Leading By Example: Towards Our Targets

Measuring Progress on Executive Order 484

Massachusetts Department of Energy Resources

October 2014

About This Report

This report documents the progress made by Massachusetts State government in meeting the targets set forth in Governor Deval L. Patrick's Executive Order No. 484, issued in 2007.

This report tracks ten years of progress and achievements for a state portfolio that includes over 80 million square feet of buildings, 3,000 vehicles, employs more than 85,000 people, and is made up of hospitals, college and university campuses, prisons, visitor centers, state parks, roads and tunnels, airports, dams, waste water treatment facilities, and dozens of other property types.

The report also highlights many state government agency and campus accomplishments, ranging from specific improvements implemented at particular facilities to broader programs implemented across a broad portfolio of buildings and campuses.

The report uses energy, fiscal and project data from a variety of sources as well as examples of projects and programs to paint a picture of the hundreds, if not thousands, of efforts that have taken and continue to take place across an extraordinarily, diverse set of operations.

Acknowledgements

The Leading By Example (LBE) Program extends its gratitude to the members of the LBE Council for lending their time and expertise to provide critical feedback, and for their ongoing efforts to support clean energy and environmental initiatives across hundreds of state facilities.

A special thanks to the many state officials who have recognized the importance of leadership and provided critical support to the LBE Program along the way. These include current Executive Office of Energy and Environmental Affairs (EEA) Secretary Maeve Vallely Bartlett and Undersecretary for Energy Mark Sylvia, Acting Commissioner at the Department of Energy Resources (DOER) Meg Lusardi, Commissioner at the Division of Capital Asset Management (DCAMM) Carole Cornelison, as well as former EEA Secretary Ian Bowles and Secretary Rick Sullivan, and former DOER Commissioner Phil Giudice.

We would also like to acknowledge all former and current LBE Program staff, including Janet Curtis, Jillian DiMedio, and Charlie Tuttle for their work with LBE Program and this report; Hope Davis, Jenna Ide, and the DCAMM Energy team for their work and documentation on energy efficiency projects and investments at state facilities; the DOER Energy Markets team and Sharon Weber (Massachusetts Department of Environmental Protection) for their technical expertise and review of various chapters.

The report also greatly benefited from the work of all our past interns who helped support the LBE team.

Finally, special recognition goes to the DOER team that managed the process, and researched, wrote, edited and designed this report: Meg Lusardi, Eric Friedman, Lisa Capone, Maria Andrea Hessenius, Maggie McCarey and Jane Pfister.

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October 20, 2014

Dear Residents of the Commonwealth,

Massachusetts is pursuing a nation-leading clean energy agenda—from legislation passed and signed into law by Governor Deval Patrick, to our nation-leading utility efficiency programs, renewable energy growth and our first-in-the-country regional market for electricity sector greenhouse gas emissions—the Commonwealth is leading the way in securing our cleaner energy future.

One catalyst for our clean energy leadership is Executive Order No. 484: Leading By Example—Clean Energy and Efficient Buildings. Through this order, the Commonwealth has invested in clean energy programs and practices to reduce greenhouse gas emissions, increase energy efficiency, reduce energy costs and increase renewable energy generation at myriad state facilities. When Governor Patrick signed E.O.484, the Commonwealth managed over 64 million square feet of buildings, representing hundreds of facilities that annually consumed over one billion kilowatt hours of electricity, 22 million gallons of heating oil, and 46 million therms of natural gas.

E.O. 484 led to the creation of the Leading By Example Program, which is housed in the Department of Energy Resources and has achieved impressive results through collaboration among state agencies, campuses, and authorities. Greenhouse gas emissions are down by 25 percent over the past decade, despite a 10 percent increase in the size of the state building portfolio. The installed capacity of solar photovoltaic systems at state facilities has increased 70-fold, from 100 kilowatts in 2007 to more than seven megawatts in 2013, while wind energy installations at state facilities have increased 18-fold, from 600 kilowatts installed in 2007 to more than 10 megawatts in 2013. Meanwhile, the use of fuel oil to heat state buildings is down by more than 16 million gallons since 2006 (a 72 percent reduction), and the executive order's directive to construct more energy efficient buildings has yielded 33 LEED-certified buildings in the state's portfolio, 21 of them at the hard-to-achieve Gold rating and one at the even higher Platinum level. These and other efforts have helped to avoid energy costs of more than $93 million from 2007–2012 across state government, resulting in significantly lower energy bills for Commonwealth agencies.

The greenhouse gas impacts, deployment of new technologies, significant energy savings and other benefits of the Leading By Example program will continue for years to come, thanks to dedication, vision, and leadership at state agencies, campuses, and authorities. The impressive results highlighted in this report illustrate how state government is leading the way down the path toward a cleaner energy future for all Commonwealth residents.

Sincerely,

Maeve Vallely Bartlett
Secretary

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Executive Summary

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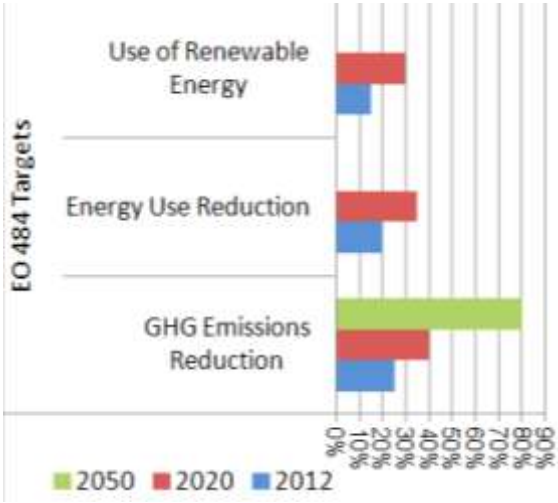
An integral component of the Patrick Administration's clean energy agenda, the Leading By Example Program (LBE) is dramatically advancing Massachusetts state government's use of technologies and strategies that save energy and water resources, increasing the deployment of renewable energy, and reducing greenhouse gas (GHG) emissions in support of the Commonwealth's efforts to address climate change.

Established in April 2007 by Governor Deval Patrick's Executive Order 484 (E.O. 484), "Leading by Example—Clean Energy and Efficient Buildings," LBE applies to all Massachusetts' Executive branch agencies, public institutions of higher education and the Massachusetts Trial Court—entities that own 80 million square feet of buildings, utilize 3,000 vehicles, employ more than 85,000 people, and include all 29 of the Commonwealth's public colleges and universities. Several independent authorities also voluntarily participate in LBE efforts. As the largest energy user among all sectors of the Massachusetts economy, state government consumes over one billion kilowatt hours (kWh) of electricity, emits over one million metric tons of greenhouse gases, and spends over $250 million on energy each year.

Working through various initiatives, LBE strives to reduce the overall environmental impacts of state government operations through adoption of practices that reduce energy use and GHG emissions, and promote waste reduction, water conservation, green buildings, alternative fuels, efficient transportation, and recycling.

In the short run, E.O. 484 directed state government to reduce its GHG emissions by 25 percent, cut energy consumption (per square foot and weather normalized) at state facilities by 20 percent, and increase use of renewable energy to 15 percent of all state government electricity consumption by 2012. By 2020, the E.O. 484 envisions expansion of those goals to 40, 35, and 30 percent, respectively. In addition, it calls for all new state buildings and major renovations to meet a "Massachusetts LEED Plus" standard that requires LEED (Leadership in Energy and Environmental Design) certification by the US Green Building Council, as well as energy performance 20 percent better than the Massachusetts energy code.

Executive Order No 484 called for greenhouse gas emission reductions at state facilities of 25 percent by 2012, 40 percent by 2020, and 80 percent by 2050.



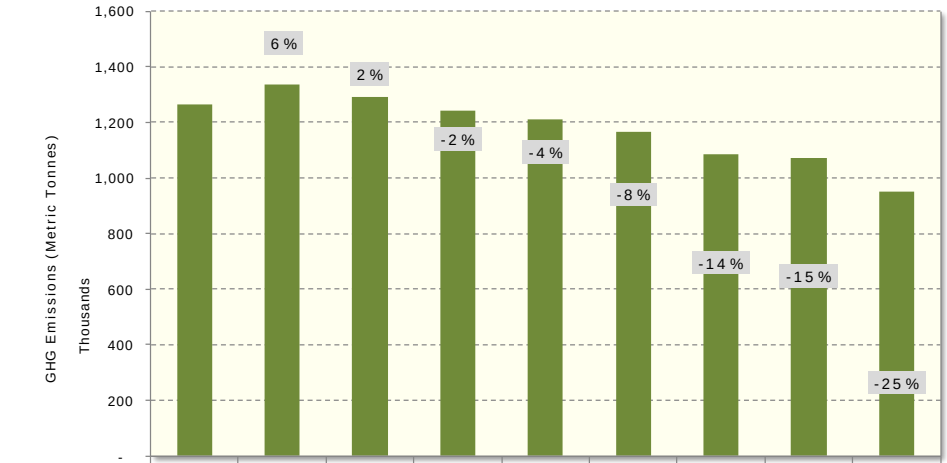
In setting this high bar just three months after taking office, the Governor challenged state agencies and employees to be pacesetters for the rest of Massachusetts—asking state government to not just "talk the talk," but to decidedly "walk the walk" toward his vision of a clean energy future. Six years later, LBE has clearly moved beyond its initial charter—sparking a clean energy revolution throughout multiple levels and agencies of state government.

With efforts ranging from large-scale energy efficiency initiatives and significant wind and solar power installations to fuel switching and replacement of conventional light bulbs with highly -efficient LED technology, LBE continues to make progress in meeting the original goals of E.O. 484, but it also transcends them—catalyzing a sea change in the way the state thinks about, conducts and powers its business.

On its way to instituting a "new normal" for state government operations, LBE has already achieved significant results. To name a few, these include:

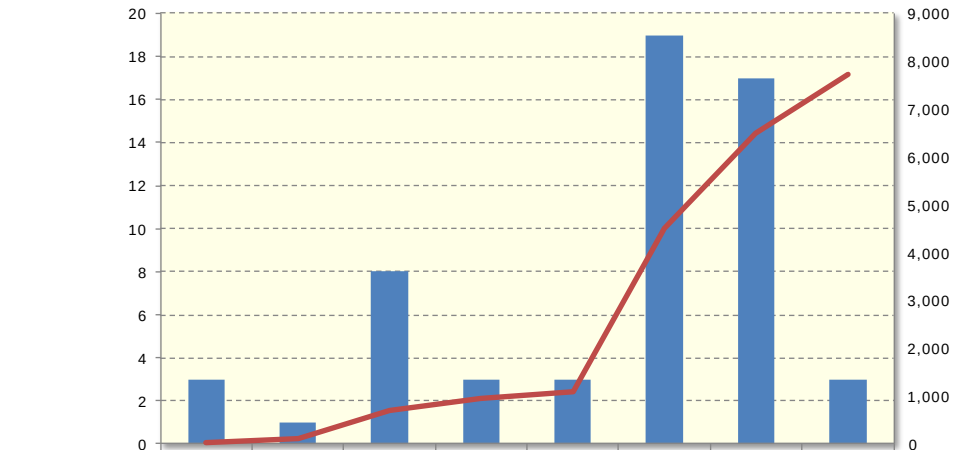
- reducing GHG emissions by 25 percent from the LBE Baseline (the average from FY02 through FY04) to FY12;
- increasing the amount of installed solar photovoltaic (PV) at state facilities from 100 kilowatts (kW) in 2007 to more than 7 megawatts (MW) in 2013;
- increasing the amount of installed wind energy at state facilities from 660 kW in 2007 to over 10 MW in 2013 (an 18-fold increase);
- reducing the use of fuel oil to heat state buildings by over 16.7 million gallons since 2006 (a 72 percent decrease), with eleven agencies or campuses ceasing all heating oil use and nine reducing it by at least 50 percent;
- increasing state government's reliance on clean, on-site generated electricity (including combined heat and power (CHP), solar PV, hydro, wind, and anaerobic digestion) to some 210 million kWh of clean electricity in fiscal year 2012, approximately 15 percent of the total electricity consumption at state facilities; and
- constructing 33 LEED certified buildings (one achieving Platinum rating and 21 achieving a Gold rating), with at least 30 more pending building projects registered with the LEED Program.

Not surprisingly, Massachusetts state colleges and universities are among LBE's brightest stars. The 29 state college and university campuses (producing approximately 41 percent of state government's GHG emissions) have reduced their emissions by some 26 percent since the Program began. This achievement—occurring against the backdrop of expanded square footage, hours of operation and enrollment in the state higher education system—was led by the state's flagship campus, the University of Massachusetts Amherst (UMA). The single largest energy user among all LBE partners and responsible for 11 percent of all state government GHG emissions, UMA cut its GHG emissions by 34 percent as of June 2012—exceeding the 25 percent E.O. 484 reduction goal.



