Greenhouse Gas Reduction Plan

July 18, 2017

Worcester Polytechnic Institute

Greenhouse Gas Reduction Plan

Executive Summary

Introduction: WPI's Commitment to Sustainability

The mission of WPI includes the commitment "To create, to discover, and to convey knowledge at the frontiers of academic inquiry ***for the betterment of society***." This commitment to the importance of societal impacts led to the creation of our Plan for Sustainability, including the major goal of development and implementation of a Greenhouse Gas (GHG) Reduction Plan. Recognizing that the increase of carbon dioxide and other greenhouse gases in the atmosphere is a major contributor to climate change, and further recognizing that the emission of these gases due to human activities is a primary cause of this increase, WPI commits to taking responsible action to track our emissions and to minimize the quantity emitted.

Accomplishments to Date

While this formal GHG reduction plan is just being finalized, WPI has been active in minimizing its environmental impact for many years. Salient accomplishments include the following:

- Implementation of campus-wide recycling in 1990, with major enhancements, 2006;
- Replacement of the central power house boilers with efficient, natural gas units, 2006;
- Commitment by the WPI Board of Trustees to design all future buildings to LEED standards, 2007 (Four LEED-certified buildings have been completed and a fifth is under construction.);
- Creation of the President's Task Force on Sustainability, co-chaired by the Provost and CFO, 2007;
- Development and acceptance by the Board of Trustees of the ***WPI Sustainability Plan***, 2013;
- Investment of approximately $500,000 annually in energy efficiency upgrade work, beginning in FY2014;
- Receipt of AASHE STARS Gold rating for overall performance in operational, educational, research, and community aspects of sustainability, 2017.
- Establishment of a Green Revolving Fund to institutionalize the commitment to continued work to reduce energy and other resource consumption, FY18;

All of these activities have had a positive impact on the reduction of our direct or indirect[1] GHG emissions. While this GHG Plan is important, it is just one component of our overall commitment to sustainability as documented in our ***WPI Sustainability Plan***.

[1] Direct campus emissions, such as from our boilers and vehicles, are referred to as Scope 1; emissions due to production of the electricity used on campus are referred to as Scope 2; other emissions related to WPI operations, such as commuting and business travel, are referred to as Scope 3.

Emissions History and Current Status

In the period after FY07 and continuing to the present WPI has been in a period of substantial growth in floor space, student, faculty and staff population, and research activity. All of this is reflected in the growth in energy usage and greenhouse gas emissions depicted in the early years of Figure 1. By FY09 we were emitting a total of 17,710 metric tons of CO_2e annually. This represents the highpoint for campus energy usage and emissions. Thanks to aggressive energy conservation work, even in a period when WPI added 263,000 gross square feet of floor space, our usage and our emissions have decreased. Without these efforts our utility usage, and cost, would have been expected to increase by about 15%, corresponding to approximately an additional 4.4 million kWh and 22,300 million BTU annually, along with an additional utility cost of approximately $840,000. Another major contribution to reduction of GHG emissions was the conversion of our central heating plant from fuel oil to natural gas in FY06. This

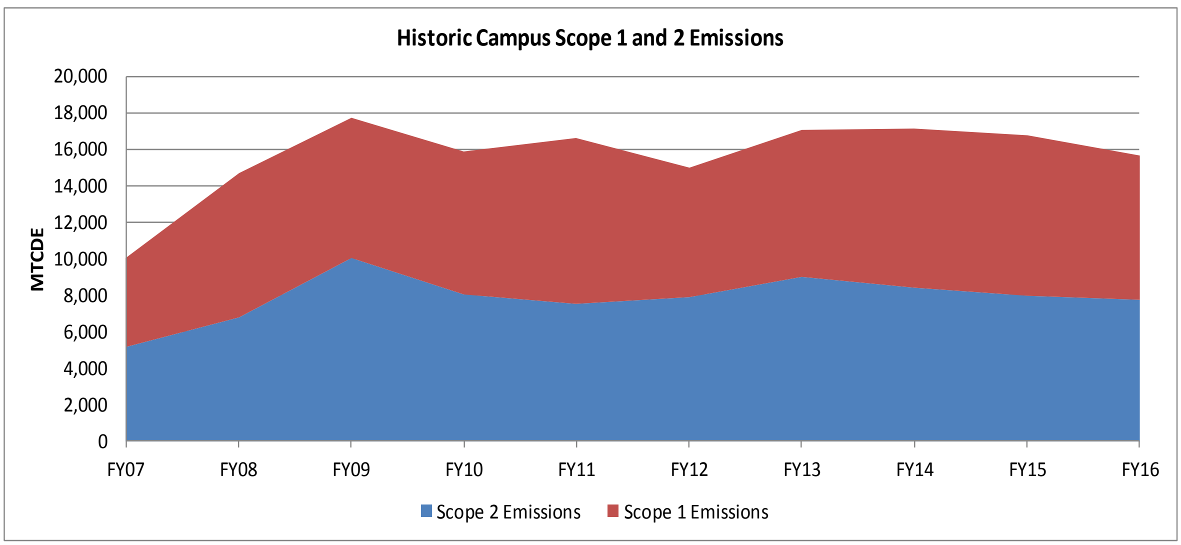

Figure 1 WPI Scope 1 and Scope 2 emissions. Scope 2 is due entirely to electricity use. Scope 1 is due primarily to natural gas for building heating with contributions from campus vehicles and power equipment.

conversion reduced our Scope 1 GHG production by approximately 25%.

Determination of GHG Reduction Actions

The cornerstone of essentially every GHG reduction plan is energy efficiency. Reduction of the amount of energy used by WPI reduces greenhouse gases, reduces the stress on the electric grid, and saves money. WPI has successfully implemented several major energy conservation efforts, targeting both electric and thermal energy. An extension of this program forms the basis for this Greenhouse Gas Reduction Plan. GreenerU, a firm with substantial experience in campus energy efficiency auditing and upgrades was engaged to continue previous work in auditing campus buildings for energy usage and efficiency upgrade potential.

Details of the building audit results are presented in the full report. These audits, together with previous, non-implemented building studies, demonstrate the potential for significant additional savings in energy, utility costs, and greenhouse gas emissions. If completely implemented, these specific projects would reduce WPI's energy use by approximately 21.6 million BTU annually, or approximately 8.5% of total energy use. Further, an additional 38% of WPI's building floor space appears feasible for energy upgrades.

Financial Aspects

An understanding of the financial as well as the energy and GHG implications of potential projects is essential. Figure 2 shows the simple payback periods for each studied project and Figure 3 shows the cumulative GHG savings as a function of project payback. This chart demonstrates that approximately 85% of the potential GHG savings can be realized with payback periods of 7.5 years or less.

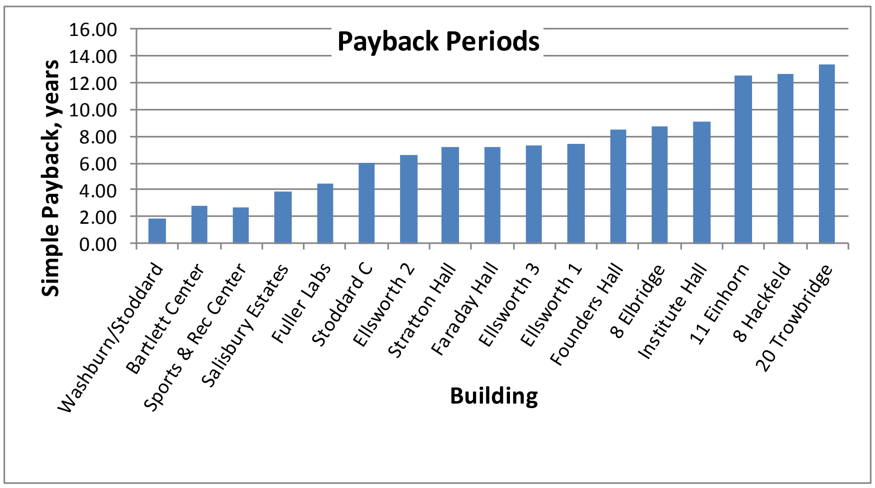

Figure 2. Simple payback periods for audited buildings, in order of increasing payback time.

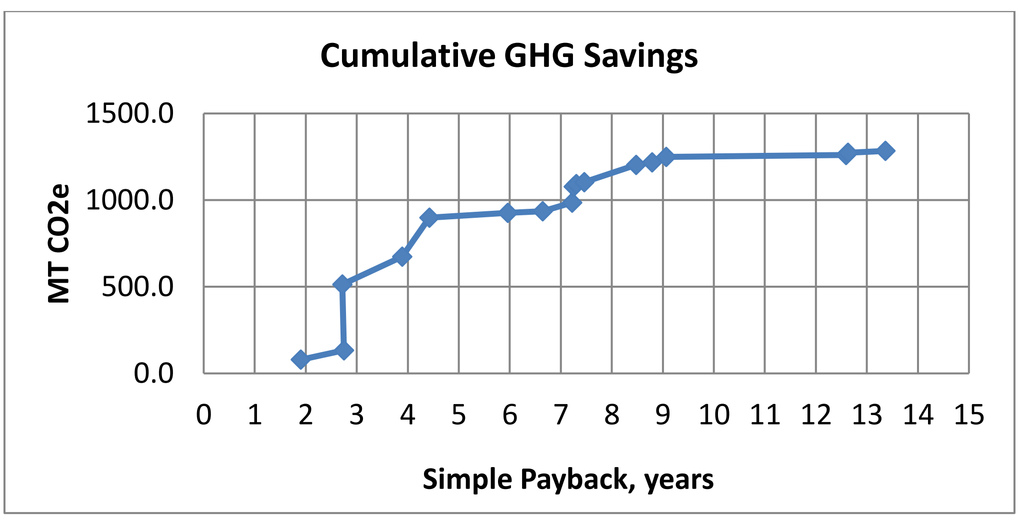

Figure 3. Total cumulative annual GHG savings achievable with multiple projects, ordered by project from the shortest payback period to the longest.

A key implication of the financial analysis is that all of these projects ***pay back their implementation costs*** in 7.5 years or fewer, and after the payback period, they provide an ***annual savings in WPI's energy costs***. This is illustrated with the cash flow depicted in Figure 4 for one possible sequence of project implementation. It shows that in year seven the cumulative balance of WPI's investment cost and energy savings becomes positive, and continues to grow in future years. Of course this approximate analysis must be refined prior to project implementation.

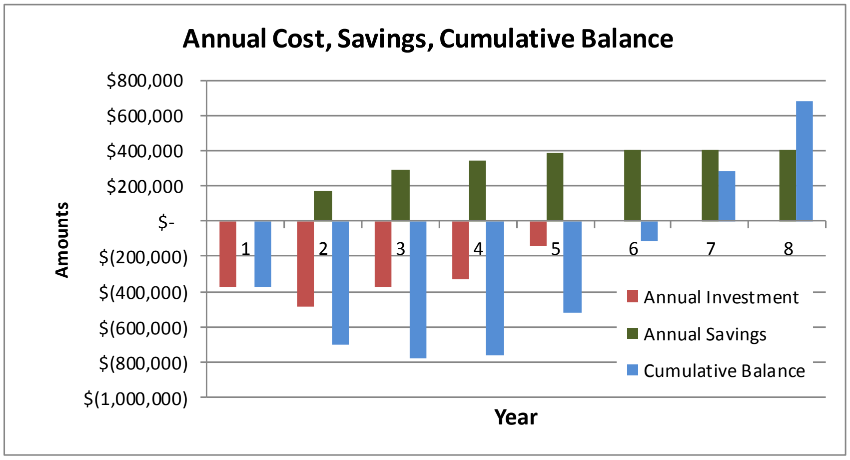

Figure 4. Illustration of one possible set of energy upgrades. The cumulative balance indicates the cumulative sum of investment costs (negative) and utility savings (positive), showing a net positive benefit in year 7 and beyond.

