether there is a role for university experts at the federal level in the legislative process. There may be fewer opportunities to influence pending legislation at the federal level, but the group agreed that with our resources, close proximity to Washington, DC, and its government affairs staff, the university does have a role to play on the federal level.

4.6 Recommendations

1. **Create a Community-based Learning Working Group** at the administrative level, with the stipulation that the CBLWG ensure that sustainability related community-based learning will be a principal theme for projects.
2. **Provide financial and organizational support for a permanent staff position** dedicated to this effort. This person would take the following actions:
    a) Recruit "point persons" in academic departments who will coordinate with professors who are interested in collaborative projects with the community.

b) Working with the City, community groups, and local businesses, develop a clearing house of potential projects that professors may want to consider as they develop courses and which they may want to use as practical, credit earning opportunities for students.

c) Tap resources in the community by setting up a directory of environmental organizations seeking interns and who would like to have their name listed so that students seeking internships can contact them. Set up a career-services group that offers students environmentally-based internships.

d) Work with central and divisional development offices to contact alumni who have energy or environmental expertise seeking advice and contributions to support efforts.

3. **Promote "learning by doing"** at JHU by engaging staff on resource conservation efforts on campus and eliciting participation by rewarding suggestions that will save resources.
4. **Establish workshops and training modules** on topics that emphasize how to take advantage of energy savings, alternative commuting options, and available financial incentives.
5. **Establish a Green Office Reps Program** that utilizes peer-to-peer outreach at the departmental level to encourage more environmentally preferable behaviors.
6. **Make better use of JHU communications networks**, such as newspapers, newsletters, daily announcements and Green Office Reps, to promote resource conservation within JHU.
7. **Establish a Green Leader award program** that recognizes staff who go above and beyond to improve sustainability at Johns Hopkins.
8. **Leverage lines of communication at the state and federal level** to promote Johns Hopkins University as a leader in the areas of sustainability and climate change research.
9. **Develop, update, and maintain a list of active JHU faculty and staff who can serve as expert witnesses** for testimony at the state or federal level, and promote this expertise to policymakers.
10. **Establish a sustainability public policy committee** comprising JHU climate and sustainability experts who will meet twice yearly to develop a list of cutting edge issues that should be considered by policymakers. Acting as an informal policy "think tank," the committee should evaluate the current state of technologies and scientific conditions and develop a list of ideas that could be used by policymakers to draft new legislation. The committee should also assess drafts of new legislation and provide comments or suggestions when appropriate.

Appendices