	Baseline	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12
Total GHG Emissions	1,265,350	1,335,159	1,292,331	1,243,143	1,212,582	1,164,969	1,086,862	1,071,977	950,904
% Difference from Baseline	0%	6%	2%	-2%	-4%	-8%	-14%	-15%	-25%

Figure 4: *Annual Change in GHG Emissions, Baseline Year to FY12*
Overall GHG emissions have decreased 25 percent from the LBE Baseline through FY12, reducing overall emissions by some 314,000 metric tons. (also on page 11)



	2006	2007	2008	2009	2010	2011	2012	2013
Installations	3	1	8	3	3	19	17	3
kW Installed	37	118	692	952	1,100	4,519	6,504	7,714

Figure 19: *Growth in Solar PV Installations at State Facilities since FY06*
Solar PV installations have multiplied throughout the Commonwealth since the executive order was signed, with over 53 installations to date. (also on page 35)

Transforming its energy portfolio has benefitted UMA's bottom line; replacing the university's old coal-fired power plant with a 10 MW combined heat and power system has reduced the campus' purchase of grid-based electricity by over 60 percent throughout state government, as the smart investment and leveraging of public funds is making the Commonwealth's operations not only cleaner and "greener," but also leaner and more self-reliant. For example, over the past five years, the Division of Capital Asset Management and Maintenance (DCAMM) has initiated $265 million worth of clean energy projects, while supporting Massachusetts companies and jobs. In addition, the Department of Energy Resources (DOER) invested $24.6 million from the American Recovery and Reinvestment Act (federal funding that was unforeseen when LBE launched) in state facility energy efficiency and renewable energy projects estimated to yield $200 million in lifetime cost savings.

Since 2006, installed solar PV at state facilities has increased from 100 kW to 7.5 MW, use of fuel oil has been reduced by 72 percent and 33 LEED certified buildings have opened.

As the Commonwealth has sped up the pace of energy efficiency and clean energy projects at state facilities in support of E.O. 484, it has utilized a new, innovative financing plan that relies on general obligation bonds—the least expensive source of state financing—to support projects that pay off their financing debt through energy savings. Enabling the Commonwealth to ramp up energy efficiency investments at state-owned facilities, the Commonwealth Clean Energy Investment Program has provided $136 million in financing for 21 projects across 15.3 million square feet of state buildings, with an estimated annual energy savings of $14.3 million.

The pages that follow highlight many of these and other projects, along with individual agency efforts that combine to address the overall goals and targets of the Governor's 2007 Executive Order. The results detailed in this report also set the stage for the next phase of LBE, as the work performed so far has laid the groundwork for a large number of additional projects that are now underway. Through its Accelerated Energy Program, for example, DCAMM expects by the end of 2014 to have energy projects completed or in progress across more than 50 million square feet of state buildings —with a goal of reducing energy use, costs, and emissions by at least 25 percent. All applicable state facilities will have been upgraded or audited during 2007-2014. This and other initiatives on the horizon promise to maintain the momentum sparked by E.O. 484, leading to even greater progress toward the Commonwealth's clean energy goals in the years ahead.

1 Introduction

In April 2007, Governor Deval Patrick issued Executive Order 484, titled "Leading by Example—Clean Energy and Efficient Buildings," ushering in a new era in Massachusetts state government operations. Laying out aspirational goals for state agencies and facilities from prisons and college campuses to state office buildings and public hospitals, Executive Order No. 484 (E.O. 484) established a culture of clean energy and environmental stewardship throughout state government. Aimed at reducing state government's environmental footprint, while transitioning the Commonwealth away from over-dependence on fossil fuels, programs and policies adopted under E.O. 484 are stabilizing the Commonwealth's energy costs and contributing to its energy independence and resiliency.

Through greater use of on-site renewable energy and aggressive energy efficiency efforts, state agencies and facilities are blazing a new path—away from reliance on grid-based electricity and out-of-state (and often out-of-country) fossil fuel sources for heating and toward locally-based energy self-sufficiency. The Leading By Example (LBE) Program created by E.O. 484 also supports a burgeoning clean energy economy that saw job growth of 11.8 percent in 2013, the 2nd straight year of double digit increases in employment.

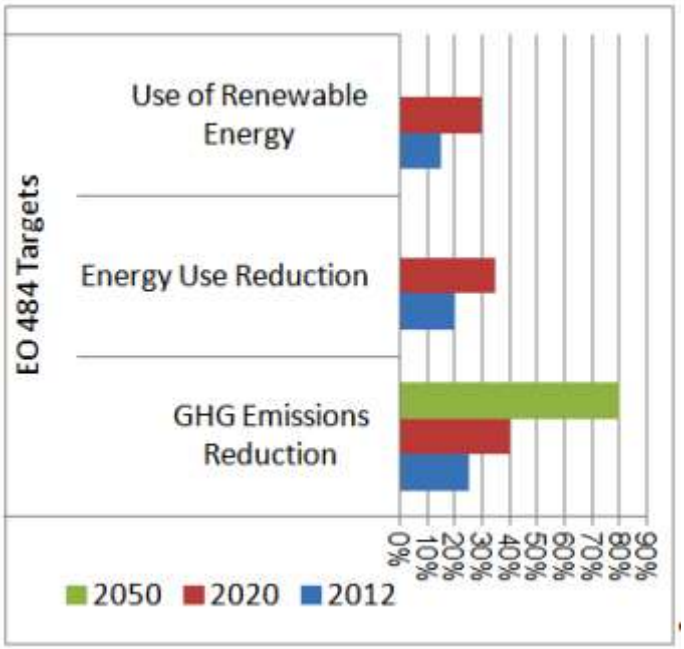
A Massachusetts Clean Energy Center survey shows that there are more than 88,000 employees working in the clean energy sector across Massachusetts, up from 60,274 just four years earlier.

The construction of large solar arrays and wind turbines at college campuses, correctional facilities and other state-owned properties is also setting an example that is bolstering the Commonwealth's ongoing renewable energy revolution. Just over 3 megawatts (MW) each of solar and wind power existed across Massachusetts when the Governor took office. As of September 2014, the state's installed renewable energy capacity has grown to more than 664 MW of solar and over 106 MW of wind power—with significant installations at state facilities from Cape Cod to the Berkshires.

The LBE Program collaborates with all Executive Branch agencies, the 29 state college and university campuses, Massachusetts Trial Court facilities, and several independent authorities (see page 17 for full list of LBE Partners). Encompassing 80 million square feet of building space, operation of some 3,000 vehicles, and employing over 85,000 people, state government is the largest single user of energy in the state. LBE's reach extends to a wide range of facilities and operations, including dormitories and labs, large office complexes, public hospital and health facilities, hundreds of state parks and highway depots, dozens of courts, and thousands of passenger vehicles, vans, and light duty trucks. Spending over $250 million on energy annually, these LBE partners consume over 1 billion kWh of electricity and emit over one million metric tons of greenhouse gases each year.

In an effort to rein in that environmental impact, E.O. 484 set bold targets to:

- Reduce energy use (normalized by weather and square footage) 20 percent by 2012 and 35 percent by 2020
- Obtain 15 percent of total electricity consumption from renewable sources by 2012 and 30 percent by 2020
- Reduce GHG emissions 25 percent by 2012, 40 percent by 2020, and 80 percent by 2050.



Mass. LEED Plus Requirements

- LEED Certification
- 20 percent better energy performance than the state building code
- 3rd party commissioning
- 50 percent outdoor and 20 percent indoor water reduction over baseline projections

Also under the order, all new state construction or major renovation projects must meet a "Massachusetts LEED Plus" (Mass. LEED Plus) standard, which requires LEED certification by the U.S. Green Building Council and energy performance that is 20 percent better than required by the Massachusetts building energy code (for all projects greater than 20,000 square feet).

A number of additional programmatic goals are also included in E.O. 484, such as the purchase of energy efficient products, conservation of potable water, use of bioheat (generally a combination of bio based fuel with petroleum fuel) in place of #2 heating oil, deployment of innovative technologies, development of an energy efficiency training and maintenance program, installation of energy efficiency HVAC equipment, and implementation of low-cost financing to maximize the number of energy efficiency projects the state can afford to undertake.

Spearheaded and implemented by DOER's LBE staff, in close collaboration with Division of Capital Asset Management and Maintenance (DCAMM), the LBE Program is jointly overseen by the Executive Offices of Energy and Environmental Affairs (EEA) and Administration and Finance (ANF). In addition, support and advice is provided by a LBE Coordinating Council that meets six times yearly. The Council comprises agencies that own or operate a significant portion of the Commonwealth's facilities, including state colleges and universities and the Departments of Conservation and Recreation (DCR), Correction (DOC), Transportation (MassDOT), and Public Health, as well as those responsible for managing related sustainability programs such as the Department of Environmental Protection (MassDEP) and the Operational Services Division (OSD) (the state's purchasing office).

This report reviews the impacts associated with hundreds of projects and programs that have been undertaken since the executive order was issued, documents trends over the past 10 years, provides information on key programs and agencies that have resulted in significant progress toward the E.O. 484 targets and highlights more recent efforts that are expected to result in even greater progress over the next several years.

The remainder of this report is divided into seven major sections:

- Data Collection and Analysis—Summary
- Reducing Greenhouse Gas Emissions
- Reducing Energy Consumption
- Increasing Renewable and On-Site Energy Generation
- Energy Costs
- Other LBE Efforts
- Conclusion and Future Efforts

In addition, there are subsections throughout that address data trends and progress toward the relevant E.O. 484 targets and describe of the major programs/efforts undertaken.

2 Data Collection and Analysis—Summary

Although E.O. 484 was signed in 2007, many state government entities began tracking energy data several years earlier, in 2002. Annual data provided in this document are reported by Massachusetts government fiscal year, which begins each July 1. Data related to the executive order targets are based on data from fiscal years 2002 through 2012. This report includes energy consumption, renewable energy generation, GHG emissions and cost data from a variety of sources, including:

- Data reported directly by agencies and campuses to LBE staff;
- information from statewide contract vendors;
- fiscal data from the state accounting system (Massachusetts Management Accounting and Reporting System, or MMARS);
- MassEnergyInsight, the online energy consumption tracking database funded by DOER's Green Communities Division;
- Enterprise Energy Management System (EEMS), DOER's real-time metering system installed at 25 million square feet of state buildings; and
- renewable generation from the Massachusetts Production Tracking System.

See pages 46 through 49 for more details related to data sources and tracking protocols.

Of Massachusetts state government's more than 100 agencies, campuses, boards, and commissions, the LBE Program has identified 49 agencies and campuses that make up more than 95 percent of the government's environmental footprint and this report covers the data from those entities. A full list of covered agencies and campuses can be viewed on pages 17 and 29. It should be noted that some agencies, such as the Bureau of State Office Buildings (now part of the DCAMM) manage buildings and operations for multiple smaller agencies.

Additionally, county sheriffs' offices are not included in this report due to the lack of available energy data back to FY02 for those facilities. All 29 public higher education campuses are included in this report, as are two non-executive agencies that voluntarily participate in the LBE Program—the Massachusetts Port Authority (MassPort) and the Massachusetts Water Resources Authority (MWRA).

Viewed in the aggregate, data from LBE Program participants clearly show that state government has already shifted toward the vision of sustainability embodied in E.O. 484—a significant accomplishment in light of the Commonwealth's growing portfolio of buildings and expanded hours of operation at many campuses and agencies. The sections below provide detailed information on LBE partner progress. Resulting from a clean energy investment of more than $300 million[1] at hundreds of state sites since 2007, overall GHG emissions associated with state government operations have decreased every year over the same period. There has also been steady growth in the installation of on-site clean power, including a 60-fold increase in solar photovoltaic (PV) and significant progress in replacing dirty fuels such as coal and fuel oil with renewable energy, CHP facilities, and much cleaner burning natural gas.

Overall, data tracking and analysis by the LBE Program indicates a clear pattern: the Commonwealth is advancing in the right direction—"walking the walk" in terms of clean energy, energy efficiency and sustainability, as envisioned by the Governor's Executive Order.

[1] Based on an independent analysis of DCAMM energy projects implemented between 2008 and 2012 the average payback of these projects was approximately 13 years.

LEED Buildings

LBE partners with buildings currently LEED certified and their respective certification levels.

Agency	Project Name	Certification Level
Bridgewater State University	Crimson Hall	Silver
Bridgewater State University	Marshall Conant Science Building	Silver
Bridgewater State University	Pope Hall	Silver
Bridgewater State University	Scott Hall	Silver
Bunker Hill Comm. College	Health & Wellness Center	Gold
Cape Cod Comm. College	Lyndon P. Lorusso Applied Technology Building	Gold
Dept. of Environmental Protection	Senator William X. Wall Experiment Station	Platinum
Dept. of Fire Services	Expansion / Firefighting Academy	Gold
Dept. of Mental Health	Worcester Recovery Center and Hospital	Gold
Dept. of Youth Services	Girls Facility, Zara Cisco Brough Center	Silver
Fitchburg State University	Mara Village Building 8	Silver
Framingham State University	North Hall	Gold
Greenfield Community College	Core Renovation / Main Building	Gold
Mass. College of Art & Design	Kennedy Campus Center	Gold
Mass. Maritime Academy	Cadet Housing, Companies 1 & 2 additions	Gold
Massachusetts Military Division	Methuen Readiness Center	Silver
MassPort	Terminal A, Logan International Airport	Certified
North Shore Comm. College	Health Professions & Student Services Building	Gold
Salem State University	Marsh Hall	Gold
Trial Court	Fall River District Courts	Gold
Trial Court	J. Michael Ruane Judicial Center (Essex County Juvenile Court)	Gold
Trial Court	Taunton District Court	Gold
UMass Amherst	Campus Police Station	Gold
UMass Amherst	College of Natural Sciences Research & Education Greenhouse	Gold
UMass Amherst	George N. Parks Minuteman Marching Band Building	Gold
UMass Amherst	Hampshire Dining Commons	Gold
UMass Lowell	UMass-ETIC	Gold
UMass Medical School	Albert Sherman Center	Gold
UMass Medical School	Ambulatory Care Center	Silver
UMass Medical School	UMass Memorial Medical Center-Ophthalmology	Silver
UMass Medical School	MBL Research & Administration Building	Silver
Worcester State University	Dowden Hall	Gold
Worcester State University	Helen G. Shaughnessy Administration Building	Gold

3 Reducing Greenhouse Gas Emissions

Overview

The Patrick Administration and state lawmakers began collaborating in 2007 on a suite of clean energy bills which, when signed into law the following year, would recast the state's energy future. Against this backdrop, Governor Patrick's E.O. 484 set aggressive greenhouse gas (GHG) emission reduction targets for state government, challenging the Commonwealth to "lead by example" by reducing state government emissions by 25 percent by 2012, 40 percent by 2020, and 80 percent by 2050.