A common metric in GHG reduction studies is the ***cost per metric ton of GHG reduced***. For the projects described here, that net cost over the payback period considering project investments balanced against utility savings will actually be ***negative*** – representing a ***dollar savings*** to WPI as well as a reduction in GHG emissions.

Goal and Related Commitments

WPI's goal, even as we grow in size, is to achieve a 20% reduction in gross Scope 1 and Scope 2 Greenhouse Gas emissions by FY25, relative to the benchmark year of FY14.

This goal can be achieved with implementation of the energy conservation plan presented in this report, together with small reductions due to additional efforts. To reach this goal WPI makes the following commitments:

1. WPI will strive to continue to reduce emissions at a rate that matches recent success, approximately 1.5% annually via continuation of the energy upgrade program. As has been demonstrated to date, continuation of these measures will yield net ***financial savings*** to WPI.

2. WPI will actively pursue the implementation of additional measures such as advanced energy conservation techniques, support for continued growth of “clean” electricity, and use of advanced heating/cooling technology.
3. WPI will undertake to measure and report those components of Scope 3 emissions (principally faculty/student/staff commuting and WPI-related travel) that are feasible to quantify, and to develop programs to reduce or compensate for these emissions.
4. WPI commits that its education will impart the knowledge and skills necessary for its graduates to bring about major reductions in greenhouse gas emissions through their careers.
5. Finally, WPI commits to continued support for its research programs that are advancing the scientific knowledge and the engineering implementations that will reduce greenhouse gas emissions globally.

Implementation Plan

The following strategies are recommended for implementation in the short (1-5 year) term for Scope 1 and 2 emissions:

- Energy Upgrades
    - Continuation of the program of thermal and electric energy efficiency upgrades to campus buildings at the rate of at least one major building per year, or the equivalent in some number of smaller buildings. It is recommended that this effort be implemented via a green Revolving Fund.
    - Upgrade of exterior campus lighting with more efficient LED fixtures and appropriate controls
    - Implementation of flexible controls for athletic field lighting and possible conversion to LED fixtures to minimize energy use while providing appropriate lighting for activities.
- Complementary efforts
    - Implementation of a “Green Labs” program including education and incentives on the many ways in which energy and other resources may be used more efficiently in the laboratory environment.
    - Implementation of an ongoing monitoring system as part of the building automation systems to minimize the degradation of energy performance of buildings over time and to document the actual energy savings achieved by upgrade and conservation work.
    - Inclusion of energy efficiency considerations in all major maintenance projects.
    - Conduct of a comprehensive study of campus water use, identifying waste, leaks, and opportunities for efficiency improvements, and implementation of the results. The GHG impact will be relatively small but the water resource conservation is worthwhile in itself.

    - Implementation of building and space access policies and controls to concentrate the use of space, recognizing the dynamic nature of campus utilization, resulting in both electricity and heating/cooling savings.
    - Conduct of an ongoing education program to support behaviors that conserve energy. Numerous studies report energy reduction results in the 5% range for targeted behavioral programs, but also caution that long term effects require ongoing programs.
    - Verification that the state's "no idle" policy is implemented for campus vehicles.
- Major purchases
    - Performance of an engineering study of the potential for further reduction of energy use in our information technology equipment, and implementation of the recommendations.
    - Attention to energy use in all new equipment purchases.
    - Consideration of fuel efficiency in all campus fleet and power equipment purchases, and purchase of hybrid, electric or biodiesel vehicles where feasible.

Greenhouse Gas Reduction Plan

Introduction and Principles

The mission of WPI includes the commitment "To create, to discover, and to convey knowledge at the frontiers of academic inquiry ***for the betterment of society."*** This commitment to the importance of societal impacts led to the creation of our Plan for Sustainability, including the major goal of development and implementation of a Greenhouse Gas (GHG) Reduction Plan. Recognizing that the increase of carbon dioxide and other greenhouse gases in the atmosphere is a major contributor to climate change, and to global warming in particular, and further recognizing that the emission of these gases due to human activities is the primary cause of this increase, WPI commits to taking responsible action to track our emissions, and to take steps to reduce the quantity emitted. Further, as a research and educational institution, we commit to advancing the state of scientific knowledge and technology to reduce greenhouse gas emissions while continuing to provide the types and amounts of energy that are essential to human welfare. We have committed to the incorporation of the principles of sustainability in our teaching and research activities as well as in our campus operations. The balance among these three dimensions will guide the resource allocation in our GHG reduction efforts. We understand that resources devoted to undergraduate and graduate education in sustainability principles and to clean energy research are potentially even more important over the long term than the resources spent in reducing campus emissions.

At WPI we have adopted the commonly-accepted definition of sustainability as the stable situation in which humans and nature exist in mutual harmony to support both present and future generations. We strive to reach this goal through consideration of the three sub-goals of environmental stewardship, social justice, and economic security for all. Actions toward these goals includes minimizing our carbon footprint and other negative environmental impacts, educating our students through sustainability-related courses and project work, performing relevant research, and carrying out positive community engagement locally and globally. While the major goal of this plan is to put in place a set of targets and strategies for management and reduction of our CO_2e (CO_2e refers to the amount of CO_2 with the same global warming potential as the actual mixture of all the emitted gases) emissions, another goal is to establish a comprehensive communications plan to educate the community on the extent of the CO_2e emissions from each of the major sources, together with information on the negative impact of these emissions and the ways in which they can be reduced or offset. This effort will help build awareness in the WPI community of the need to include reduction of these unseen impacts in our campus decisions.

This document sets the institutional context, clarifies the definitions, documents our current situation, compares WPI to peers and benchmarks, lists and evaluates alternative reduction strategies, and sets near-term and medium-term targets and reduction strategies. The formal adoption of this plan represents WPI's commitment to institutional responsibility in securing our planet's future.

With this plan we commit to tracking and working to reduce the greenhouse gas emissions on our campus and those produced in the generation of our electricity. These are referred to as Scope 1 and Scope 2 emissions. We also commit to development of a plan to track and minimize other emissions that result from our operations, referred to as Scope 3 emissions. These includes activities such as commuting and other WPI-related travel.

Accomplishments to Date

While this formal GHG reduction plan is just being finalized, WPI has been active in minimizing its environmental impact for many years. Salient accomplishments include the following:

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All of these activities have had a positive impact on the reduction of our direct or indirect[1] GHG emissions. While this GHG Plan is important, it is just one component of our overall commitment to sustainability as documented in our WPI Sustainability Plan.

Determination of a GHG Emissions Goal

While the justification and details are presented later, the following goal has been established:

WPI's goal, even as we grow in size, is to achieve a 20% reduction in gross Scope 1 and Scope 2 Greenhouse Gas emissions by FY25, relative to the benchmark year of FY14.

This magnitude of reduction in our actual gross emissions during a time of substantial growth in floorspace and campus population represents an aggressive target. Energy conservation will be the primary tactic

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but this will be complemented by additional operational, educational, and research activities that represent our commitment to the broad definition of sustainability.

One of the essential components of the application of the principles of sustainability is consideration of the external and long-term impacts, both positive and negative, of all that we do. Positive impacts include our contributions to the productive lives of our students, and our conversion of a brownfield into an economically and intellectually thriving component of the city of Worcester. On the other hand, we have a responsibility to minimize the negative impacts of the solid waste that we generate, the water and other resources that we use, and of our gaseous emissions. The overall basis for the targets for these items can be stated as: "Minimization of resource use and waste/emissions generation consistent with accomplishment of our institutional mission." This principle embodies the balance among disparate and competing forces that often arises in sustainability planning. Minimization of our GHG emissions is an important element of our commitment to environmental stewardship, but it is not the only element. We strive to implement an optimum balance, given available resources, among the following:

- Minimization of energy use,
- Minimization of direct and indirect greenhouse gas emissions,
- Support for development of zero GHG electricity generation,
- Effective student education in the application of the principles of sustainability in their careers and their personal lives,
- Research that advances the implementation of clean energy and that reduces the emissions associated with conventional energy.

This report is focused on items one and two, but the overall impact of the other items on global greenhouse gas emissions will likely be ***greater***, and hence are appropriate components of this plan. Our activities in these areas include the following:

- Student projects that develop and implement appropriate technologies (water, energy, erosion control, etc.) and social programs at project centers in the developing and developed world,
- An academic program in Environmental and Sustainability Studies, and a Minor in Sustainability Engineering,
- Commitment to the development of large-scale off-site solar energy sites via virtual net metering contracts,
- Research in technologies including advanced batteries, recovery of high value resources from discarded electronics, and increase in solar cell efficiency.

The effects of these activities cannot be precisely quantified in terms of metric tons of CO_2e reduction, but the following example helps to demonstrate the potential impact. Consider the decision to either invest WPI's resources in purchasing Renewable Energy Certificates or in research to improve solar cell efficiency. If that research could increase PV efficiency by just 0.5% (for example, from 10% to 10.05%), installed solar generation capacity in 2016 would have increased by 58,000 MWh which is more electric energy than WPI consumes annually. Hence this activity can be viewed as offsetting all of the greenhouse gases emitted in WPI's electricity production.

WPI commits to the following principles:

- Minimization of GHG emissions on our campus,
- Support for research regarding technologies and policies that reduce GHG emissions,
- Education for all students regarding personal and professional decisions that impact global climate change.

In summary, we are confident that our decision to commit resources to reduction of our own emissions and to relevant research and education, rather than to the purchase of Renewable Energy Credits or other offsets, will yield greater global benefits.

Definitions and Methodology

Definitions

Scope 1 Emissions are direct emissions from sources entirely within WPI's control. The primary sources of Scope 1 emissions are activities that burn fossil fuel such as oil or gas fired boilers and internal combustion engines, such as the powerhouse boilers that burn natural gas to generate steam for campus heating and the emergency generators that burn diesel or natural gas to provide back-up electricity to the campus. Small sources of Scope 1 emissions include the gasoline and diesel used for campus vehicles and the "fugitive" sources such as leaks of refrigerants from campus air conditioning systems.

Scope 2 Emissions are indirect emissions resulting from the production of some type energy (principally electricity) that is purchased by WPI. This electricity is delivered from the New England grid, and is generated from natural gas combustion, nuclear power plants, hydroelectric facilities, fuel oil plants, coal plants, as well as solar photovoltaics, wind turbines, biomass combustion, and refuse incineration.

Scope 3 Emissions include all emissions related to WPI's operations that are not included in Scope 1 or 2. This is an extremely broad category of emissions, including factors such as the emissions associated with the construction of campus buildings and other infrastructure, and purchased equipment and supplies. Institutions that track Scope 3 emissions commonly identify a subset of the possible sources to track. Most commonly this includes commuting travel to and from campus for faculty, staff, and students, and may include other institution-related travel, such as to conferences and student off-campus sites. Also, emissions related to the processing of solid waste and waste water may be included. In this initial plan WPI is not including Scope 3 emissions but we do commit to adding this dimension in the future..

Carbon Dioxide Equivalent (CO_2e) is a measure of the global warming potential of a mixture of gases in terms of the potential of pure CO_2. For example, the CO_2e of 1 metric ton of CO_2 is 1 metric ton and the CO_2e of 1 metric ton of methane is approximately 25 metric tons.

Normalized emissions In addition to the total CO_2e emissions in each scope, we will track emissions normalized by floor space and WPI's full time equivalent population (faculty, staff, and students).