State Government's emissions profile has changed dramatically over the past decade. Just a few years prior to the issuing of E. O. 484, the majority of emissions came from grid electricity, with oil, coal and natural gas emitting the vast majority of the remaining emissions. Fast forward to 2012, and the share of emissions from grid electricity have decreased slightly, despite an increase in square footage, mainly due to the switch to cleaner on-site electricity production from renewable energy and CHP. Meanwhile emissions from coal have been

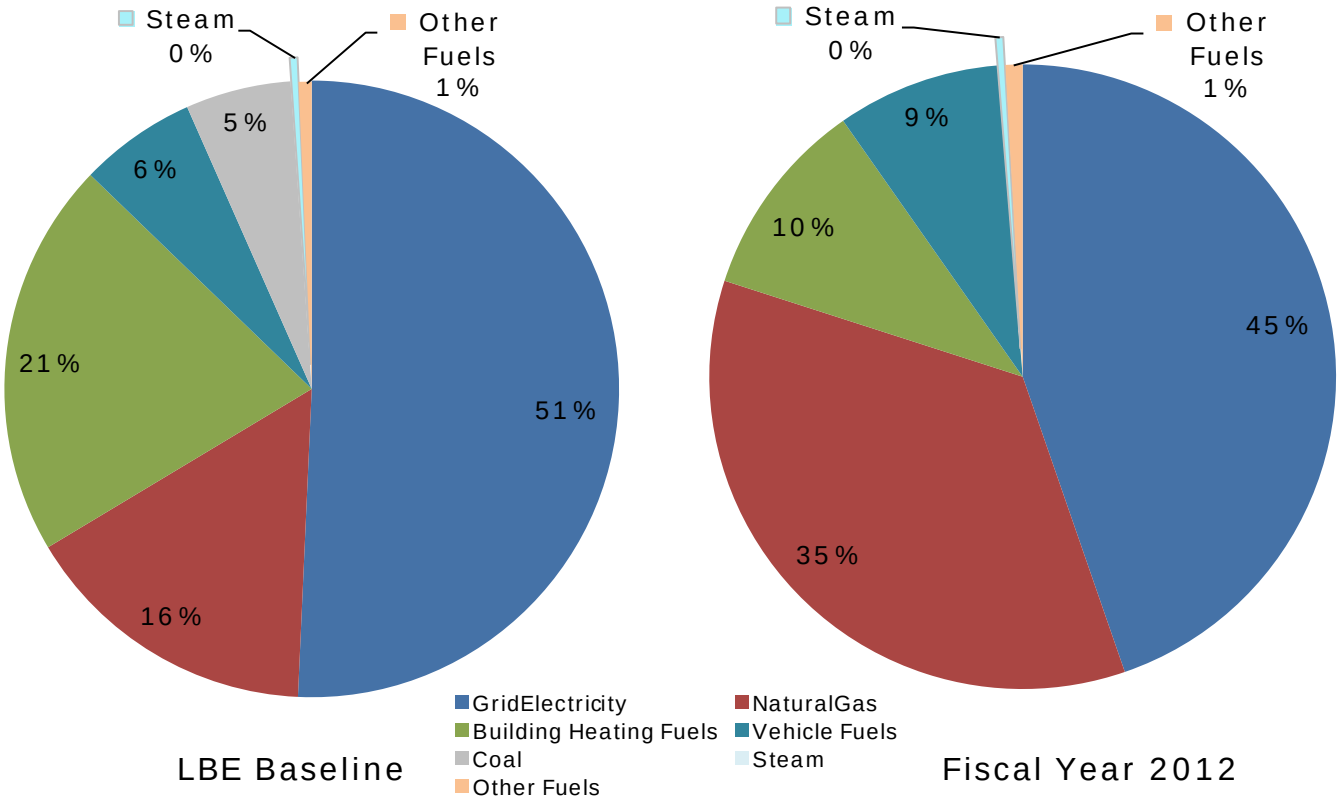


Figure 1: State Government Greenhouse Gas Emissions Sources—Baseline vs. FY12
The greenhouse gas (GHG) emissions profile for state facilities has changed since the baseline, with significantly lower emissions from coal and oil, and increases in emissions from natural gas. Although less than 1% of emissions are from steam in both charts, no emissions came from coal in FY12.

eliminated and those from oil have been more than halved, both displaced by a significant increase in the use of cleaner burning natural gas. Efficiency efforts across millions of square feet of state buildings have also contributed to slowing the growth in some fuels and dramatically reducing consumption of others.

While the fuel source of emissions has changed, the share of emissions from each category of LBE partners has remained relatively constant. The pie chart (on right) illustrates that the five UMass campuses, 15 community colleges and nine state universities together contribute 40 percent of total emissions, while MassPort and the MWRA make up nearly 20% of total emissions. The remaining 13 agencies—including public safety, environmental, health and human services and transportation agencies—make up the remaining 40 percent of emissions.

The figure below shows that UMA is the largest single state government GHG emitter, with MassPort a close second. UMMS, MWRA and the DOC round out the top five, with MassDOT,

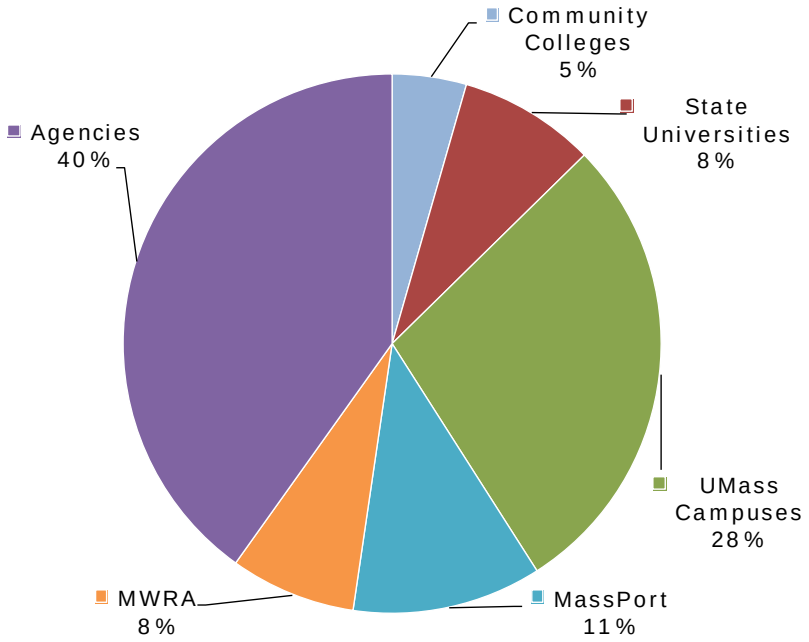
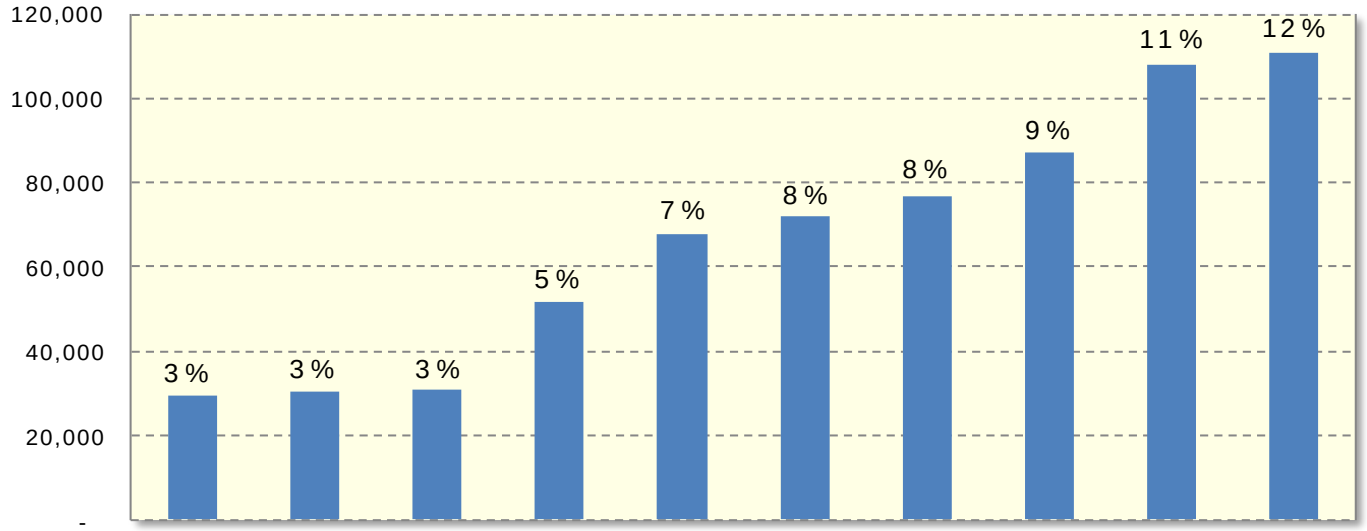


Figure 2: GHG Emissions by Major Contributor in FY12
Within all state government categories, UMass campuses are the largest emitter of GHG emissions with 28 percent of all GHG emissions within the state portfolio in FY12.



	UMass Lowell	Trial Court	Dept. of State Police	Dept. of Develop-mental Services	MassDOT, Highway & Turnpike Divisions	Mass. Water Resources Authority	Dept. of Correction	UMass Medical	MassPort Authority	UMass Amherst
GHG Emissions (metric tons)	29,566	30,630	31,126	51,951	67,972	71,857	76,938	87,207	108,184	110,635
% or Overall GHG Emissions FY12	3%	3%	3%	5%	7%	8%	8%	9%	11%	12%

Figure 3: Top Ten GHG Emitters for FY12
The ten LBE partners with the largest amounts of GHG emissions for FY12 make up 70 percent of overall state government GHG emissions while the top five partners account for 47 percent of total emissions.
See page 17 for a full list of emissions by LBE partner.

the Department of Developmental Services, Trial Courts, UMass Lowell and State Police rounding out the top ten emitters. Except for State Police and the MWRA, the vast majority of emissions come from the fuels used to heat, cool and power buildings. (Note: Police emissions are primarily from vehicle use while MWRA's emissions are for the operation of water and waste water treatment facilities that serve millions of customers.)

It is important to note that higher emissions do not necessarily reflect the efficiency of building operations, but can be associated with larger facilities (e.g. universities, prisons), longer operating hours (e.g. prisons), sites with particularly high intensity energy uses (e.g. hospitals, labs), and/or sites where emissions are affected by circumstances beyond their control such as weather or traffic (e.g. waste water treatment facilities, airports, highways).

Department of Correction

A 2012 Leading By Example Awardee, the Department of Correction (DOC) has taken aggressive greenhouse gas (GHG) emissions reduction measures across its seven facilities since the agency began greening its operations several years ago. Some of the most significant achievements include facilities generating their own renewable electricity on site, with more than 1 MW of generating capacity through large-scale PV and 3.3 MW through two commercial-scale wind turbines. Further, GHG emissions reductions are expected at the Gardner and Framingham facilities through converting boilers from No. 6 oil to natural gas.

The DOC's license plate manufacturing facility has become a near zero-emission operation, eliminating the use of paints and other volatile compounds in the manufacturing process. Instead, a heat-transfer system is used to image the license plate background and colorize the characters. In addition, the DOC has changed out its sodium vapor light bulbs for LED wall packs, saving $50,000 in annual electricity costs at its Cedar Junction facility. Other sustainability achievements include replacing 40 percent of the department's older vehicles with newer fuel-efficient vehicles and, since 2002, cutting solid waste generation by almost 40 percent, going from 10,000 tons to just over 6,000 tons in fiscal year 2012. In addition, the DOC was recognized in 2009 by the U.S. Environmental Protection Agency for its combined heating and power (CHP) plant at Bridgewater.

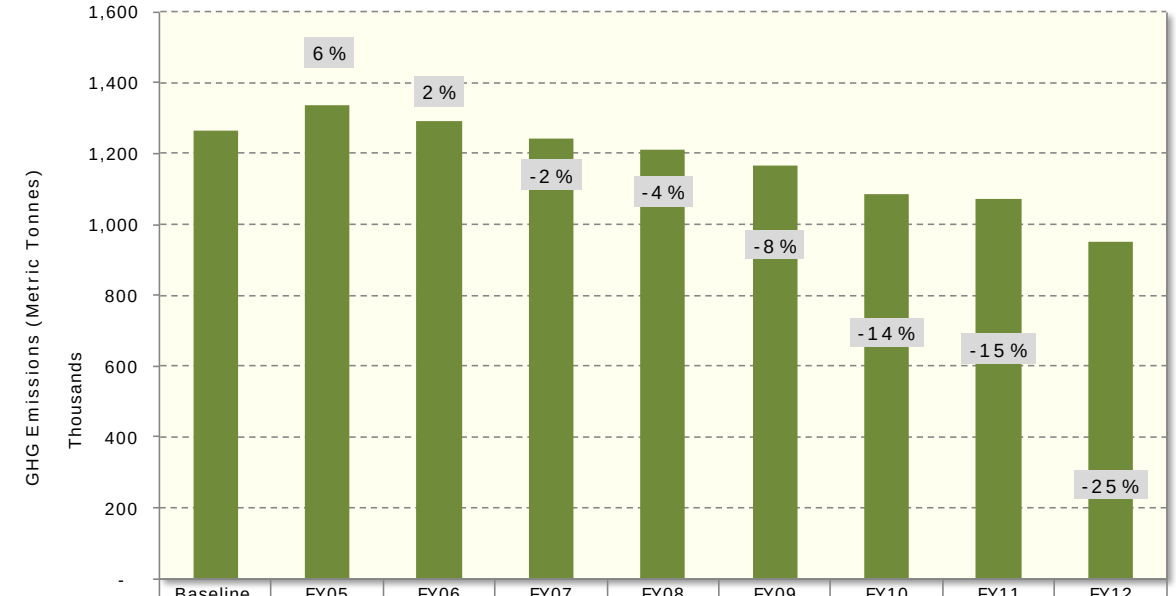
DOC by the numbers:

- 4.3 MW of on-site renewable electricity, enough generating capacity to power 655 average Massachusetts homes.
- $50,000 in electricity cost savings through LED lighting at the Cedar Junction facility
- 40 percent less waste going to landfills through improved recycling efforts

Results

Over the past several years, Massachusetts state government has been stepping up to address it in a big way. At the end of Fiscal Year 2012 (FY12), GHG emissions at state government facilities decreased by 314,000 metric tons, a 25 percent reduction from the LBE Baseline—and equivalent to taking over 66,000 cars off the road.