Energy Intensity Energy consumption normalized by floor space and FTE population. An additional normalization by heating degree days for heating energy assists in comparison across years with different average temperatures.

Inventory Methodology

Data Sources

The inventorying of Scope 1 and Scope 2 emissions is relatively straightforward, making use of the following information:

- Scope 1 emissions
  - Natural gas usage: utility bills,
  - Vehicle fleet: gasoline and diesel fuel purchases,
  - Emergency generators: diesel fuel purchases, natural gas utility bills,
  - Power equipment: fuel purchases,
  - Refrigerant leaks: refrigerant purchases,
  - Data on CO_2e emissions factors from each type of fuel or refrigerant.
- Scope 2 emissions
  - Electric utility bills,
  - Fuel mix for the electricity used by WPI and data on CO2e emissions factors from each type of fuel.

Emissions Factors

Emissions factors (i.e. the amount of CO_2 equivalent released from the combustion of each material) for this assessment were primarily derived from the IPCC 5th Assessment [1], with additional information from sources such as the Departments of Energy and Transportation and the Environmental Protection Agency [2].

Reporting and Analysis

Emissions are reported both in gross, or total terms, and in normalized terms. Reporting normalized emissions allows WPI to compare emissions from year to year while considering the impacts of the variation in campus population and square footage.

Baseline and Reporting Year

In development of the WPI Sustainability Plan, Fiscal Year 2014 (July 1, 2013 - June 31, 2014) was established as the baseline year for most reporting purposes, and will serve as the benchmark year for this plan. With regard to the heating energy component of the GHG emissions, the large year-to-year variability in temperature, as measured in heating degree days, results in substantial fluctuations that can mask the impacts of reduction efforts. Hence, it will be important to observe longer-term trends. For example, FY12 (including heating degree days from July, 2011 through June, 2012) happened to be approximately 18% warmer than average in terms of heating degree days. From Figure 1 it can be seen that our natural gas usage declined substantially in FY12 while our electricity usage remained approximately constant.

The fiscal year has been chosen rather than the calendar year for reporting since essentially all of WPI's reporting is on a fiscal year basis. Each fiscal year incorporates one academic year and represents the period over which WPI's financial income and expenses are reported.

Reporting Boundary

This inventory focuses on all buildings and grounds that WPI owns, as well spaces that WPI leases for additional classroom, office, and laboratory space. Due to practical constraints, this inventory does not include spaces where WPI does not pay the utility bills. The Scope 3 emissions are not tracked directly, and in some cases the CO_2e content would be difficult to determine. As part of this Plan WPI commits to the development and implementation of a system to measure, or estimate to a reasonable degree of precision, the greenhouse gases emitted under Scope 3.

Context: GHG Trends, and Current Status

Historical Energy and GHG Data

In the period after FY07 and continuing to the present WPI has been in a period of substantial growth in floor space, student, faculty and staff population, and research activity. All of this is reflected in the growth in energy usage and greenhouse gas emissions depicted in the early years of Figures 1 and 2. By FY09 we were emitting a total of 17,710 metric tons of CO_2e annually. This represents the highpoint for campus energy usage and emissions. Thanks to aggressive energy conservation work, even in a period when WPI added 263,000 GSF of floor space, our usage and our emissions have decreased. Without these efforts our utility usage, and cost, would have been expected to increase by about 15%, corresponding to approximately an additional 4.4 million kWh and 22,300 million BTU annually, for an additional cost of approximately $840,000. Another major contribution to reduction of GHG emissions was the conversion of our central heating plant from fuel oil to natural gas in FY06. This conversion reduced our Scope 1 GHG production by approximately 25%.

The sources of WPI's Scope 1 emissions are illustrated in Figure 3. The burning of natural gas for space heating and domestic hot water heating (designated "boilers") produces 97.7% of our Scope 1 emissions, with our vehicle fleet ("Motor") contributing 1.3% and emergency generators and refrigerant leaks contributing the remainder. Primary data for Scope 1 emissions are taken from the annual report filed with the Massachusetts Department of Environmental Protection. [3]

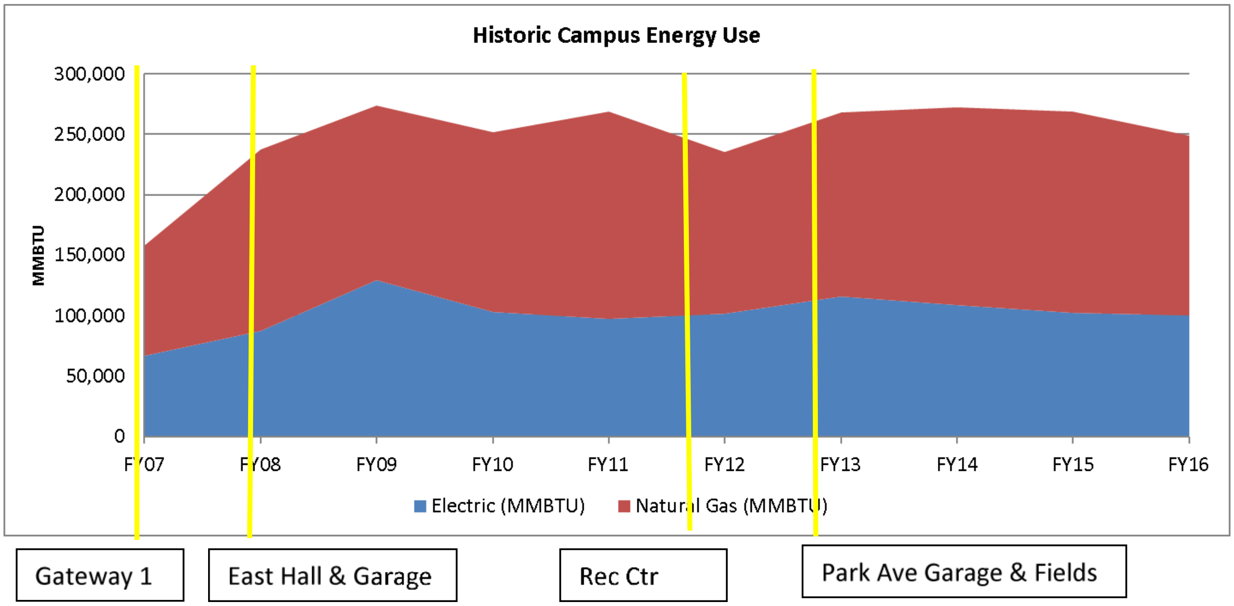

Figure 1 Historic WPI electricity and natural gas use in the period from FY07 through FY16. The approximate opening dates of four major campus buildings are indicated. Note that MMBTU represents one million BTU.

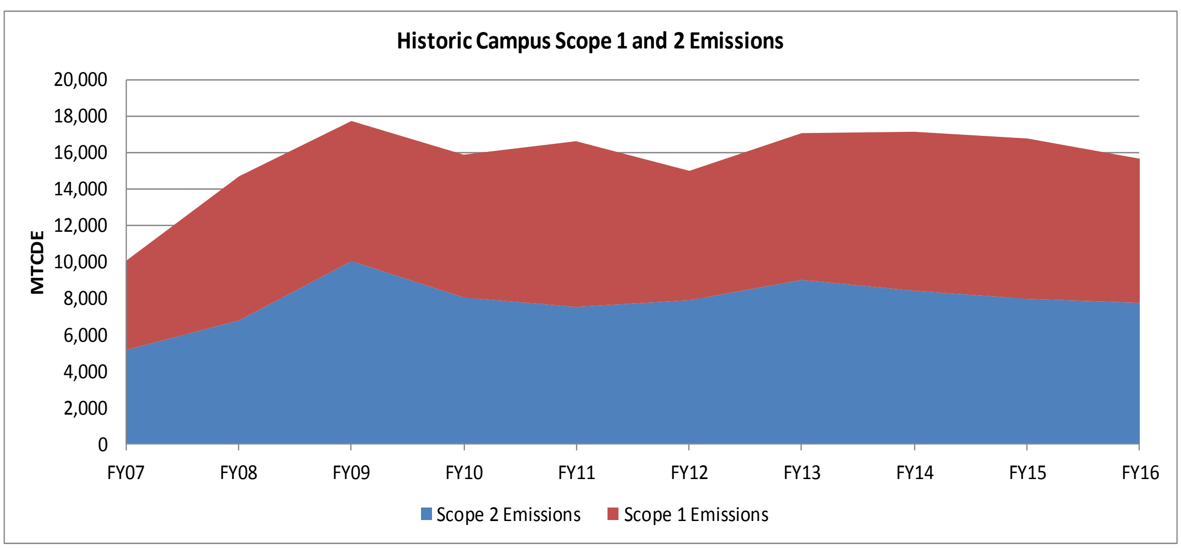

Figure 2 Historic WPI Scope 1 and Scope 2 emissions. Scope 2 is due entirely to electricity use. Scope 1 is due primarily to natural gas for building heating with contributions from campus vehicles and power equipment.

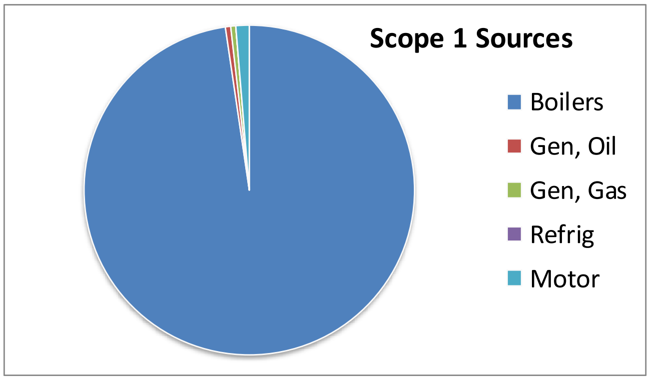

Figure 3 Relative contribution of each component of WPI's scope 1 CO_2e emissions. Boilers refers to all heating uses of natural gas.

All of our Scope 2 emissions are due to the electricity used by WPI. While not emitted on campus, we are responsible for the emissions from fuels burned to produce the electricity that we use. An exact allocation of emissions to kWh used cannot be made because of the interconnected grid nature of the electric network. WPI draws from the grid at our geographic location, but power is input to the grid from a myriad of large and small power plants with their energy input coming from sources that include natural gas, oil, coal, sunlight, wind, biomass, and hydropower. The power sources in New England are relatively clean, with only a small amount of coal being used, along with large amounts of hydro and nuclear power. While nuclear energy is controversial for its potential long-term waste issues, its generation adds no greenhouse gases to the atmosphere. The proportion of these energy sources is shown in Figure 4. The CO_2e contribution of the various type of biomass is a matter of some debate, but with its inclusion 47% of this region's electricity is generated from zero CO_2e sources. These data originate with WPI's energy supplier and are referred to as the "regional average fuel mix." The data reported here represent the time period of 04/01/2015 through 03/31/2016 [4].