As can be seen in Figure 4, both annual and overall trends are encouraging, with emissions falling below the LBE Baseline in every year since 2006 and emissions reductions occurring for seven straight years.



	Baseline	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12
Total GHG Emissions	1,265,350	1,335,159	1,292,331	1,243,143	1,212,582	1,164,969	1,086,862	1,071,977	950,904
% Difference from Baseline	0%	6%	2%	-2%	-4%	-8%	-14%	-15%	-25%

Figure 4: *Annual Change in GHG Emissions, Baseline Year to FY12*
Overall GHG emissions have decreased 25 percent from the LBE Baseline through FY12, reducing overall emissions by some 314,000 metric tons.

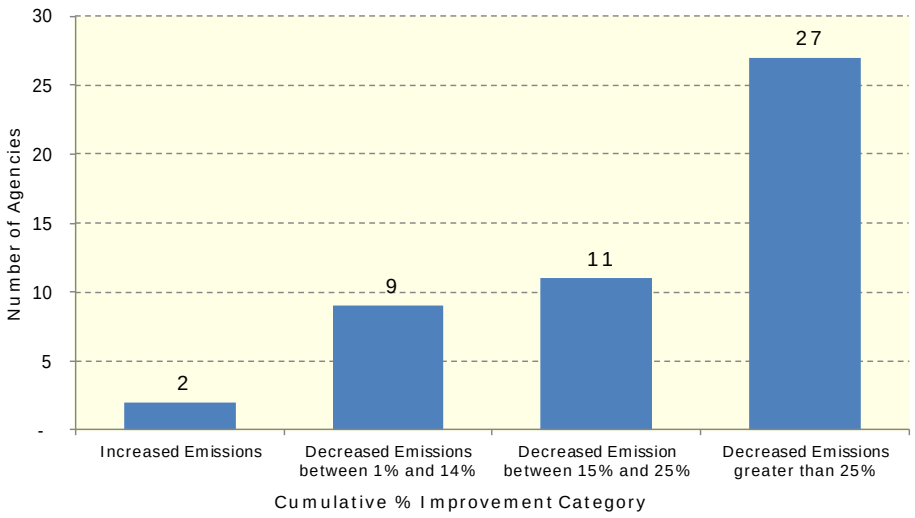
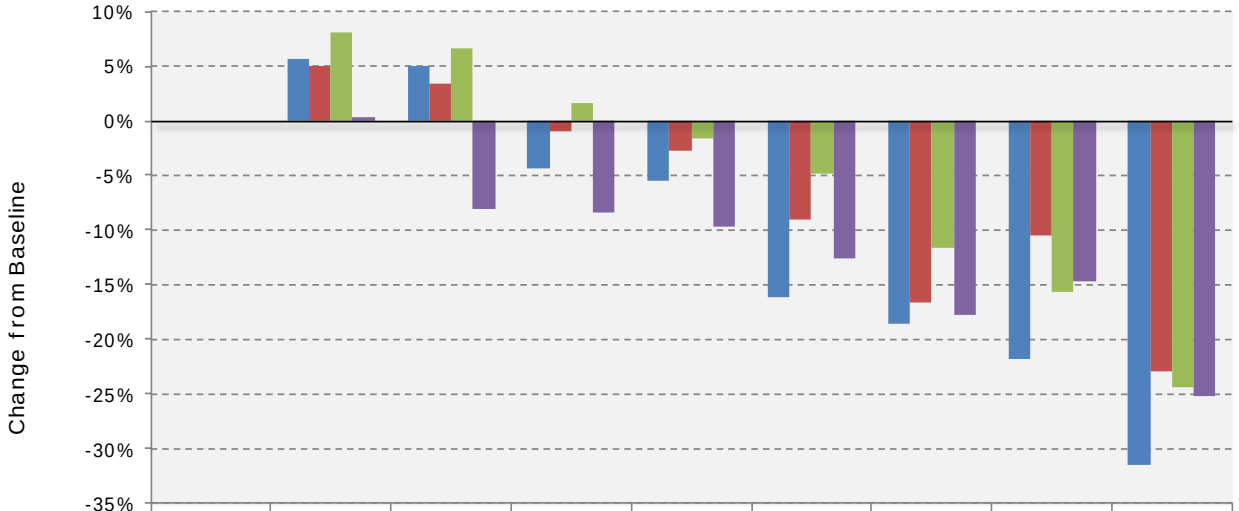


Figure 5: *Agency Improvements in Reduction of GHG Emissions, Baseline to FY12*
Twenty seven of the 49 agencies tracking emissions have reached the 25% GHG emissions reduction target set by E.O. 484. Mount Wachusett Community College leads the percent reduction from the Baseline.

Emissions reductions have occurred across virtually all agencies and campuses (Figure 5). Forty-seven out of the 49 agencies and campuses being tracked by LBE have reduced emissions below the LBE Baseline, 38 of 49 (78 percent of the total) have reduced emissions by more than 15 percent, and 27 (55 percent of the total) have reduced emissions beyond the Executive Order's 25 percent reduction target.

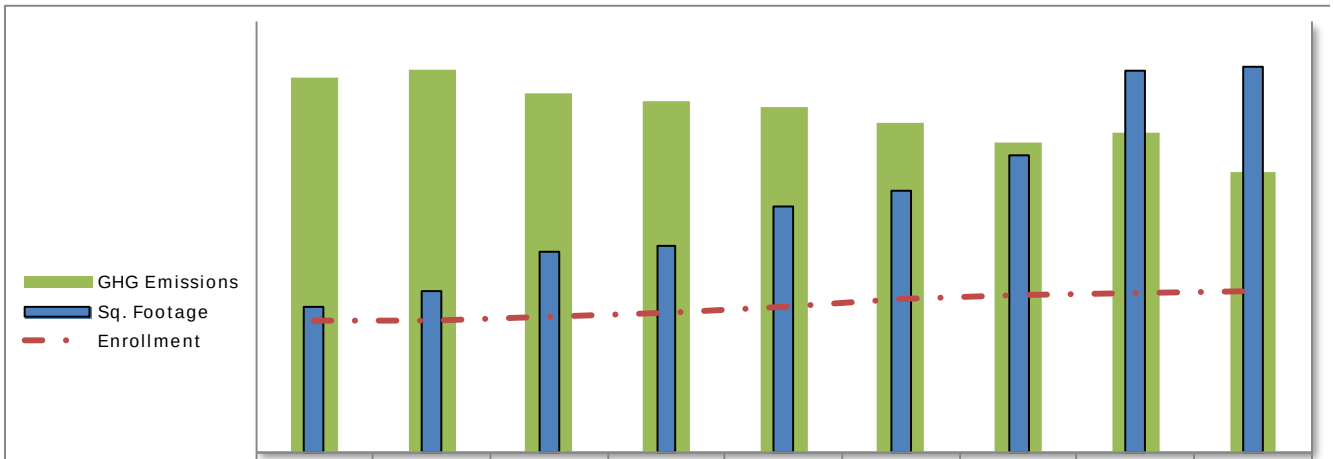


	Baseline	2005	2006	2007	2008	2009	2010	2011	2012
Community Colleges	0%	6%	5%	-4%	-6%	-16%	-19%	-22%	-31%
State Universities	0%	5%	3%	-1%	-3%	-9%	-17%	-10%	-23%
Agencies & Authorities	0%	8%	7%	2%	-2%	-5%	-12%	-16%	-24%
UMass Campuses	0%	0%	-8%	-8%	-10%	-13%	-18%	-15%	-25%

Figure 6: *Percentage Change in GHG Emissions by Agency Type, Baseline to FY12*

Even when broken out by category, each sector of state government has reduced GHG emissions by at least 23% since the LBE Baseline year. The greatest overall reductions in emissions are associated with community colleges, which saw a 31% decline.

Emissions decreases are occurring across all agency categories, with the largest emissions decrease (31 percent) seen in the 15 community colleges, a 25 percent reduction at the five UMass campuses, and reductions of 23 percent across state universities, Executive branch agencies and authorities.



	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012
GHG Emissions	522,711	532,601	500,127	488,656	481,578	458,455	430,762	445,506	389,359
Sq. Footage	60,734	61,109	62,100	62,260	63,264	63,692	64,609	66,765	66,864
Enrollment	183,491	184,161	188,065	194,388	201,753	214,740	220,029	222,329	223,681

Figure 7: *Changes in Student Enrollment, Square Footage, and GHG Emissions; Baseline to FY12*

Square footage (shown in thousands) at community colleges, state universities, and UMass campuses has increased by 16% since 2004. Student enrollment has also increased by 22% since 2004. GHG Emissions are shown in metric tons.

These significant reductions have been achieved despite increased square footage and number of buildings, as well as increased hours and enrollment at many state colleges and universities. Across all LBE partners, square footage has increased by 10 percent since 2004, while enrollment at all state colleges and universities has increased 22 percent since 2004.

A leader in the state's GHG reduction efforts, Mt. Wachusett Community College (MWCC) leads all other state government entities with a 96 percent reduction in GHG from the LBE Baseline through FY12. Expected to be the

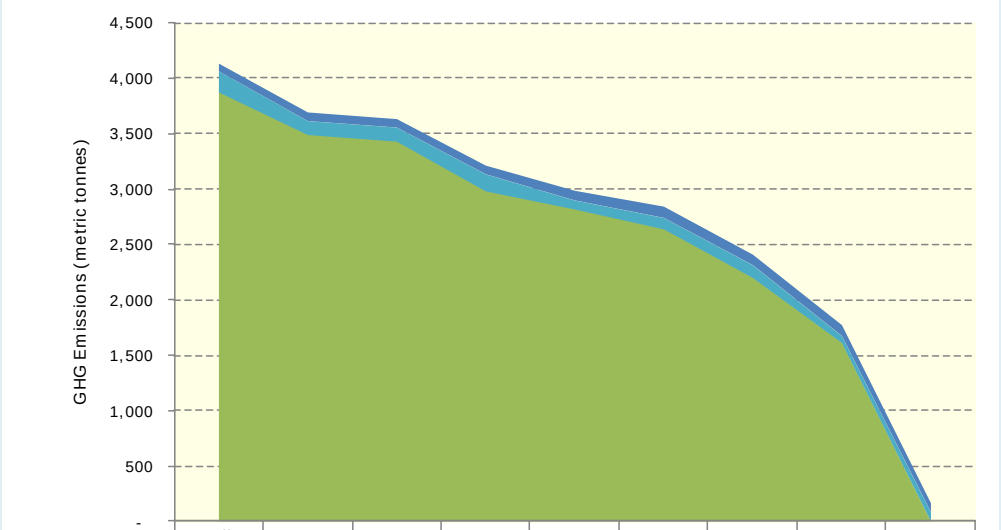
Mount Wachusett Community College

In 2011, Mount Wachusett Community College (MWCC) was identified as the largest greenhouse gas (GHG) reducer of any Massachusetts state college, university, or agency. In the same year, the college moved decisively toward carbon neutrality with the activation of two 1.65 MW Vestas V82 wind turbines, expected to generate enough electricity to meet 97 percent of the college's annual demand.

The college has reduced GHG emissions by 96 percent below the LBE Baseline through numerous efficiency and renewable energy initiatives. MWCC utilized a variety of grants and energy rebates to fund lighting upgrades and lighting controls, a new pool cover, efficient ventilation systems, and a host of HVAC upgrades. Electricity consumption has decreased even as the campus has continued to grow in size and as the number of computers in use has tripled.

The $9 million wind project adds to the college's preexisting renewable energy capacity—biomass heating, a solar PV array, and solar thermal domestic hot water technologies. MWCC has integrated its renewable technologies with learning opportunities, particularly within its Natural Resources and Energy Management Academic Programs.

DOER selected MWCC for a 2011 Leading By Example Award in recognition of its renewable energy and energy efficiency accomplishments. The college has also been recognized by the U.S. Environmental Protection Agency (EPA) and other organizations for its outstanding clean energy improvements.



	Baseline	2005	2006	2007	2008	2009	2010	2011	2012
Vehicle Fuel	69	78	76	78	87	101	95	98	80
Oil 2	191	126	127	154	81	103	114	62	81
Grid Electricity	3,877	3,492	3,432	2,982	2,819	2,639	2,200	1,612	-

Figure 8: *Change in GHG Emissions from Baseline to FY2012 at MWCC*
Overall GHG emissions reduced from over 4,000 metric tons of GHG to less than 200 metric tons of GHG at MWCC. Much of the reduction in GHG emissions is attributed to the reduction of grid electricity emissions offset by on-site renewable energy.

state's first zero net energy campus, the Gardner college is accomplishing this through a diverse array of clean energy strategies, including energy efficiency, installation of a wood chip heating plant, 100 kW of solar PV and 3.3 MW of wind power.