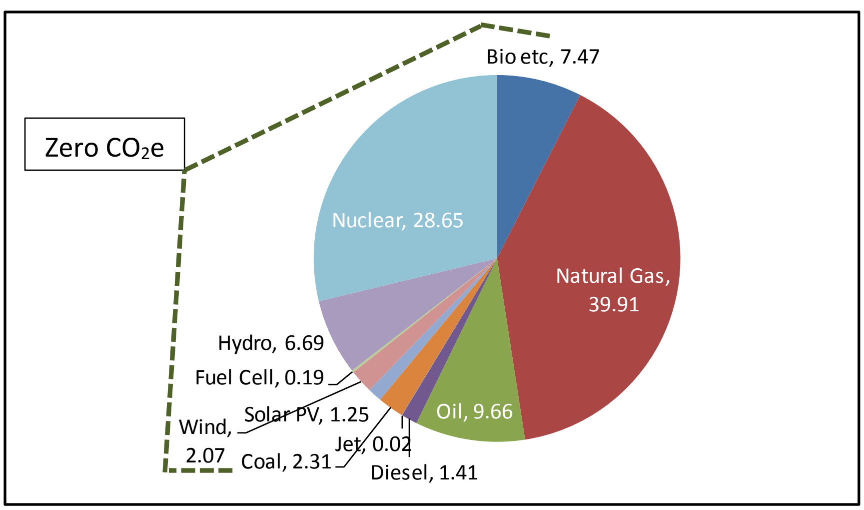

Figure 4. Fuel mix for WPI's electricity generation, 2015-2016

While total emissions represent the fundamental quantity to track and manage, it is also appropriate to track WPI's energy use and emissions normalized by a measure of our size. Figure 5 depicts our energy use normalized by gross square footage of campus structures from FY12 through FY16. The green line indicates what might be expected in a "business as usual" scenario over time as energy usage of space tends to grow over time. A 1% annual growth is depicted. The red line represents a target of 15% reduction in energy intensity over the FY12 to FY17 period. With the current energy upgrade work in Atwater Kent, Morgan, and Alden, this target should be met in FY17.

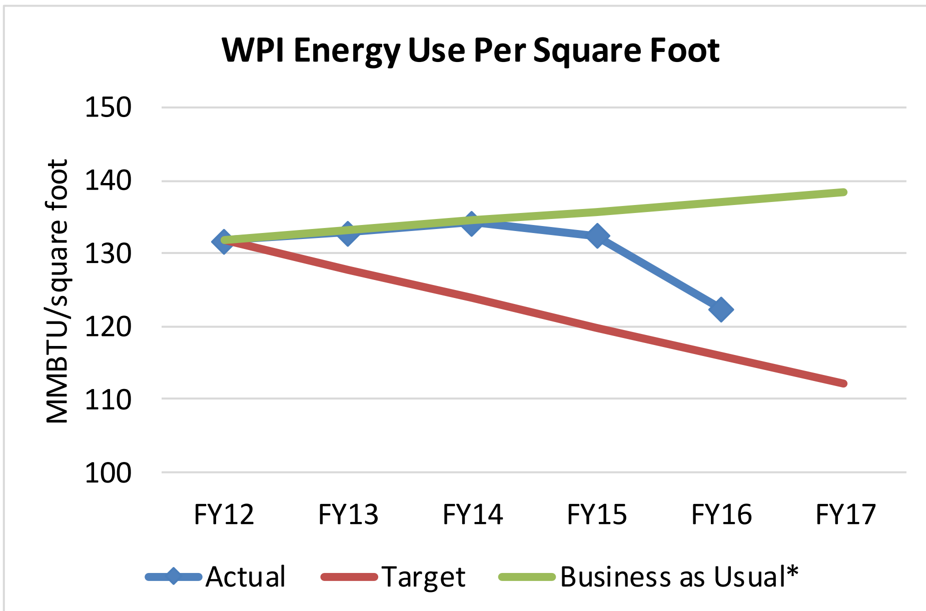

Figure 5: WPI's total (electricity plus natural gas) energy use normalized by gross floor space. "Business as usual" represents a 1% annual growth in energy usage – an amount that is commonly observed.

Comparison to Peers

Figure shows a comparison of total Scope 1 and 2 emissions across a range of institutions. The institutions shown, with the exception of WPI, have all signed the Presidents' Climate Commitment to reduce their CO_2e emissions to zero by some time in the future, demonstrating their commitment to Figure 6 shows a comparison of total Scope 1 and 2 emissions across a range of institutions. Emissions data were obtained from the Second Nature website, http://reporting.secondnature.org/ and enrollment data were obtained from ipeds, https://nces.ed.gov/ipeds/. WPI compares quite favorably to these institutions. A comparison to a larger survey group of universities is provided by the NACUBO/APPA survey that reports a range of emissions from 0.85 metric tons CO_2e per FTE student for community colleges to a level of 6.3 metric tons per FTE student for research institutions. These values represent the median reported across all the reporting institutions in each institution category. WPI is at a level of 3.7 metric tons per FTE student.

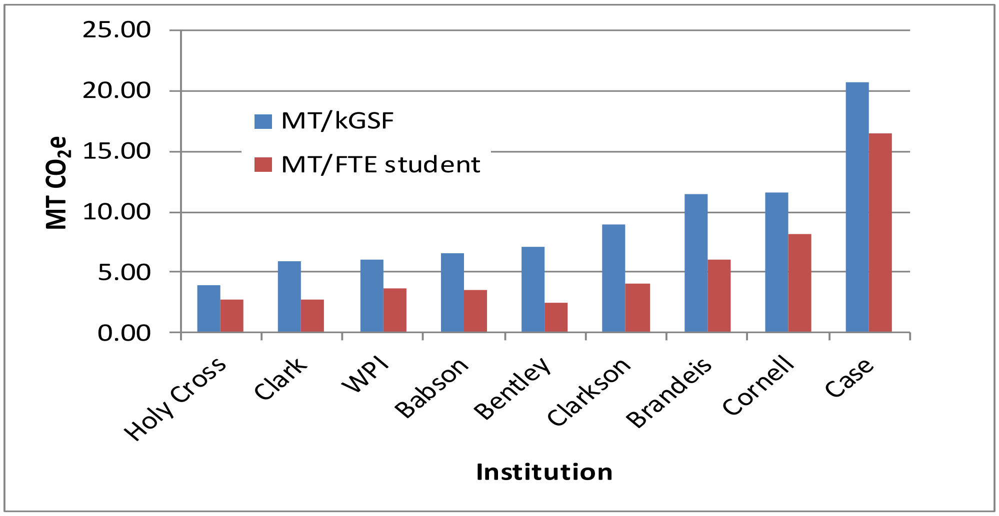

Figure 6. Annual metric tons of CO2 equivalent emitted by the listed institutions, normalized by gross square footage and FTE student enrollment.

Mitigation Strategies

Introduction

Regardless of the specific quantitative target, which will be discussed later, WPI has accepted the responsibility to minimize our greenhouse gas emissions. A broad range of possible strategies is discussed below, and it is fortuitous that a primary approach to CO_2e reduction is simply to reduce overall energy use, which also reduces our utility costs. In fact, this approach to CO_2e reduction has already been shown to often represent a net financial ***savings*** to WPI, often with short payback periods.

Review of Possible Approaches

Scope 1 (principally space heating and campus vehicle and power equipment) emissions are directly under WPI's control. Following are the principal means of emissions reduction:

- Enhanced energy efficiency,
    - Enhanced heating plant (boiler) efficiency in converting fuel to usable heat,
    - Enhanced efficiency in heat distribution (steam piping),
    - Enhanced efficiency in heat energy use: insulation, air leak sealing, optimal air flow and outside air exchanges,
    - Flexible, programmable HVAC controls incorporating diagnostics,
    - Correct user behavior in using the controls appropriately,
    - Enhanced vehicular fuel efficiency and migration to hybrid/electric vehicles,
    - Fuel efficiency improvements in power equipment, and/or alternative approaches to reduce use of power equipment.

- Change to alternative heat sources such as thermal solar systems or ground- or air-sourced heat pumps,
- Change to lower carbon fuel (such as from fuel oil to natural gas),
- Utilize bio-diesel in campus diesel fleet and possibly in emergency generators,
- Behavior change: prohibit idling of campus vehicles, user controls for HVAC, optimal use of fume hoods and other laboratory energy-consuming devices,
- Replace HVAC systems with systems using refrigerants with lower global warming potential.

The emissions related to our electricity use (Scope 2) are not directly under WPI's control, but there are several indirect means to greatly impact the amount of emissions, as listed below:

- Increased energy efficiency
  - Improved HVAC system efficiency (including chiller/heater efficiency, air flow volume) and appropriate controls,
  - Appropriate and appropriately used user controls,
  - Improved lighting efficiency with appropriate controls,
  - Efficient IT and other office and lab equipment,
  - Energy-aware behavior by building occupants.
- Purchased electricity generated from low- or zero-carbon sources such as wind, solar, hydro, nuclear, some types of biomass via Purchased Power Agreements or other types of contracts. This generally requires purchase of Renewable Energy Certificates, increasing the cost of electricity.
- On-site generation of electricity from low or zero GHG means:
  - Solar PV,
  - Fuel Cells for potentially lower but non-zero GHG emissions,
  - Co-generation with combined cooling, heat, and power generation for potentially lower but non-zero GHG emissions,
  - Note that wind generation is infeasible on WPI's campus.

As mentioned previously, WPI is not considering the purchase of offsets for Scope 1 or 2 emissions.

Although WPI's tracking and reduction efforts for Scope 3 emissions have been deferred, it is worthwhile to list the reduction approaches relating to faculty, staff, and student travel:

- Reduction of usage of single occupancy vehicles via:
  - Increased use of mass transit,
  - Carpooling,
  - Walking, bike riding,
  - Consolidation of trips,
  - Telecommuting.
- Increase in efficiency of vehicles (hybrids, electrics, etc.)
- Use of biofuels
- Reduction in travel, particularly air travel, via:
  - Teleconferencing,
  - Consolidation of trips,

- Alternative transportation (train, bus).

While the above measures would be helpful, substantial reduction of net Scope 3 emissions typically requires the use of offsets. For example, student travel by air to project sites is an essential part of our educational mission for which no feasible alternative exists. Rather than purchasing external offsets, investment of equivalent resources in further reducing our Scope 1 and 2 emissions is an attractive strategy.

Building Scoping Audit

Building Selection

The cornerstone of essentially every GHG reduction plan is energy efficiency. Reduction of the amount of energy used by WPI reduces greenhouse gases, reduces the stress on the electric grid, and saves money. WPI has successfully implemented several major energy conservation efforts, targeting both electric and thermal energy. An extension of this program forms the basis for this Greenhouse Gas Reduction Plan. GreenerU, a firm with substantial experience in campus energy efficiency auditing and upgrades was engaged to continue previous work in auditing campus buildings for energy usage and efficiency upgrade potential.

The list of buildings to be audited was developed in collaboration with WPI Facilities staff, and represents about a third of WPI's total built square footage. The feasible scope of this audit limited the number of buildings that could be included but a representative selection of building types was made. Also, buildings that have been recently upgraded, will soon be renovated, or are not energy priorities were excluded. Seventeen building were identified for this study, listed in Table 1. Energy efficiency reduction opportunities were identified through walkthroughs, energy use data provided by WPI, and benchmarking of these buildings against similar buildings in the GreenerU database.

Table 1 Buildings Studied in Scoping Audit
(Note that some small residential buildings are currently used for office purposes)

Building Type	Building Name
Small residential	8 Hackfeld, 11 Einhorn, 8 Elbridge, 20 Trowbridge
Large Residential	Stoddard C (Stoddard A & B can be assumed to be equivalent), Ellsworth 1, 2, 3, Institute Hall, Founders Hall, Faraday Hall, Salisbury Estates
Administrative	Bartlett Center
Academic	Fuller Labs, Stratton Hall, Washburn/Stoddard
Athletic	Sports and Recreation Center

The buildings in Table 2 have been previously studied and upgraded.