Although MWCC is a shining example, the state's public higher education system as a whole is showing exemplary results in reducing GHG emissions as outlined above. In fact, all 29 campuses are among the 517 public colleges and universities that have signed onto the American College and University Presidents' Climate Commitment[2]. In 2011, MWCC was selected as a winner for the Second Nature Climate Leadership Awards, a supporting organization for the American College & University Presidents' Climate Commitment (ACUPCC), while Massachusetts Maritime Academy and the UMMS were among 20 college campuses nationwide selected as 2012 finalists in that award competition.

Other agencies that have seen substantial progress include:

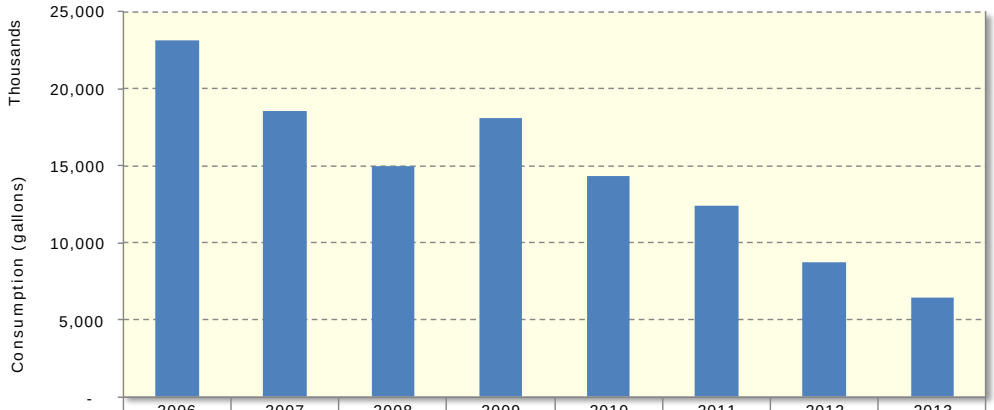
- The Bureau of State Office Buildings (now part of DCAMM) has seen a 38 percent emissions reduction as a result of a host of measures ranging from conversion of heating systems from steam to natural gas, large scale installation of efficient lighting, including CFLs and LEDs, replacement of HVAC equipment, and upgrades of mechanical and building controls.
- The MWRA has reduced emissions 35 percent through a large scale renewable initiative that generates 18 percent of the Authority's total electricity consumption on-site. As MWRA reduces GHG emissions, it has reduced its overall fuel oil consumption by 48 percent since fiscal year 2007.
- Chelsea Soldiers' Home reduced emissions by 29 percent through fuel switching and energy reduction efforts. Chelsea Soldiers' Home reduced its oil usage over 74 percent since 2004.
- The Massachusetts Military Division saw a 42 percent reduction in GHG emissions from the LBE Baseline. State military facilities have reduced their fuel oil consumption by over 50,000 gallons since the LBE Baseline.

Strategies

Fuel Switching

In addition to many efficiency and renewable energy strategies documented later in this report, a key element of LBE's strategy to cut GHG emissions involves reducing the consumption of heating oil, the highest GHG emitting fuel per British Thermal Unit (BTU) still in use at state facilities. Between FY06 and FY13, through the installation of newer, more modern boilers and power plants, the use of heating oil at state facilities decreased by more than 16.7 million gallons—a 72 percent reduction. This dramatic reduction over just seven years has resulted in lower emissions, cleaner air, reduced maintenance required of older systems, and reduced fuel costs. Nine state agencies and campuses have stopped all heating oil use and another 11 have reduced its use by at least half.

The decrease in oil use has been accompanied by a corresponding increase in use of cleaner burning natural gas. From 2006 through 2013, consumption of natural gas has increased from 37.5 million to 70 million therms, a jump of 88 percent. Numerous state facility and campus sites are now in the process of converting from fuel oil to cleaner burning natural gas. Additionally, many agencies are exploring and installing a variety of renewable thermal technologies as a way of moving away



	2006	2007	2008	2009	2010	2011	2012	2013
Gallons of Heating Oil	23,124,431	18,504,690	14,949,706	18,131,522	14,377,913	12,402,735	8,763,805	6,438,641
% Change from FY06	0%	-20%	-35%	-22%	-38%	-46%	-62%	-72%

Figure 9: *Overall Heating Oil Consumption, FY06 to FY13*
Overall heating oil consumption has decreased over 72% since FY06.

[2] http://www.presidentsclimatecommitment.org/

entirely from fossil fuels. Examples include biomass and pellet boilers, solar thermal for hot water, and high efficiency air and ground source heat pumps. All these efforts will eliminate the combustion of hundreds of thousands of gallons of heating oil as state government moves toward even greater reductions of heating oil use by 2020. Framingham State University and the Department of Developmental Services' (DDS) Wrentham Developmental Center and Hogan Regional Center in Danvers, for example, are in the process of virtually eliminating the use of 1.7 million gallons of heavy fuel oil. Preliminary data from the Wrentham Developmental Center show that the facility's winter monthly natural gas bill is about equal to what it previously paid for oil over two days, while the Hogan Regional Center has reduced GHG emissions and energy costs by 75 percent.

It is worth noting also the percentage change in the state's relative reliance on fuel oil. As seen in the chart below, in 2004 state government used roughly the same amount of fuel oil and natural gas to provide heat and hot water to state facilities. By 2013, natural gas use increased to more than 80 percent of state government's thermal fuel use while oil made up 11 percent of total on site combustion of fossil fuels.

Other Strategies to Reduce GHG Emissions

Other ways the LBE Program has sparked reductions in GHG emissions, which are detailed further in other sections of this report, include:

- Investing approximately $7 million in American Recovery and Reinvestment Act (ARRA) funding to install 37 solar PV systems at 19 state-owned facilities, totaling 2.8 MW and, over 30 years, eliminating over 38,000 metric tons of emissions (see Chapter 5);
- Investing $1.7 million to buy down the cost of electricity under the terms of solar energy power purchase agreements, facilitating the installation of 1 MW of solar PV at the MWRA's Deer Island Wastewater Treatment Plant, Logan International Airport, Bridgewater and Worcester State Universities, and the Canton Housing Authority to eliminate nearly 14,000 metric tons of emissions over 30 years;
- Investing $3.8 million for DCAMM staff to oversee a comprehensive portfolio of energy efficiency projects at 20 facilities, which will reduce emissions over 30 years by nearly 600,000 metric tons;
- Investing $590,000 in low emissivity ceilings at five DCR skating rinks, expected to offset nearly 15,000 metric tons of emissions over 30 years; and
- Investing $1.7 million in ARRA funds in small-scale energy efficiency and efficient lighting projects at 66 state properties for expected emissions savings over 30 years of over 20,000 metric tons.

Looking ahead, the LBE Program will continue to figure prominently as the Commonwealth works toward statutory goals set by the Global Warming Solutions Act of 2008, which calls for reducing GHG emissions by 25 percent from 1990 levels by 2020 and 80 percent by 2050 across all sectors of the Massachusetts economy. The Accelerated Energy Program (AEP), to be implemented through 2015, is expected to reduce emissions by an additional 135,000 metric tons.

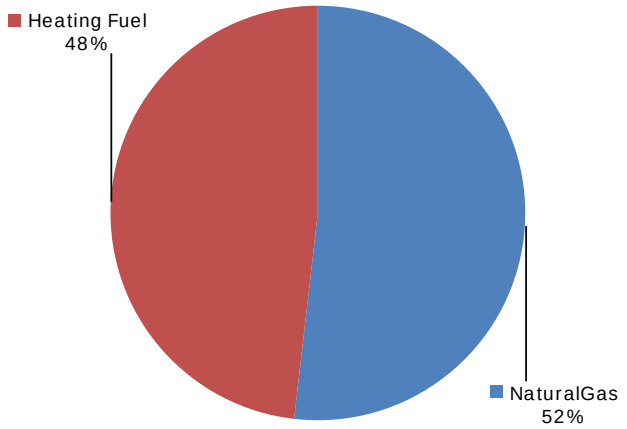
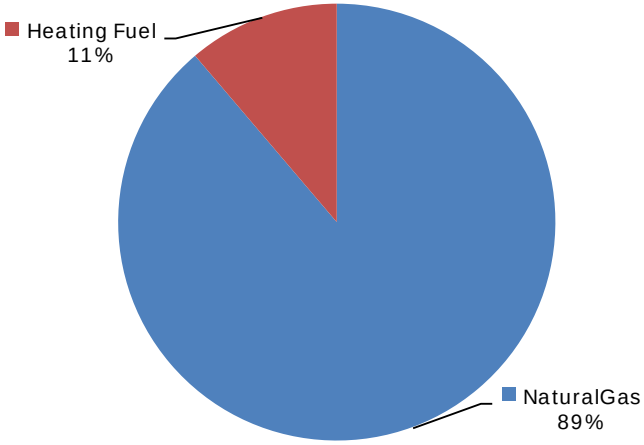


Figure 10: *Natural Gas vs. Heating Oil Use*
Consumption of heating oil and natural gas as a percentage of total on-site fuel demand in the Baseline Year (shown above) and in FY12 (shown below).



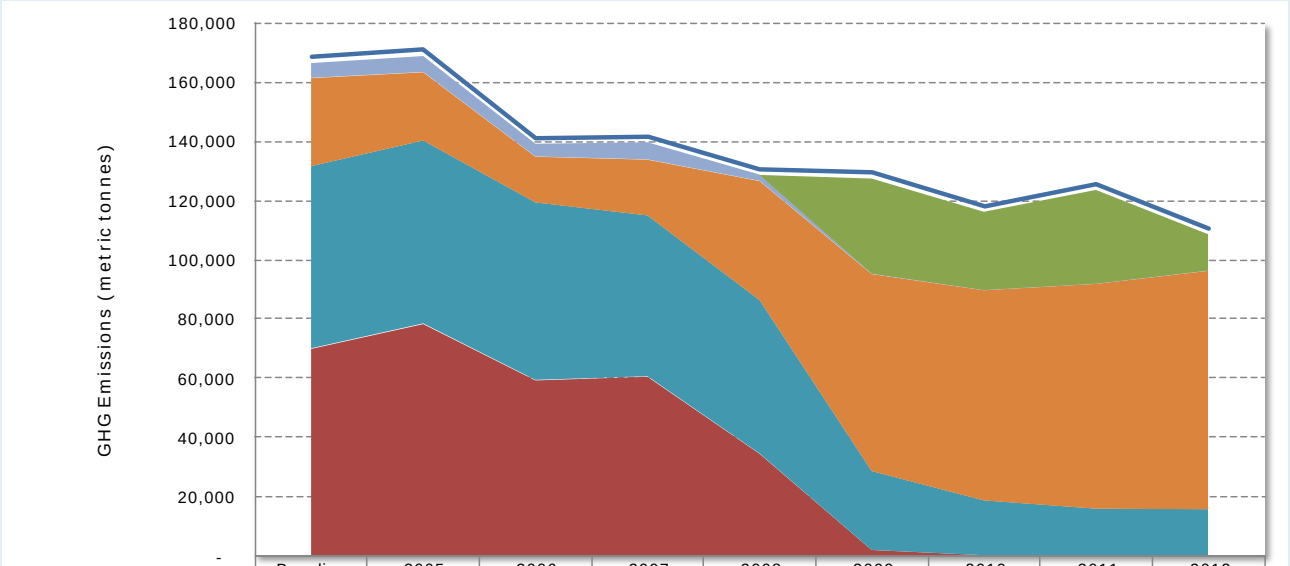
UMass Amherst

The University of Massachusetts Amherst (UMA)—the largest energy consumer of all state facilities in Massachusetts—has reduced its greenhouse gas emissions by 26 percent below the LBE Baseline. Coal emissions were completely eliminated at UMA by FY10, and the university's overall emissions have been reduced to less than 123,000 metric tons of GHG.

UMA has initiated or completed at least two dozen energy efficiency or renewable energy projects to date. Standout initiatives have included the 10 MW Combined Heat and Power (CHP) facility powered by natural gas, a $42 million efficiency project, and two LEED Gold Certified buildings. The new power plant enabled the campus to replace its coal-fired power plant and reduce the amount of electricity purchased from the grid by 71 percent. The natural gas combined heat and power plant covers all of the heating needs and up to 75 percent of the electricity needs for the entire campus. The LEED certified buildings include increased insulation and high efficiency HVAC systems, with the campus Police Station using about half the energy of comparable buildings.

UMA earned a 2010 Leading By Example Award for its efforts and has also earned many additional honors. In 2012, its Campus Sustainability Initiative placed first internationally for "Education and Awareness" and for the "Top Ten for Most Acts of Green" in Earth Day Network's MobilizeU Competition. The new central heating plant has been recognized as the cleanest plant of its size in New England, earning awards from the U.S. EPA, the International District Energy Association, and Combined Cycle Journal.

Moving forward, UMA has a number of energy-related plans in the works. The UMA Climate Action Plan Update draft, released in 2012, presents concrete strategies for achieving carbon neutrality by 2050. UMA will seek to achieve its robust clean energy goals simultaneously with a $1 billion capital improvement program to add two million square feet to the campus.