Table 2   Buildings Recently Upgraded

Gateway I	Higgins Labs	Alden Hall
Gateway Garage	Atwater Kent	Goddard Hall
Rubin Campus Center	Morgan Residence Hall	

Partial upgrades have been performed in the following buildings listed in Table 3

Table 3   Buildings with Partial Upgrades

Sports & Rec Ctr (LEDs in gym)	Power House (electric)	Institute Hall (VFDs)
Sanford Riley (lighting)	Gateway sign (LEDs)	Founders Hall (VFDs)

The buildings/facilities in Table 4 have previously been studied in detail, but upgrade work has not been performed.

Table 4 Buildings/Facilities Previously Studied but not Upgraded

Salisbury Labs	Exterior Lighting (non-athletic)	Exterior Lighting (athletic)
Harrington Auditorium	Kaven Hall	Gordon Library

Finally, for completeness, Table 5 lists the major campus buildings that have not been studied or upgraded (other than minor improvements in some cases). All of these do represent potential upgrade candidates and should be considered in the future. In addition, a substantial number of small residential buildings remain candidates for upgrades.

Table 5   Buildings not Studied or Upgraded

Boynton Hall	Daniels Hall	East Hall
Facilities, 37 Lee St.	Higgins House	Hughes House
Jeppson House	Olin Hall	Wedge (Morgan-Daniels)
Project Center	Stratton Hall	

Campus Building Audit Results

An overall summary of the building audit results is presented in Table A-1 in the Appendix. These data provide one important input to the determination of a facilities upgrade plan that addresses four inter-related aspects:

- Greenhouse gas reduction,
- Deferred maintenance,
- Project cost, and
- Utility cost savings.

Figure 7 shows relative Energy Use Intensity (EUI) of each studied building. This is reported in kBTU per gross square foot where both electric and thermal (natural gas) energy use are converted to kBTU and combined. The variation in both overall EUI and the relative usage of thermal vs electric energy across buildings is dramatic. In general the more energy intensive buildings provide the greater opportunity for beneficial upgrades, but each situation must be considered individually.

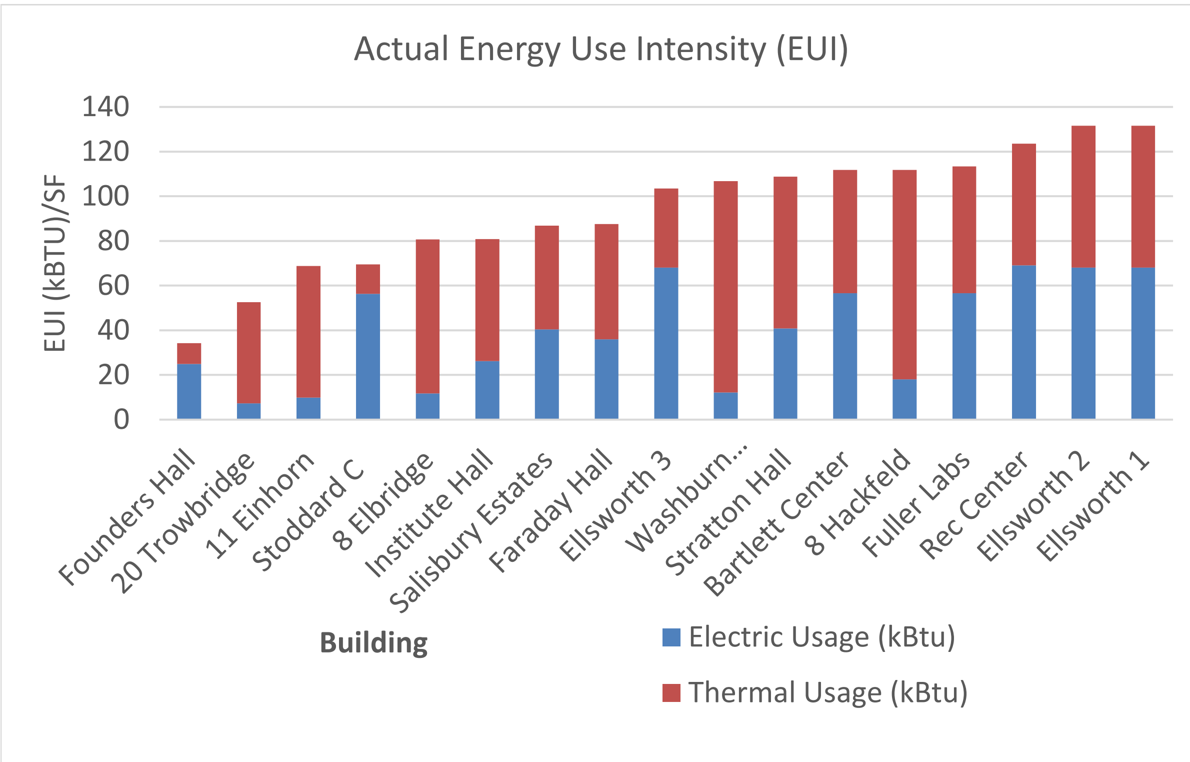

Figure 7 Energy Use Intensity of campus buildings depicting annual usage (in thousands of BTUs) for electricity and natural gas consumption. Note that some apparent discrepancies may be due to specific building activities, such as a central laundry facility, or chiller that serves multiple buildings.

The recent walkthrough audits, together with previous, non-implemented building studies, demonstrate the potential for significant savings in energy, utility costs, and greenhouse gas emissions. If completely implemented, these projects would reduce WPI's energy use by approximately 21.6 million BTU annually, or approximately 8.5% of total energy use. Further, additional buildings appear feasible for energy upgrades. Figures 8a and 8b illustrate the upgrade progress to date as well as providing a rough estimate of potentially feasible future progress, assuming the same type of upgrades that focus on HVAC controls and lighting.

The energy efficiency opportunities identified in these buildings include the following:

- Retrofit of LED Lighting,

- Intelligent lighting controls,
- Recommissioning, optimization and controls upgrades of HVAC Equipment,
- Building Envelope Upgrades (primarily reduction of air infiltration),
- Cogeneration for the Sports & Recreation Center.

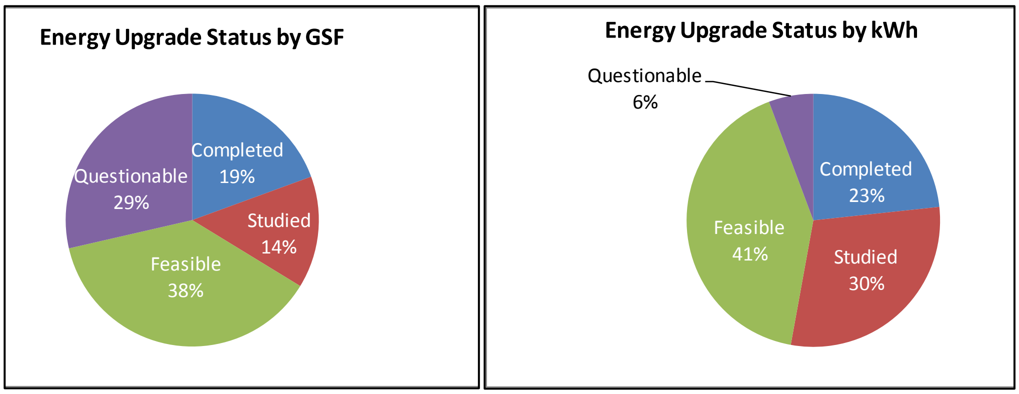

Figure 8. (a) Approximate percentages of floor space for which upgrades have been completed, studied, appear feasible, or appear questionable for upgrade. (b) Depiction of the same categories by proportion of their electricity usage.

Applying the results for actual and estimated savings from the past studies to the remaining feasible campus structures, it is possible to estimate the total energy and greenhouse gas savings that is possible via this approach. Results are illustrated in Figure 9 for electric energy. The overall chart represents the

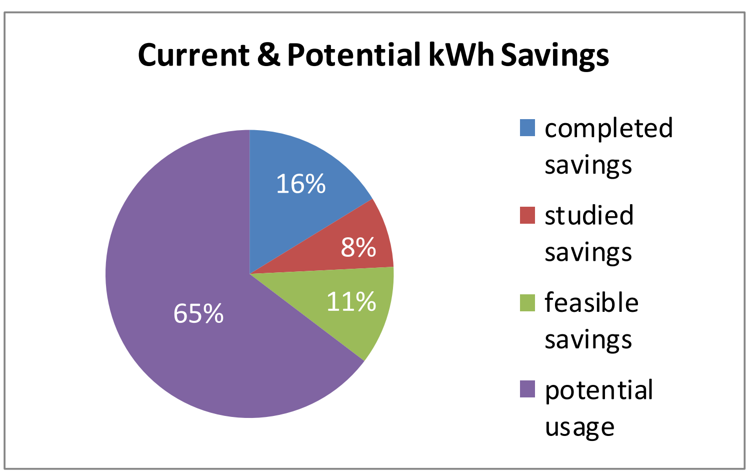

Figure 9. Depiction of WPI's overall electricity situation. The total chart area (100%) represents the electric energy that WPI would have been using if no conservation measures had been implemented. The "completed savings" portion represents the savings to date, the "studied savings" portion represents implementation of the projects at the audited buildings, and the "feasible savings" portion represents work on additional campus buildings.

amount of electric energy that we would be using with no past or future energy upgrades. The slice labelled completed savings (16%) represents electric energy that we are NOT using due to previous upgrade projects. Hence the remainder represents current usage. The slices labelled studied savings and feasible savings represent what would result from implementation of the current study results as well as extension of similar work to the remaining feasible buildings. These projects could reduce our electric energy usage by approximately an additional 19%. Similar results are possible for our thermal (natural gas) energy.

Financial Considerations

While more sophisticated financial analysis tools will be appropriate for final planning, the use of the "simple payback" measure is helpful in prioritizing projects. This factor is the result of dividing the net project cost (after any rebates or incentives) by the annual utility cost savings, resulting in the number of years required to recover the initial investment without correcting for inflation or the time value of money. The Scoping Audit provided estimates of total cost of the upgrades in each building. The net cost to WPI will in general be reduced by the amount of rebates or incentives provided by our utility companies (National Grid and Eversource). For the recently completed projects these rebates have represented as much as 60% of total project costs. This cannot be expected for all projects in the future. Based on the best information provided, rebates of 27% of installed cost are assumed in the financial estimates presented here. Figures 10, 11, and 12 provide different illustrations of costs versus impact on greenhouse gas reduction.

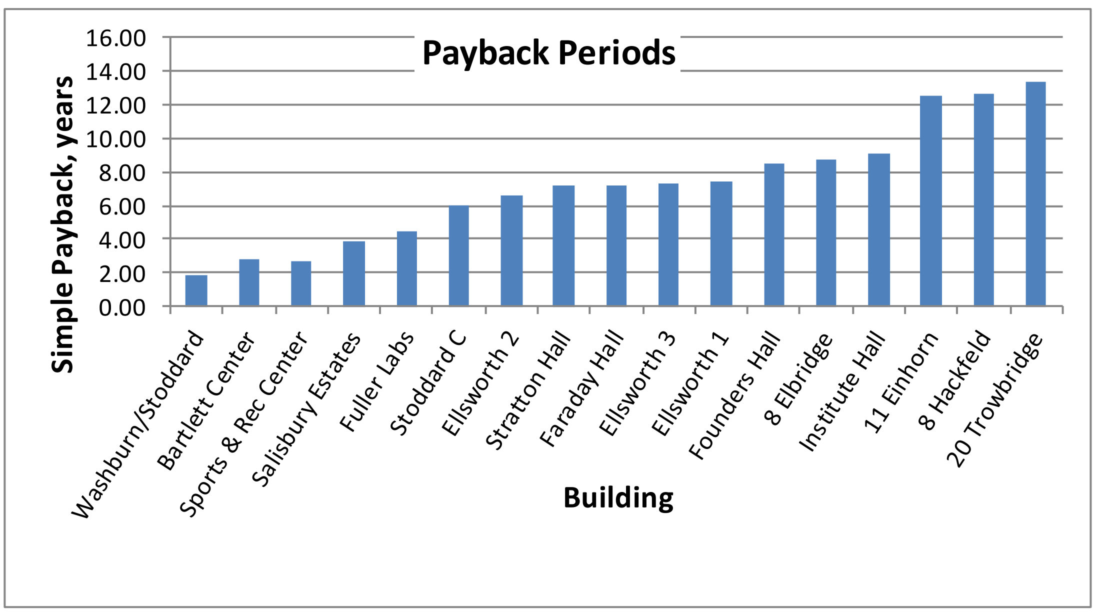

Figure 10. Simple payback periods for audited buildings, in order of increasing payback time.