	Baseline	2005	2006	2007	2008	2009	2010	2011	2012
ULSD for CHP						32,006	26,371	31,580	12,234
Oil 2	4,969	5,387	4,297	5,801	2,118	311	227	216	238
Natural Gas	29,760	23,058	15,449	18,846	40,221	66,600	71,048	75,983	80,595
Grid Electricity	61,579	61,827	60,000	54,358	51,874	26,693	18,549	15,762	15,565
Bituminous Coal	69,951	78,374	59,276	60,517	34,389	1,766			
Total GHG Emissions	168,490	171,015	141,154	141,681	130,702	129,613	118,202	125,637	110,635

Figure 11: *University GHG Emissions, Baseline to FY12*
UMA has reduced its GHG emissions by 34% below the LBE Baseline.

LBE Partners and Their FY12 Results—GHG Emissions

LBE collected data from various state agencies, authorities, and campuses for E.O. 484. Energy consumption data from all LBE partners was analyzed for GHG emissions. A subset of the energy consumption data was analyzed for EUI.

GHG Emissions

Listed below, the 49 LBE partners with their FY12 GHG emissions (in metric ton) and progress beyond the LBE Baseline.

Agency Name	GHG Emissions	% Improvement
Berkshire Community College	1,852	25%
Bridgewater State University	16,706	20%
Bristol Community College	3,124	39%
Bunker Hill Community College	4,316	11%
Bureau of State Office Buildings	15,548	38%
Cape Cod Community College	1,625	32%
Chelsea Soldier's Home	3,933	29%
Department of Conservation and Recreation	22,301	43%
Department of Correction	76,938	23%
Department of Developmental Services	51,951	26%
Department of Environmental Protection (MassDEP), owned facilities	955	-155%
Department of Fire Services	2,308	38%
Department of Fish and Game	1,940	27%
Department of Mental Health	17,360	59%
Department of Public Health	22,067	12%
Department of State Police	31,126	4%
Dept. of Transportation (MassDOT), Highway & Turnpike Divisions	67,972	0%
Department of Youth Services	5,542	2%
Division of Capital Asset Management	22,862	-9%
Environmental Police	940	42%
Fitchburg State University	9,383	29%
Framingham State University	8,421	29%
Greenfield Community College	2,464	9%
Holyoke Community College	2,937	15%
Holyoke Soldier's Home	1,667	16%
Massachusetts Bay Community College	2,087	53%
Massachusetts College of Art & Design	5,173	17%
Massachusetts College of Liberal Arts	4,076	28%
Massachusetts Maritime Academy (MMA)	7,745	11%
Massachusetts Military Division	5,466	42%
Massachusetts Water Resources Authority (MWRA)	71,857	35%
Massasoit Community College	3,780	30%
Massachusetts Port Authority (MassPort)	108,184	21%
Middlesex Community College	2,652	28%
Mount Wachusett Community College	161	96%
North Shore Community College	2,556	26%
Northern Essex Community College	3,283	38%
Quinsigamond Community College	2,145	31%
Roxbury Community College	2,382	30%
Salem State University	9,897	25%
Springfield Technical Community College	7,016	11%
Trial Court	30,630	25%
UMass Amherst	110,635	34%
UMass Boston	19,122	27%
UMass Dartmouth	22,319	24%
UMass Lowell	29,566	22%
UMass Medical School	87,207	11%
Westfield State University	10,794	24%
Worcester State University	5,936	21%

4 Reducing Energy Consumption

Overview

Early in his first term, Governor Patrick announced that Massachusetts would consider energy efficiency its "first fuel"—in effect, committing to wring all the efficiencies possible out of existing operations before considering new sources of power generation. Recognizing that energy efficiency can be the most cost-effective way to reduce energy costs and associated GHG emissions, LBE efforts across dozens of agencies and campuses have resulted in the implementation of hundreds of projects, including large comprehensive efficiency efforts, an array of smaller projects working in concert with utilities, and a host of equipment and fixture replacement projects. Additionally, more than two dozen new construction projects were designed and built under the Mass. LEED Plus standard and have achieved LEED certification. Efforts to utilize real-time energy use data on a building level are well underway and already resulting in operational changes at a number of state facilities.

Measurement of Energy Use Intensity

In calculating progress toward energy reduction targets, the LBE Program employs the commonly used Energy Use Intensity (EUI) metric, which measures total energy consumption on a square footage basis. Energy use at Massachusetts agencies is obtained from various sources (described in detail in Appendix B), converted to kilo British Thermal Units (kBtu) to allow direct comparisons between various fuels, and then divided by the total square feet of buildings at that agency or campus. The resulting EUI for each year tracks the energy "intensity" of a particular LBE partner. Thus, an agency with a lower EUI is using energy more efficiently, even if its overall energy use may be higher than that of another agency. It is important to note, however, that many factors can contribute to varying EUIs at different buildings, such as building type, efficiency and type of installed equipment, usage patterns, age, and hours of operation. These should be taken into account when comparing EUI across buildings and agencies. For example, one would expect that a data center or a prison facility in operation 24 hours a day, seven days a week, would have a higher EUI than a state office building that is in full operation from 8 a.m. to 8 p.m., Monday through Friday, even if they have installed high efficiency equipment. Additionally, certain high intensity buildings, such as labs or hospitals, are likely to have higher EUIs even if they are being operated efficiently.

Energy Use Intensity

Energy Use Intensity (EUI) metric measures total energy consumption on a square foot basis. Energy use data is converted to kilo British Thermal Units (kBtu) to compare between different fuels, divided by a building's total square footage yielding an annual EUI number.

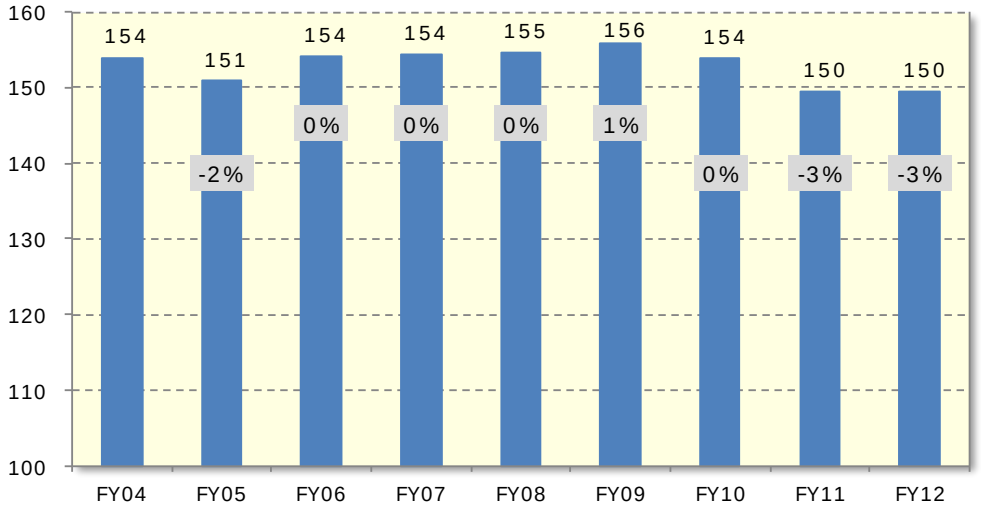
In calculating energy use and energy reduction progress for this report, data have been weather normalized. The EUI baseline of FY04 is further referred to as the weather normalized baseline in the report. See Appendix B for a detailed description of the weather normalizing process used for this report.

The EUI of six LBE partners was not calculated for this report due to the primary functions of those agencies and the fact that much of the electricity, natural gas, and fuel oil use are not directly attributable to building operations[3]. See Fact Sheet III on page 29 for the list of agencies and reasons for not including each in the EUI target on page 48.

[3] List of agencies not included in EUI target: Department of Conservation and Recreation, Department of Transportation, Department of Fish and Game, Massachusetts Environmental Police, Massachusetts Port Authority and Massachusetts Water Resource Authority.

Results

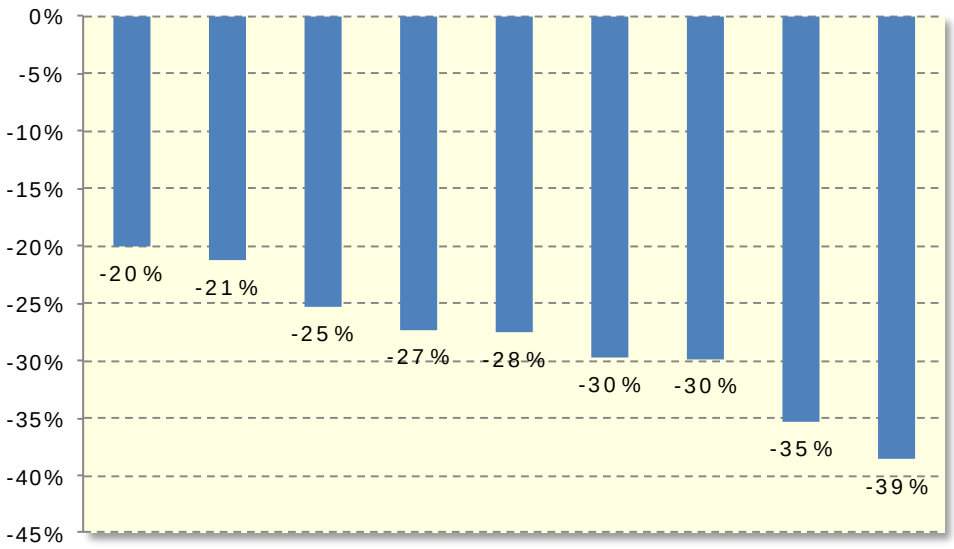
As seen in Figure 12, overall, Massachusetts agencies have reduced collective EUI from 154 to 150 kBtu per square foot, a 3 percent reduction from the weather normalized baseline.



However, despite the relatively small change in overall EUI, the vast majority of agencies have experienced efficiency gains. Of the 43 LBE partners whose EUI was tracked for this report, two-thirds saw EUI improvements, with nine achieving an EUI reduction of more than 20 percent or greater.

Figure 12: *Change in Energy Usage Intensity, FY04 to FY12*
Overall EUI number (rounded) from FY04 (the Baseline) for 43 of the LBE partners.

Figure 13: *LBE Partners with EUI Reduction more than 20%, FY04 to FY12*
EUI reduction shown left to right for these nine LBE partners; UMass Lowell, Quinsigamond Community College, Mass. Military Division, Worcester State University, Dept. of Mental Health, Mass. College of Liberal Arts, Framingham State University, Cape Cod Community College, and Dept. of Fire Services.



Factors Impacting the **LBE Program's** Progress Towards Its EUI Goal Are Varied and Add Challenges

Factors include:

- EUI allows for year to year comparisons, normalizing for square footage changes. However, it does not normalize for other changes within a building. For example, most state colleges and universities have dramatically expanded hours of operation and have seen student enrollment increase significantly. Eighteen of the 29 state colleges and universities (62 percent) have reduced EUI despite these increase.
- Given the age of equipment at many state facilities, a number of large projects focused on replacing older boilers using dirtier fuel such as coal or heavy fuel oil. While some energy savings do result from upgrading to more efficient boilers, the primary benefit of these fuel-switching projects is a much cleaner burning system with dramatically reduced GHG emissions (see Chapter 3), lower emissions of other pollutants such as particulates or nitrous oxides, and reduced energy costs. More information on fuel switching projects can

be found in the Fuel Switching section under Reducing Greenhouse Gas Emissions.

- Significant efforts were spent in development and installation of on-site renewable power and on-site energy from CHP plants, as a way to ensure more stable energy prices and reduce GHG emissions (see Chapter 5 which begins on page 30). These installations have significant benefits, such as reducing reliance and dependence on dirtier and less efficient grid-based electricity, but do not reduce on-site consumption and therefore do not directly contribute to EUI reduction.
- After E.O. 484 was signed, DCAMM, DOER, and state agencies began to ramp up comprehensive efficiency projects. However, before moving forward, the state needed to develop a financing mechanism to fund the projects. Additionally, the large, complex efficiency projects undertaken by DCAMM require lead time to scope, audit, bid, and implement. The LBE Program anticipates that much of the energy reductions associated with the ramp up of energy projects since 2012 will significantly reduce EUI across those agencies and will be documented through data tracking over the next three years. See the next page for more information on the ramp-up of comprehensive efficiency projects at state facilities.

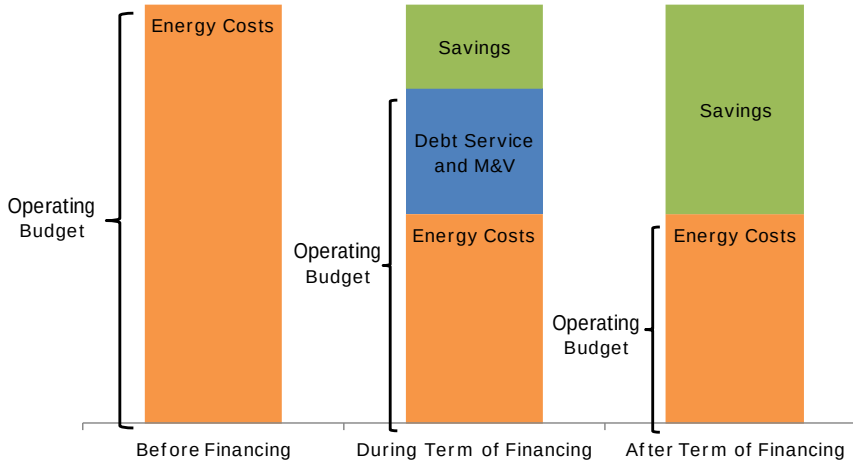
Strategies

Energy Reduction Programs

Agencies and campuses have taken a variety of approaches to reduce energy consumption, ranging from large comprehensive and small efficiency projects to building retro-commissioning, ongoing commissioning, equipment purchases, and outreach and behavior programs. Additionally, new construction projects have produced more than twenty-four LEED certified buildings as well as two buildings designed to meet zero net energy building standards. Information below provides an overview of programs, projects, and efforts that are contributing to Massachusetts' comprehensive strategy for meeting the energy efficiency goal of E.O. 484.