Including the value of the estimated rebates, simple payback periods are seen to range from two years to about 13 years. From a purely financial viewpoint, payback periods less than approximately 5-7 years are generally considered desirable, although in some situations longer payback are appropriate to consider.

Also, financial payback is not the only consideration here; the primary goal of this work is greenhouse gas reduction while maintaining financial feasibility. Figure 11 illustrates the net project cost to WPI per

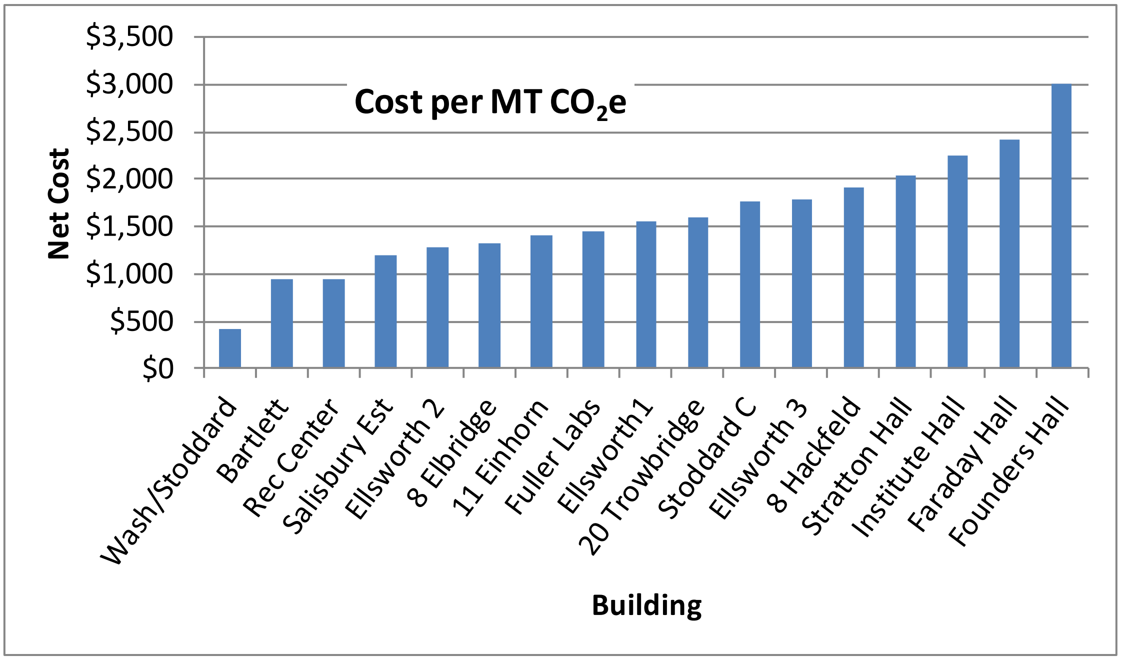

Figure 11. Net project cost to WPI (after rebates but not considering utility cost savings) per metric ton of CO2e saved for each building studied.

metric ton of CO_2e saved annually without inclusion of the utility cost savings. Comparing Figures 10 and 11 it is seen that there is a general, but not perfect, correlation between those projects with the greatest financial benefit and those with the lowest cost per metric ton of greenhouse gas saved.

Figure 12 shows the cumulative impact on greenhouse gases of implementation of conservation measures on all of the studied buildings, ordered by shortest to longest payback period. This helps to determine the implementation plan with the largest GHG impact for a particular payback period. Finally, Figure 13 illustrates the estimated savings as a function of building type. This measure does not appear to be useful in planning the upgrades since the individual building results show as large a variation among buildings within a type as among types.

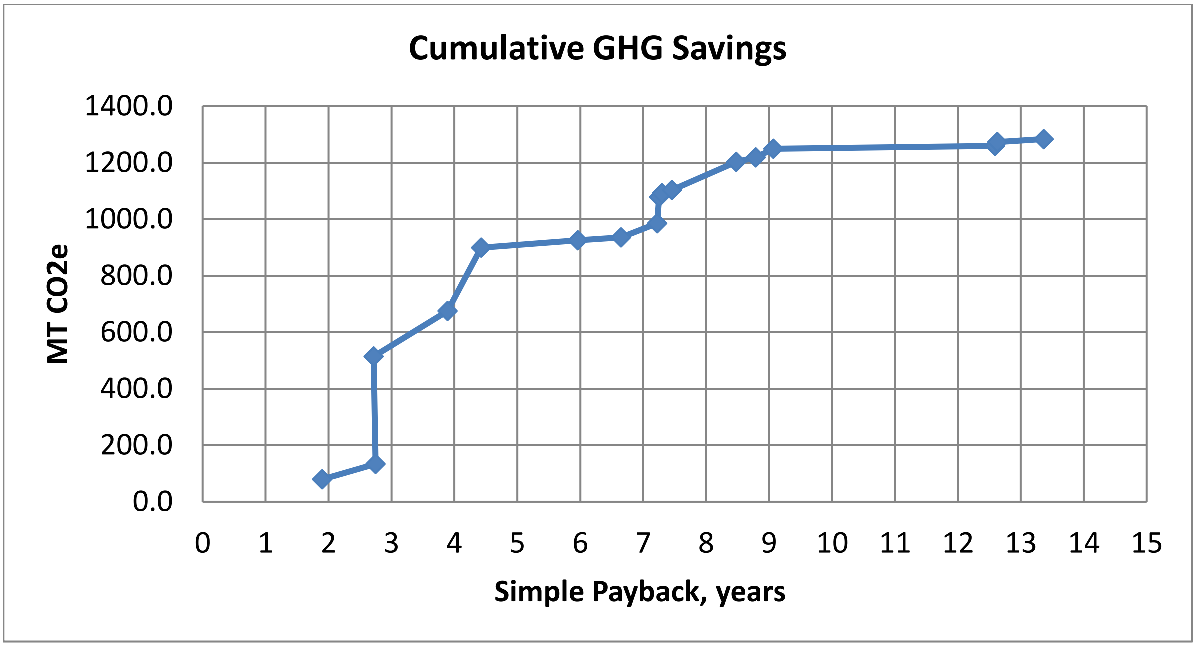

Figure 12. Total cumulative annual GHG savings achievable with multiple projects, ordered by project from the shortest payback period to the longest.

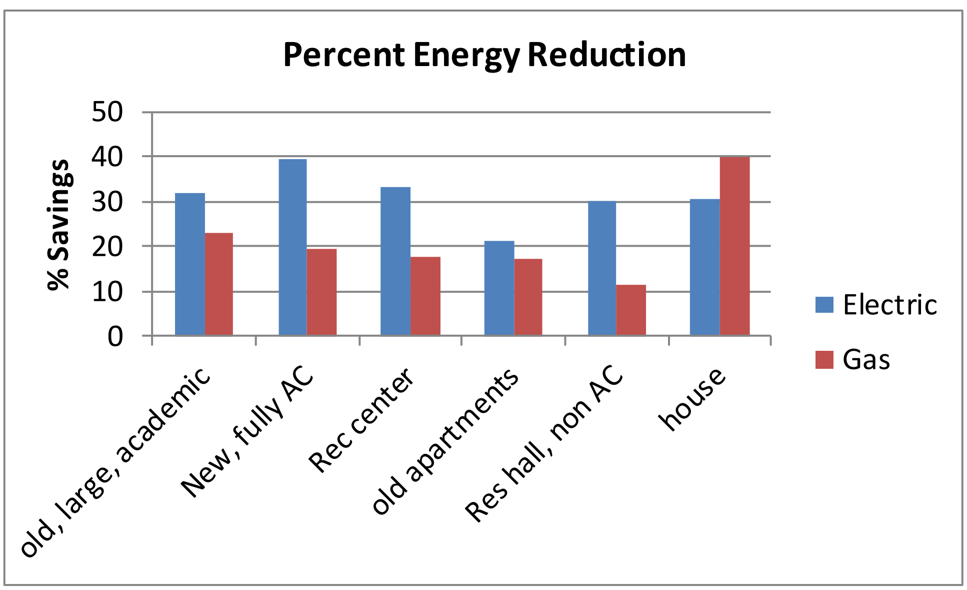

Figure 13. Variation in percent energy savings for both electricity and gas as functions of building type.

Summary of Findings

Overall results of the building walk-through audits present attractive opportunities for retrofits that will both reduce greenhouse gas emissions and reduce utility expenses. While a more detailed financial analysis for each project will be appropriate, the results demonstrate that for most, if not all, of the studied buildings, the net financial impact on WPI after inclusion of utility cost savings will be ***positive***. Hence, this greenhouse gas reduction will come at zero (actually negative) cost to WPI.

As an example, Table 6 shows a possible selection of upgrade projects over a five-year period with their net costs and annual savings. Figure 14 illustrates the cash flow, annual savings, and financial balance over an eight-year period.

Table 6 Example of Possible Annual Projects and Financial Implications

Year	Project	Net WPI Cost	Annual Savings
1	Washburn/Stoddard, Bartlett, Rec Ctr	$439,911	$166,796
2	Salisbury Estates, Fuller Labs	$516,532	$122,700
3	Stoddard C, Ellsworth 2, Stratton	$385,951	$54,800
4	Ellsworth 3, Ellsworth 1	$342,151	$41,100
5	8 Elbridge, Institute Hall, 11 Einhorn, 8 Hackfeld, 20 Trowbridge	$145,927	$14,300

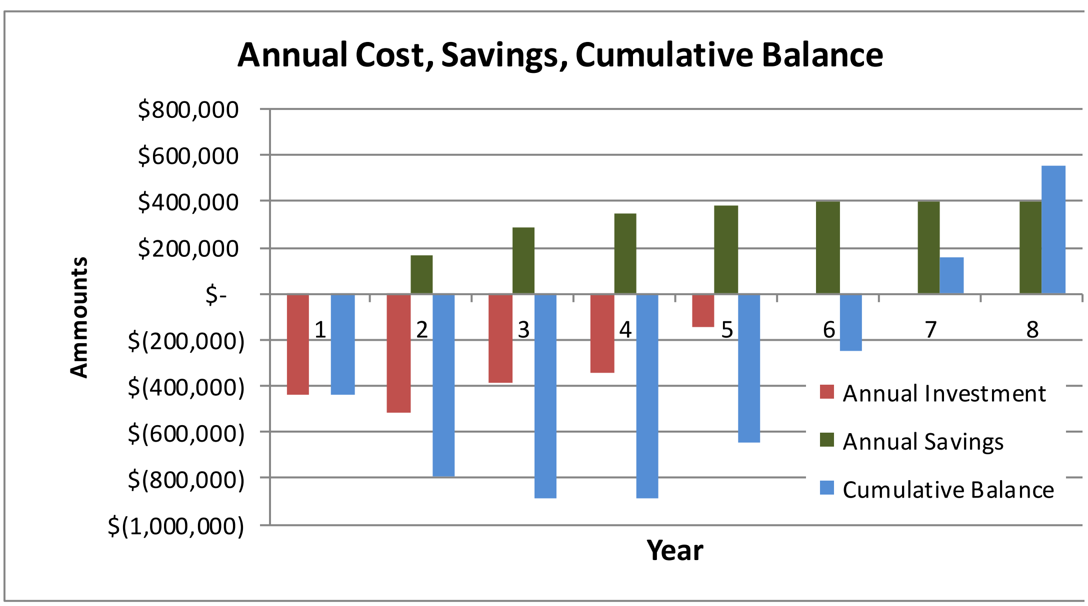

Figure 14. Illustration of one possible set of energy upgrades. Upgrades are performed in years 1 through 5 with the indicated net cost to WPI for each project. Savings from each upgrade begin to accrue in the following year and continue indefinitely. The cumulative

The selection of specific upgrades and the overall multi-year project scheduling should be made as part of the Facilities planning and budgeting processes. In addition to GHG reduction, other important factors include financial scale of the project, deferred maintenance that the project can address, and programmatic needs.