Efficiency Project Financing and Streamlining

Due to the national financial crisis in 2008, Massachusetts, like the rest of the U.S., found itself with restricted access to previously available capital project financing. With E.O. 484's bold clean energy targets on the line, the LBE Program sought a solution that would enable the Commonwealth to cost-effectively self-finance a large number of energy projects without bumping up against state debt ceiling limits. Through development of the Clean Energy Investment Program (CEIP) in 2009, the Commonwealth began using state-backed general obligation bonds to finance projects that pay off the debt through savings in energy costs. CEIP allows DCAMM to secure low-cost financing for large efficiency projects while ensuring that agencies experience cost reductions, even after all debt service is paid. By relying on low-interest state bonds resulting from the Commonwealth's favorable bond rating, state projects are able to finance deeper and broader measures that result in greater savings (program structure visualized on left).



At the same time this new financing program was developed, DCAMM worked with other agencies and efficiency stakeholders to examine ways to streamline the timeline for large efficiency projects, resulting in faster implementation of more projects, and leading to quicker savings for the Commonwealth. After many months of public and internal meetings, DCAMM developed a series of recommendations, which are now implemented. These include:

- Bundling of similar sites together within a single agency to reduce administrative and fiscal resource demands;
- Reducing upfront auditing requirements for bidders; and
- Early phasing in of certain energy conservation measures where savings are well documented (e.g. lighting upgrades).

Comprehensive Efficiency Projects

Simultaneous to the development of new efficiency financing and streamlined project processes, DOER provided DCAMM with $3.8 million through the ARRA State Energy Program (SEP) grant from the U.S. Department of Energy. The grant enabled DCAMM to hire 18 full-time employees to ramp up the development and oversight of a large number of comprehensive energy efficiency and renewable energy projects at state-owned facilities.

Since 2007, DCAMM projects have resulted in an investment of over $163 million in 20 comprehensive energy and water conservation projects across 16.2 million square feet of state buildings, with more than 90 percent of these projects implemented in 2010 or later. Only two such projects comprising less than one million square feet were implemented in the three years preceding the development of the financing program and the ARRA investment, highlighting the critical nature of both those efforts.

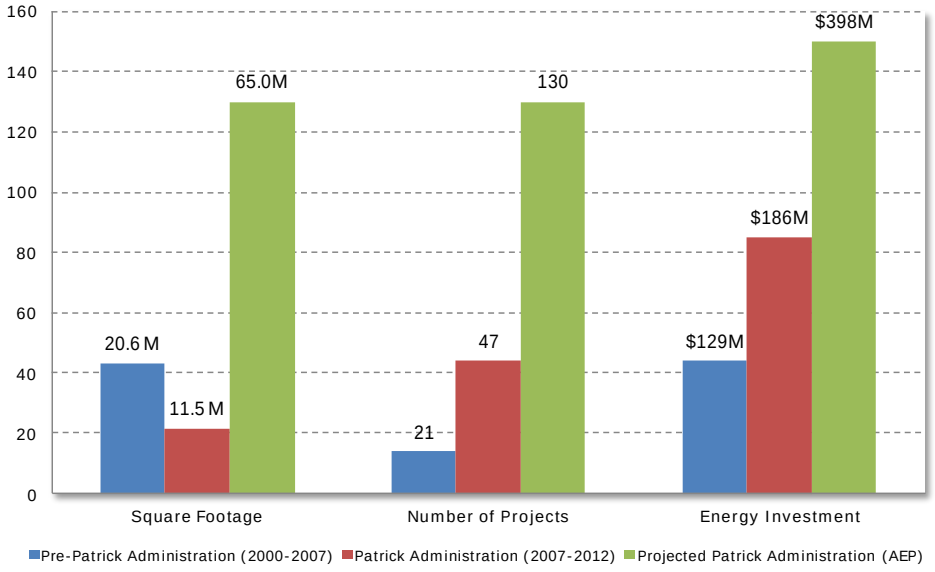
This successful staff ramp-up in 2010 formed the basis for a new effort, launched in 2012, called the Accelerated Energy Program (AEP). Through 2014, the AEP will ensure an energy efficiency upgrade for every state building that had not undergone efficiency improvements as of 2007. Figure 14 below, illustrates that progress under the Patrick Administration has been significant and promises to be even more robust in the years to come.

Small Efficiency Projects

More recently, efforts to address smaller buildings not covered through DCAMM's comprehensive energy projects have expanded significantly. Through a provision in the 2008 Green Communities Act, public entities are now authorized to contract directly with utilities or utility approved vendors for small-scale energy conservation projects that do not exceed $100,000 in total project costs. This legislative provision, along with other new initiatives to address efficiency at smaller facilities, has led to a significant expansion of efficiency measures at these sites, while maximizing utility incentives.

Some examples include:

- A commitment of $1.7 million of ARRA SEP funding in 2011 financed 66 small efficiency projects across the state consisting primarily of indoor and outdoor lighting upgrades, as well as other measures. These projects leveraged $1.4 million in utility incentives with projected annual savings of $680,000 and a simple payback period of just two and a half years;
- The DCR's replacement of approximately 6,800 incandescent traffic light systems with LED lights, reducing maintenance costs by 80 percent, cutting electricity use by about 7 percent, and saving $248,000 over five years (a 13-month payback).
- An ARRA investment of $590,591 to install low emissivity ceilings at five DCR ice skating rinks that will reduce energy use by 30 percent, and save $4.3 million over 30 years;
- Through collaboration with utilities and Philips Lighting, the LBE Program worked with dozens of state facilities and municipalities to install more than 37,500 LED bulbs and high efficiency fluorescent tubes. The new bulbs are projected to save



	Square Footage	Number of Projects	Energy Investment
2000-2007	20,621,258*	21	$129,002,968
2007-2012	11,504,741	47	$185,872,223
AEP	64,989,754	130	$398,099,900

Figure 14: *DCAMM Energy Efficiency Project Ramp-Up*

In the seven years prior to Governor Patrick's Administration, DCAMM invested some $129 million in energy projects, while over the next five years, the state invested close to $200 million in energy projects. Between 2012 and 2014, as part of the Accelerated Energy Program, DCAMM expects to initiate energy projects valued at $400 million across 65 million square feet of state buildings.

* One project at UMA during this time period covered 9,000,000 square feet, which accounts for nearly half of the total square footage at projects occurring before 2007.

over 4.2 million kWh of electricity annually—equivalent to the electricity use of 561 homes—and reduce energy bills by over $583,190 each year.

- Greenfield Community College converted to LEDs at its Downtown Center campus building, resulting in an annual reduction of 54,273 kWh and lifetime cost savings of over $107,000.
- The DOC conducted upgrades to the water system at the Norfolk-Walpole complex, installing water conservation devices and flow restrictors that have reduced daily water usage by 100,000 gallons per day, a 25 percent savings.
- Holyoke Soldiers' Home replaced all electric controls on two main passenger elevators with variable voltage variable frequency drives. Estimated savings of this measure alone total over $22,000 a year.
- The Department of Mental Health completed a lighting retrofit at the Gandara Mental Health Center in Springfield, replacing all T12 and magnetic ballasts with T8 fixtures. DMH leveraged utility rebates for 45 percent of the project cost and the retrofit is expected to pay back in three and a half years, saving almost $2,000 annually. The exterior parking lighting was also converted from 250W metal halide fixtures to 80W new induction fixtures, reducing lighting energy use by 68 percent.

The success of a number of these small-scale efficiency projects in coordination with the utilities helped form the basis for small-scale projects planned at an additional 438 small sites that are part of DCAMM's Accelerated Energy Program.

ACCELERATED ENERGY PROGRAM
COMMONWEALTH COMMITMENT TO A CLEAN ENERGY FUTURE

Comprehensive Efficiency Projects, Division of Capital Asset Management and Maintenance

DCAMM has made significant progress over the last five years, ramping up both the number and size of comprehensive efficiency projects undertaken at state facilities.

- Through the development of the Clean Energy Investment Program (CEIP), DCAMM has been able to secure low-cost financing to invest in larger projects. In 2011, DCAMM initiated the largest comprehensive efficiency project in its history, a $49 million project at UMass Dartmouth, expected to result in energy savings of $2.8 million annually. The project consists of comprehensive energy and water upgrades including, but not limited to, central building management controls, lighting and water upgrades, and a combined heat and power system at the central heating plant.
- Through bundling of buildings and sites in various locations across the Commonwealth, DCAMM has streamlined implementation across multiple sites under a single contract, enabling projects to proceed at agencies that may not have otherwise been considered for large, comprehensive projects. In 2010, DCAMM initiated the first of multiple phases of efficiency projects at Trial Court facilities across the state. Through two regional bundles, DCAMM retrofitted over three million square feet of Trial Court facilities.

- Through the phasing of projects, DCAMM has been able to mitigate delays and initiate implementation of simple energy conservation measures quickly, resulting in immediate savings to the state. In 2010, DCAMM and Massasoit Community College began implementing three phases of an energy and water conservation project, starting with simple lighting and water upgrades and advancing through HVAC and controls upgrades, demand controlled ventilation, envelope improvements, and energy management system upgrades.

Retrocommissioning

As another part of the state's multi-pronged approach to efficiency, DCAMM and DOER recognize that, in addition to energy retrofits, there is a need to address efficiency issues in buildings that may not require a complete energy overhaul. Building retrocommissioning projects have identified low- and no-cost- measures such as optimization of controls, minor repairs, system balancing, equipment tune-up, occupancy and ventilation controls, and re-setting of occupancy schedules.

DCAMM has completed 11 retrocommissioning studies at 1.9 million square feet of state buildings, resulting in proposed investments of $1.88 million with an annual savings of $1 million. Average payback across all sites is 1.85 years. DCAMM has moved forward with implementation of measures at six sites to date.

Site	Location	Sq. Footage	Project Implementation Cost	Projected Savings	Payback (years)
Brooke Courthouse	Boston	425,300	$5575,000	$395,000	1.46
UMass Boston, Campus Center	Boston	330,000	$186,000	$188,000	0.99
DYS, Paul Leahy Center	Worcester	45,236	$320,000	$28,000	11.43
Salem State College, Building One	Salem	94,669	$107,000	$80,100	1.34
State Police Barracks, Dartmouth	Dartmouth	14,200	$63,000	$10,000	60.30
State Police Barracks, Millbury	Millbury	14,200	$85,000	$12,000	7.08
Worcester District Court	Worcester	427,457	$290,000	$200,000	1.45
Taunton Career Center	Taunton	7,650	$27,900	$13,600	2.05
DEP, Wall Experiment Station	Lawrence	35,000	$200,000	$76,000	2.63
DYS, Westborough	Westborough	180,550	$30,000	$17,000	1.76
Total		1,574,262	$1,883,900	$1,019,700	

Table 1: *Results from retrocommissioning studies at state facilities*

Ongoing Commissioning Through Real-time Meter Data

Going forward, the Commonwealth's energy efficiency investments promise to be more targeted than ever, thanks to the LBE Program's investment of $9.7 million in ARRA funds to develop and support the Enterprise Energy Management System (EEMS)—a real-time energy use monitoring system. Designed to provide actionable energy use information to facility managers and help identify energy savings opportunities in order to prioritize energy efficiency projects, EEMS is among the largest U.S. project of its kind, with 1,291 building-level energy meters at 469 buildings covering over 25 million square feet of state facilities including 18 colleges, four public hospitals, five courts, all state prisons and several state office buildings. By enabling facilities managers to see where and how their buildings are wasting energy and informing targeted remedies, this LBE project alone is projected to yield savings of 5-15 percent.

Purchase and Use of Energy Efficient Products

According to the FY12 Annual Report of the Massachusetts Environmentally Preferable Products (EPP) Procurement Program at the Operational Services Division (OSD), state government saved over $3.5 million and reduced GHG emissions by nearly 21,000 metric tons in FY12 through the purchase by state agencies of products and services that have a reduced environmental impact compared with competing alternatives. Cost savings related to energy efficiency included over $566,000 through purchase of more efficient office equipment such as Energy Star computers, and over $2.1 million attributable to the purchase of compact fluorescent lighting.

The EPP Program allows LBE Partners the ability to learn from the vendor community about new product developments and innovative technologies that may allow for energy or water conservation, reduced use of toxic substances, less waste, and other environmental benefits. As of FY2012, the EEP Program allowed LBE partners to purchase energy efficient equipment, lighting and fixtures, renewable energy and alternative-fuel vehicles, and water conservation practices and devices to name a few of

the products and services provided. The EPP Program allows LBE Partners the ability to take into consideration more than just costs savings but also operational and maintenance efficiencies, energy and water savings, and waste reduction attributes such as less packaging or unnecessary materials that might need special handling and disposal costs and considerations.

Through the EPP Procurement Program, OSD led an interagency Toxics Reduction Task Force, assumed leadership in initiating new tracking of statewide contracts, and conducted comprehensive educational workshops on green cleaning practices and the benefits of EPPs. The strategies that OSD has implemented have produced a 46 percent increase in the use of the multi-state green cleaning products contract. These opportunities have allowed OSD to assist in educating Commonwealth purchasers on a variety of statewide contracts with environmental and energy efficiency opportunities.