Additional Measures

Only about three quarters of one percent of WPI's Scope 1 and 2 energy use is attributable to factors other than our electricity and natural gas usage. Campus vehicles account for most of this additional energy. This fact demonstrates the value of focusing on our buildings. However, it is appropriate to consider other energy uses as well as additional means of reducing energy use in and by our buildings.

Vehicles

WPI's campus fleet of approximately 50 vehicles appears to present substantial opportunities for efficiency enhancement as vehicles are retired and replaced. Substantial limitations are imposed by the vehicles' purposes that range from landscape maintenance to police use to passenger and mail vans. However, it is recommended that the following be considered in each purchase:

- Fuel efficiency, considering both gasoline and diesel vehicles. (Note that diesel engines emit somewhat more CO_2e and significantly more of other types of pollution per gallon than do gasoline engines.)
- Hybrid vehicles, particularly for stop-and-go use such as for police, shuttle, and other passenger use
- The feasibility of an electric vehicle for the task, such as for intra-campus utility vehicles.

Another recommendation is continued attention to the "no idle" policy for all campus vehicles.

Information Technology

The WPI IT department has implemented a variety of energy and resource saving measures in the past. The following additional measures are under study:

- Increase the number of office and lab computers and other IT equipment such as printers that are automatically powered down, either to an "off" or very low power state, when not in use.
- Minimize the energy use and GHG impact of centralized servers, perhaps by moving substantial computation to the cloud. The GHG impact of this is quite dependent on the energy efficiency of the off-site computers as well as the energy source for the electricity powering those servers. In a move to the cloud, the resulting greenhouse gas emissions would be accounted as Scope 3 rather than as Scope 2 emissions.

Regarding the second item, the transfer of some of WPI's computational load to the Massachusetts Green High Performance Computing Center (MGHPC, www.mghpcc.org) in Holyoke is under consideration. Most of the center's electricity is generated by a local hydro plant, and the facility was designed to the most current and aggressive energy efficiency standards.

Community Involvement

While physical upgrades such as have been discussed will be responsible for most of the GHG reduction, the involvement of all members of the WPI community can yield significant additional savings. Some conservation aspects, such as light control, can be automated, but the support and involvement of the users of the space are important for at least four reasons:

1. To use the automated systems appropriately, rather than over-riding or tricking them,
2. To take actions that save additional energy that are not automated,
3. To consider energy and GHG conservation in purchasing decisions,
4. To report malfunctions so that the energy savings are sustained.

Recommendations

Selection of GHG Target

WPI's Vision statement for sustainability includes the following promise:

> *We at WPI will demonstrate our commitment to the preservation of the planet and all its life through the incorporation of the principles of sustainability throughout the institution.*

Attention to minimization of our greenhouse gas emissions must be part of that commitment to our planet. Rather than sign a pledge with a goal at a distant future time, we commit to immediate actions that reduce our own emissions as well as contributing broadly to minimization of global environmental and climate deterioration.

Goal and Related Commitments

WPI's goal, even as we grow in size, is to achieve a 20% reduction in gross Scope 1 and Scope 2 Greenhouse Gas emissions by FY25 relative to the benchmark year of FY14.

This goal can be achieved with implementation of the energy conservation plan presented in this report, together with small reductions due to additional efforts. To reach this goal WPI makes the following commitments:

1. WPI will strive to continue to reduce emissions at a rate that matches recent success, approximately 1.5% annually via continuation of the energy upgrade program. As has been demonstrated to date, continuation of these measures will yield net ***financial savings*** to WPI.
2. WPI will actively pursue the implementation of additional measures such as advanced energy conservation techniques, support for continued growth of "clean" electricity, and use of advanced heating/cooling technology.
3. WPI will undertake to measure and report those components of Scope 3 emissions (principally faculty/student/staff commuting and WPI-related travel) that are feasible to quantify, and to develop programs to reduce or compensate for these emissions.

4. WPI commits that its education will impart the knowledge and skills necessary for its graduates to bring about major reductions in greenhouse gas emissions through their careers.
5. Finally, WPI commits to continued support for its research programs that are advancing the scientific knowledge and the engineering implementations that will reduce greenhouse gas emissions globally.

Implementation Plan – Near Term

The following strategies are recommended for implementation in the short (1-5 year) term for Scope 1 and 2 emissions:

- Energy Upgrades
  - Continuation of the program of thermal and electric energy efficiency upgrades to campus buildings at the rate of at least one major building per year, or the equivalent in some number of smaller buildings. It is recommended that this effort be implemented via a green Revolving Fund.
  - Upgrade of exterior campus lighting with more efficient LED fixtures and appropriate controls
  - Implementation of flexible controls for athletic field lighting and possible conversion to LED fixtures to minimize energy use while providing appropriate lighting for activities.
- Complementary efforts
  - Implementation of a “Green Labs” program including education and incentives on the many ways in which energy and other resources may be used more efficiently in the laboratory environment.
  - Implementation of an ongoing monitoring system as part of the building automation systems to minimize the degradation of energy performance of buildings over time and to document the actual energy savings achieved by upgrade and conservation work.
  - Inclusion of energy efficiency considerations in all major maintenance projects.
  - Conduct of a comprehensive study of campus water use, identifying waste, leaks, and opportunities for efficiency improvements, and implementation of the results. The GHG impact will be relatively small but the water resource conservation is worthwhile in itself.
  - Implementation of building and space access policies and controls to concentrate the use of space, recognizing the dynamic nature of campus utilization, resulting in both electricity and heating/cooling savings.
  - Conduct of an ongoing education program to support behaviors that conserve energy. Numerous studies report energy reduction results in the 5% range for targeted behavioral programs, but also caution that long term effects require ongoing programs. [5, 6]
  - Implementation of a “no idle” policy for campus vehicles

- Major purchases
    - Performance of an engineering study of the potential for further reduction of energy use in our information technology equipment, and implementation of the recommendations.
    - Attention to energy use in all new equipment purchases.
    - Consideration of fuel efficiency in all campus fleet and power equipment purchases, and purchase of hybrid, electric or biodiesel vehicles where feasible,

Expected results of the implementation of this plan are shown in Figures 15 - 17. Figure 15 illustrates the situation if we end the current efficiency upgrade program and bring the Foisie Center online. This does assume that current systems and programs are maintained in good operation to avoid the upward "creep" of energy use and emissions that would otherwise occur.

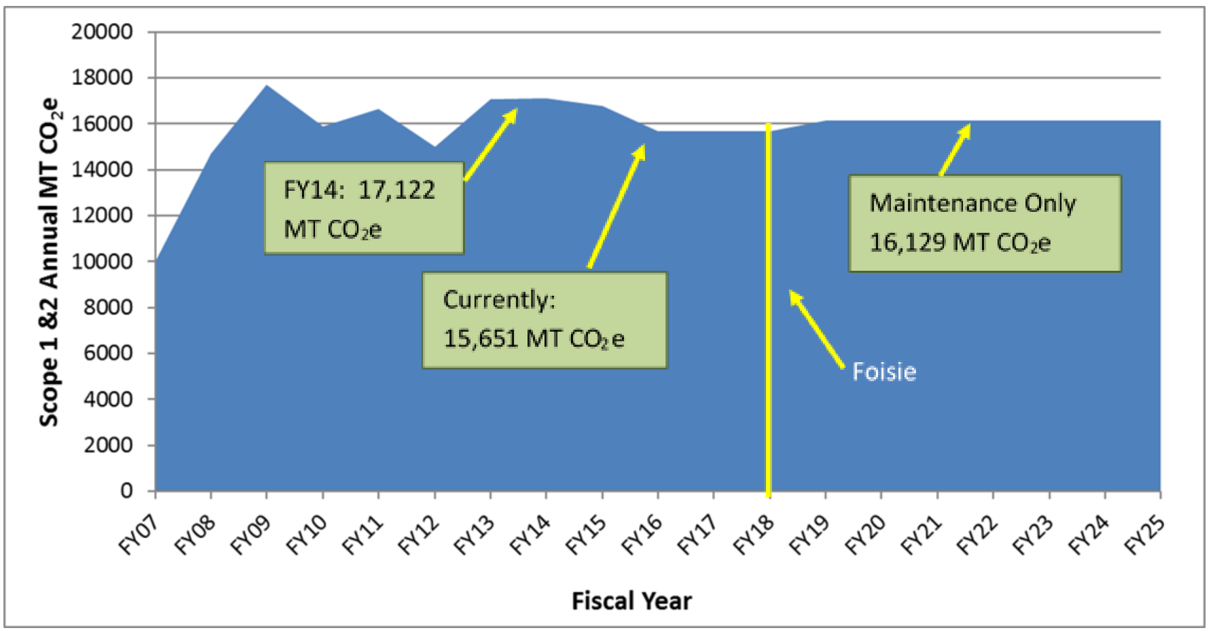

Figure 15. Scope 1 and 2 GHG emissions under a "maintenance only" plan.

The key recommendation of this plan is to continue the upgrade program at the current rate (approximately $500k investment annually) resulting in the GHG reduction shown in Figure 16. The blue area in Figure 16 represents annual greenhouse production and the red area represents greenhouse gas ***not*** produced.

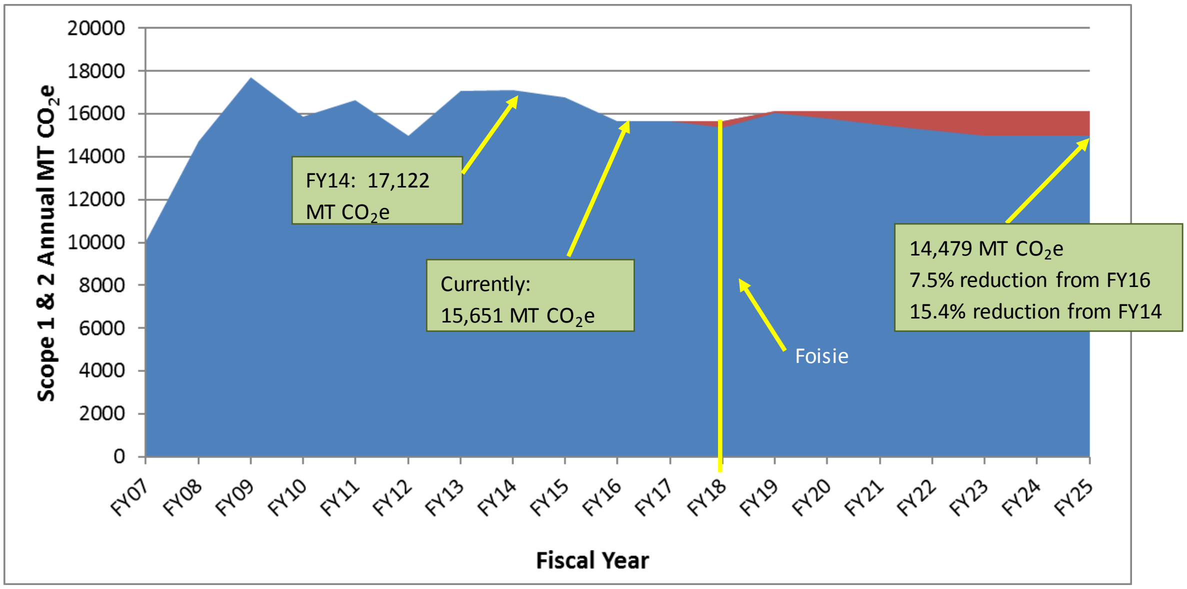

Figure 16. GHG reduction achievable with implementation of the measures identified with the current and previous building audits.

Finally, Figure 17 illustrates the further reduction possible by continuing the upgrades to the additional feasible buildings on campus, resulting in an 18.6% reduction from FY14. The additional 1.4% to reach the FY25 goal will be achieved through the other measures listed. This program can continue past the 2025 date on the chart. However, a limit will be reached, indicated by the yellow line at approximately 12,660 MT of GHG annually, when these energy conservation upgrades have been completely implemented. It is important to note that this recommended plan ***results in a positive economic benefit to WPI as well as substantial greenhouse gas reduction*** over payback periods ranging up to 13years.

Further reductions beyond the limit indicated in Figure 17 would require different approaches, including:

- Change to more efficient heating/cooling systems, such as change from steam to hot water distribution,
- Use of geothermal or air source heat pumps,
- Major upgrades to building envelopes,
- Installation of heat recovery systems on ventilation equipment,
- Change to electricity generated by zero-GHG means.

While the current energy conservation upgrade plan is yielding a net positive economic benefit to WPI, these additional measures could be expected to entail some net economic cost to WPI.

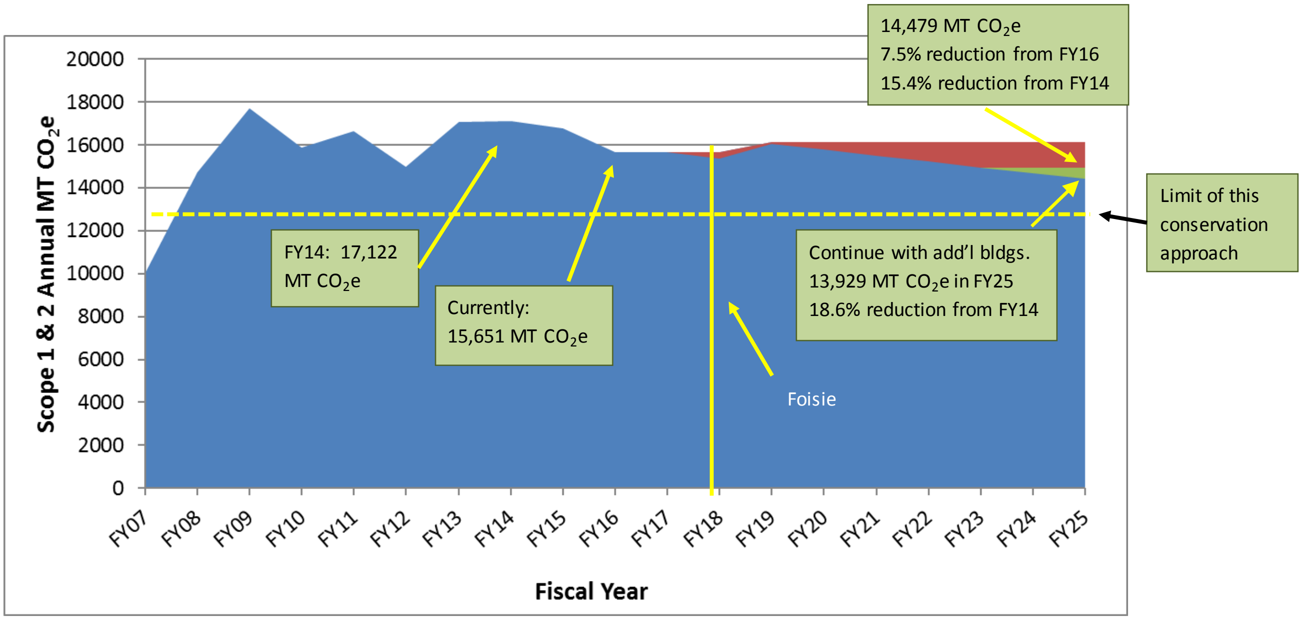

Figure 17. The green area indicates the impact of continued implementation of similar types of energy conservation measures. These may continue beyond 2025 but the limit of this approach is reached at approximately 13,000 MT CO2e emissions annually.

Longer Term Possibilities

- Implement a co-generation system to provide electricity, heat, and possibly cooling (absorption chiller) to substantially increase overall efficiency of the fuel-to-energy process. However, the impact on GHG may be minimal since the electricity from this system would be completely fossil fuel based, replacing utility electricity which has a substantial percentage of renewable generation.
- Replace the steam distribution system with a combination of individual heating plants (preferably heat pump-based) in each building and hot water distribution for those buildings remaining on a central system
- Continued attention to reduction of electric energy use, through the adoption of newer technologies as they become viable

Conclusion

WPI currently demonstrates environmental responsibility and good energy conservation practices, resulting in levels of Scope 1 and Scope 2 greenhouse gas emissions that compare well with peer institutions on both an absolute basis and normalized by building floor space and population. This report documents accomplishments to date that have resulted in a reduction in both electric and natural gas energy use and in greenhouse gas emissions. It then presents an aggressive goal for further reductions along with the specific measures to meet the goal by following the strategy that has been applied successfully to a wide range of campus buildings. Since this approach is based on energy conservation, it reduces WPI's utility expenditures and ***saves WPI net revenue*** (upgrade project costs less utility savings) over payback periods ranging from two to 13 years. WPI's implementation of the recommendations in this report will continue to demonstrate both environmental and fiscal responsibility.

Appendices

Planning team

WPI Steering Committee and Staff

- John Bergendahl, Associate Professor of Civil and Environmental Engineering
- Ryan Cooney, Student, ‘18
- Kate Hanley, Project Manager, Environmental Defense Fund
- Robert Krueger, Professor of Social Science and Policy Studies
- Martin Luttrell, Digital Communications Manager
- John Orr, Director of Sustainability
- William Spratt, Director of Facilities Operations
- Xinwen Xu, Graduate Student, Environmental Engineering

GreenerU

- Alex Davis
- Robert Durning
- Elizabeth Woodcock

Table A-1 Summary of results from Scoping Audit

Program Summary by Building

				Existing		Proposed		Savings							
	Building	GSF	Space Use	Electric kWh	Thermal kBtu	Electric kWh	Thermal kBtu	Electric kWh	Thermal kBtu	Total MMBtu	Total Cost Savings	Installed Cost	Deferred Maintenance Addressed	Simple Payback	GHG Emissions Reduction MTCO2
2016 Scoping Study	Fuller Labs	73,250	Academic	1,212,141	4,155,912	699,741	3,010,561	512,400	1,145,351	2,894	$ 73,300	$ 695,100	$ 183,100	9.5	225
	Stratton Hall	24,380	Academic	290,879	1,656,962	199,479	1,342,262	91,400	314,700	627	$ 14,200	$ 140,500	$ -	9.9	50
	Washburn ShopsStoddard Labs	42,606	Academic	151,913	4,028,823	102,413	2,925,823	49,500	1,103,000	1,272	$ 17,200	$ 470,800	$ 311,000	27.4	79
	Bartlett Center	16,200	Administration	268,078	893,592	130,151	670,192	137,926	223,400	694	$ 18,819	$ 348,300	$ 202,500	18.5	55
	20 Trowbridge	4,536	Administration	9,668	205,200	6,368	112,900	3,300	92,300	104	$ 1,300	$ 23,800	$ -	18.3	11
	Sports & Recreation Center	145,000	Athletic Facilities	2,931,400	7,887,900	1,958,560	6,507,500	972,840	1,380,400	4,700	$ 130,777	$ 1,261,600	$ 565,500	9.6	380
	11 Einhorn	3,600	Grad Housing, faculty/ staff	10,357	212,200	7,157	122,200	3,200	90,000	101	$ 1,200	$ 20,700	$ -	17.3	11
	Salisbury Estates	130,000	Grad Housing, faculty/ staff	1,537,120	6,042,990	1,212,820	5,005,990	324,300	1,037,000	2,144	$ 49,400	$ 263,300	$ -	5.3	161
	8 Elbridge	6,200	Grad Housing, faculty/ staff	21,386	427,500	17,086	246,200	4,300	181,300	196	$ 2,400	$ 28,900	$ -	12.0	16
	8 Hackfeld	3,900	Grad Housing, faculty/ staff	20,586	365,700	13,086	254,600	7,500	111,100	137	$ 2,000	$ 34,600	$ -	17.3	13
	Faraday Hall	88,000	Residence Halls	926,800	4,541,300	691,400	4,264,800	235,400	276,500	1,080	$ 31,000	$ 308,000	$ -	9.9	93
	Institute Hall	15,300	Residence Halls	117,360	834,300	73,360	623,800	44,000	210,500	361	$ 7,400	$ 91,900	$ -	12.4	30
	Founders Hall	96,994	Residence Halls	707,200	908,700	424,000	770,600	283,200	138,100	1,104	$ 35,500	$ 412,200	$ -	11.6	100
	Stoddard C	12,326	Residence Halls	203,200	161,400	142,900	116,300	60,300	45,100	251	$ 7,700	$ 62,900	$ -	8.2	26
	Ellsworth Apartments 3	5,488	Residence Halls	109,130	195,000	81,830	195,000	27,300	-	93	$ 3,300	$ 33,000	$ -	10.0	13
	Ellsworth Apartments 2	3,136	Residence Halls	62,360	199,200	46,760	199,200	15,600	-	53	$ 1,900	$ 17,300	$ -	9.1	10
	Ellsworth Apartments 1	3,920	Residence Halls	77,950	249,000	58,550	249,000	19,400	-	66	$ 2,300	$ 23,500	$ -	10.2	11
	2016 Scoping Study TOTAL	674,836		8,657,528	32,965,680	5,865,661	26,616,928	2,791,866	6,348,751	15,875	$ 399,696	$ 4,236,400	$ 1,262,100	10.60	1,284
Previously Studied, Not Implementd	Salisbury Labs	69,830	Laboratory	966,955	5,613,000	667,128	4,791,000	299,827	822,000	1,845	$ 44,323	$ 442,300			137
	Exterior Lighting (Non-Athletics)		Exterior	744,120	-	172,000	-	572,120	-	1,952	$ 68,654	$ 900,000			177
	Exterior Lighting (Athletics)		Exterior	218,750	-	43,750	-	175,000	-	597	$ 21,000	$ 450,000			54
	Previously Studied TOTAL	69,830		1,929,825	5,613,000	882,878	4,791,000	1,046,947	822,000	4,394	$ 133,977	$ 1,792,300		-	368
	TOTAL Campus Opportunity	744,666		10,587,353	38,578,680	6,748,539	31,407,928	3,838,813	7,170,751	20,269	$ 533,673	$ 6,028,700	$ 1,262,100	10.60	1,652

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