Additionally, in 2008, the Information Technology Division, working collaboratively with the LBE Program, issued a comprehensive Computer Power Management Standard that required most Executive branch agencies to implement strategies to ensure that all state computers power down and get turned off when not in use. LBE staff estimated that if all agencies were in full compliance with the standard, annual savings could reach as much as $2 million. Compliance has varied, however, due to varying levels of difficulty in implementing this strategy depending on the age and capabilities of equipment. Based on a 2009 survey of agencies which garnered 26 responses, 14,988 workstations out of some 18,600 (80 percent) were reported to have installed computer power management settings.

Based on estimates of more than 50,000 workstations across the state, much work remains to identify the extent to which LBE Partners have been able to comply with this standard. LBE Staff continue to work with agencies and campuses to support efforts to achieve full compliance with this standard and will be conducting another survey to document more recent results in FY14.

Install Energy Efficient HVAC Equipment

HVAC upgrades are often a major component of the state's comprehensive energy projects (see page 23) through repair or replacement of equipment, conversions from oil to natural gas boilers, installation of CHP systems, and control upgrades. In addition to these comprehensive projects, DCAMM has undertaken a host of smaller ones to replace old, inefficient chillers or boilers with modern, more efficient models.

While the installation of new HVAC equipment is too lengthy to list, there are a number of projects worth mentioning:

- Both UMA and UMMS installed large state of the art natural gas fired CHP systems that eliminated over 30,000 tons of coal use and reduced use of #6 fuel oil by over 90%, respectively
- Highly efficient gas boilers were installed at the Wrentham and Hogan Department of Developmental Services facilities, replacing very old equipment that had been using #6 fuel oil, with expected energy and emissions savings approaching 50 percent
- Northern Essex Community College recently completed a large-scale project that replaced its electric resistance heating system with natural gas boilers, with expected greenhouse gas savings of 28 percent and annual energy cost savings of 33%, or more than $400,000 per year.
- Massasoit Community College installed new rooftop air conditioning units at its Brockton and Canton campuses with expected annual savings of 568,017 kWh.
- Framingham State University recently replaced its antiquated #6 oil fired central heating plant with a high efficiency natural gas plant that also included a small CHP system. Together, the new equipment will eliminate more than 350,000 gallons of oil annually, reducing annual energy costs by more than $500,000.

Behavioral Changes, Outreach and Engagement

While ambitious steps like erecting wind turbines and undertaking campus-wide energy savings projects undoubtedly produce big results, relatively small changes in the practices of individual agencies and employees—spread across state government and sustained over time—also add up. The authors of E.O. 484 recognized this, and made it part of the LBE mandate.

Many agencies and colleges have developed "green teams" that promote sustainability and undertake various efforts to increase awareness and affect change within various programs and processes and among staff, students, and users. The Massachusetts Trial Court's Green Team, established in 2008, is a prime example of the power of behavioral change. Promoting a culture of environmental and energy awareness among all employees, this group of Trial Court staffers identifies priorities and develops strategies to expand environmentally sound practices and energy cost containment measures across the Court's many locations. The Green Team has achieved concrete success on a range of sustainability issues—from recycling and green building standards to energy efficiency. The Trial Court received a U.S. Environmental Protection Agency Environmental Merit Award in 2011 and a state LBE Award in 2009.

Behavioral Changes

Many agencies and colleges have developed "green teams" that promote sustainability and undertake various efforts to increase awareness and affect change within various programs and processes, and among staff, students, and users.

Communicating with and engaging fellow Trial Court colleagues through an intranet/ electronic bulletin board (Green Hub) and a quarterly internal newsletter (Renew), the Green Team has initiated campaigns to turn off computers and other types of office equipment at the end of the day, to reduce paper use by instituting two-sided printing, and to reduce overall waste by moving all 72 state-owned Trial Court facilities to comprehensive recycling efforts.

Sustainability Participation and Education Program, UMass Medical School

Accompanying its forward-reaching efforts toward sustainable building design and operations, University of Massachusetts Medical School (UMMS) has a robust campus sustainability participation and education program. Growing Green was launched in 2009 and includes a web site, signage, an e-newsletter, a weekly farmer's market on campus, and a variety of outreach initiatives.

One initiative was a "Doing My Part for Growing Green" pledge campaign, in which employees were encouraged to sign up for five actions to decrease waste and take part in energy reductions. Nearly 400 employees participated. Additionally, UMMS hosted an Earth Day green campus fair with almost 50 local and campus organizations and more than 1,000 attendees.

UMMS's Growing Green platform is supportive of the goals articulated by Governor Patrick's E.O. 484 and the American College and University Presidents' Climate Commitment (ACUPCC).

"Beyond the environmental benefits, which are important in their own right, our sustainability effort is fundamental if we are going to continue expanding our science and clinical operations," said UMMS Chancellor Michael Collins, M.D

WBNER Green Team, Waquoit Bay National Estuarine Research Reserve

The Waquoit Bay National Estuarine Research Reserve (WBNER) is one of Massachusetts' most studied estuaries, a living laboratory of the Commonwealth's coastal ecosystems. In an effort to promote stewardship, this Department of Conservation and Recreation (DCR) facility established a Green Team in 2009 to work on reducing greenhouse gas emissions. WBNER Green Team success is reflected in the 17 percent decrease in energy consumption since 2009, as well as its contributions to raising community awareness around climate change.

In addition the WBNER Green Team has expanded the reach of its own efforts by creating a model for DCR to initiate similar Green Team efforts in four of the agency's districts.

The comprehensive approach taken by the WBNER Green Team includes community programs, teacher trainings, and children's programs aimed at raising awareness about climate change, saving energy, green technologies, organic gardening, and composting. The Green Team also worked closely to establish a clean energy capital and budget plan that supported the implementation of solar thermal and solar PV installations, and, with the help of Cape Light Compact, hosted a hands-on training in energy efficiency measures such as tightening building envelopes, adding insulation, and replacing inefficient lighting.

With a focus on demonstrating new ideas and technologies, WBNER has sponsored workshops where local plumbers and tech school students were trained to install solar thermal hot water systems, as well as hands-on weatherization workshops where home owners learned how to make their own homes more energy efficient. The WBNER Green Team continues its efforts to raise community awareness about energy consumption, greenhouse gas reduction, and sustainability.

WBNER Green Team efforts at a glance

- Installed renewable technologies that include a solar thermal hot water system and solar PV array.
- Offered workshops centered around energy efficiency, home weatherization, and renewable energy.
- Established an advanced recycling and composting program throughout the campus.

New Construction

While addressing existing building energy usage continues to remain a priority, LBE efforts also focus on ensuring that new construction is meeting and exceeding the Mass. LEED Plus standard set forth in E.O. 484, which requires LEED certification, minimum energy performance, and several other water and siting measures. Since 2006, 33 state building projects across 4.1 million square feet have earned LEED certification—a U.S. Green Building Council system that rates buildings based on "green" design, construction and operation. Of those, one was certified at the highest possible LEED Platinum level, 21 received the Gold rating, and ten were certified LEED Silver.

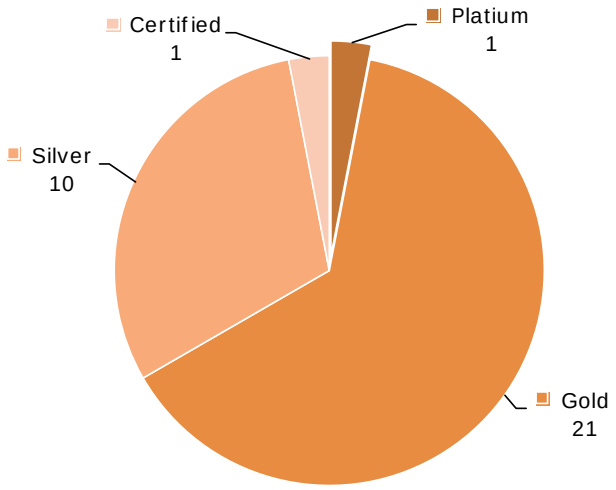


Figure 15: *Buildings Certified LEED since 2006*
The state has developed 33 LEED certified buildings.

In addition to LEED certified projects, more than 30 additional state building projects encompassing over five million square feet have been LEED-registered and are in various stages of design and construction. Of significance is the recent increase in LEED certified buildings reflecting a growing comfort level with LEED among state construction agencies. Of the 33 certified buildings, half (17) received certification since 2012 and 25 have received certification since 2010.

Moreover, in response to Governor Patrick's Zero Net Energy Buildings Task Force recommendations released in March 2009, DCAMM moved aggressively to design and construct two state-owned facilities to meet zero net energy building (ZNEB) standards. The facilities will produce as much clean energy as they consume over the course of a year. The first designed ZNEB, a 58,000-square-foot student and nursing classroom building at North Shore Community College in Danvers, opened in late 2011 and includes features such as a ground source heat pump with geothermal wells, natural ventilation, chilled beams, a highly efficient building envelope, a 345 kW solar PV array, and a green roof. In December 2012, the state broke ground on the second building, a 45,000-square-foot Department of Fish and Game Field Headquarters in Westborough, which is expected to be completed in 2014. Building energy use will be tracked over time to determine whether these buildings are performing at their targeted levels and to provide feedback for future projects. See the Project Spotlight on following page.

LEED Buildings at State Facilities
Mass. Maritime Academy Library & MassDEP Wall Experiment Station

The American Bureau of Shipping Information Commons (ABSIC), also known as the Mass. Maritime Academy Library, earned LEED Gold Certification in September 2011 becoming one of the most innovative academic buildings housing a library but also a rich program of training, study, and research space. The cutting-edge technology in this LEED Gold building includes a multimedia smart classroom and a 360-degree ship's bridge simulator as well as a museum. ABSIC's energy performance is projected to exceed the state code by 26 percent, and its energy and environmental management components have been incorporated into hands-on training and experiments for Massachusetts Maritime students. Sustainability features include:

- Passive solar and day lighting
- Water conserving fixtures
- Lighting; 4,000 CFL and LED bulbs
- Ground source heat pump heating and cooling
- Recycled construction materials including steel, concrete and insulation
- Planted landscape that requires no irrigation
- Water capture technology on the roof

MassDEP Sen. William X. Wall Experimental Station in Lawrence was the first state building to achieve in 2013 the highest possible LEED rating—Platinum. Given the more intensive energy requirements, the variable hours of operation, and the rigorous health care requirements associated with labs (pictured on right), the LEED Platinum status is considered even more impressive. The building includes:

- Use of local and recycled materials
- Double-paned low-emissivity windows
- Rainwater gardens that collect water for use in toilets and chillers
- Green and white roofs
- Day-lighting measures
- Electric vehicle charging station
- Bike storage room with shower facilities
- 53 kW solar PV array with a live data display in the lobby

What is a Zero Net Energy Building?

A zero net energy building (ZNEB) is one that is optimally efficient, and over the course of a year, generates energy onsite, using clean renewable resources, in a quantity equal to or greater than the total amount of energy consumed onsite. Zero net energy buildings are already being designed and constructed in Massachusetts, particularly in the residential sector. In addition to saving energy and reducing greenhouse gas emissions, zero net energy buildings can provide significant cost savings for residents and businesses, and stimulate clean energy technology development and job growth in the Commonwealth

ZNEBs at Division of Fisheries & Wildlife Headquarters and North Shore Community College

Two buildings are leading the way in Massachusetts' Zero Net Energy Buildings (ZNEB) initiative. North Shore Community College's Health Professions & Student Services Building (NSCC) in Danvers, the first state-owned zero net energy-designed building, was completed in 2011. Soon to follow is a new Division of Fisheries & Wildlife (DFW) field headquarters facility in Westborough, with an expected completion date of Fall 2014. ZNEBs generate energy onsite, using clean renewable resources, in a quantity equal to or greater than the total amount of energy consumed.

NSCC's $31 million, 58,000-square-foot building (pictured on left) was designed to use natural ventilation, energy-efficient lighting, a green roof, advantageous building orientation, chilled beams, geothermal energy technologies and a 345 kW photovoltaic (PV) array that was designed to provide all the building's energy needs over the course of a year.

The DFW's $25 million, 45,000-square-foot facility features a geothermal heating and cooling system, a 72 kW solar array, innovative mechanical systems, and a highly efficient envelope with a triple-glazed curtain wall, as well as structural insulated panels.

The building has been oriented to optimize production from the rooftop PV panels while minimizing heating and cooling energy. The formal groundbreaking led by Governor Patrick in December 2012 is pictured on the left.

LBE Partners and Their FY12 Results—Energy Usage Intensity, Weather Normalized

LBE collected data from various state agencies, authorities, and campus for E.O. 484. Energy consumption data from all LBE partners was analyzed for GHG emissions. A subset of the energy consumption data was analyzed for EUI.

Energy Usage Intensity, Weather Normalized

Listed below, the forty-three agencies included in Energy Usage Intensity (EUI) metric for fiscal years 2004 to 2012 with their FY12 Weather Normalized EUI metric (in kBtu/SF) and progress beyond the LBE Baseline (FY04).

Agency Name	EUI	% Improvement
Berkshire Community College	106.06	9%
Bridgewater State University	122.89	10%
Bristol Community College	125.24	-2%
Bunker Hill Community College	129.71	-8%
Bureau of State Office Buildings	91.40	4%
Cape Cod Community College	53.58	35%
Chelsea Soldier's Home	118.88	-5%
Department of Correction	219.13	-20%
Department of Developmental Services	206.93	-3%
Department of Environmental Protection (MassDEP), owned facilities	384.46	-129%
Department of Fire Services	69.54	39%
Department of Mental Health	120.09	28%
Department of Public Health	168.55	-24%
Department of State Police	101.53	-16%
Department of Youth Services	144.82	-7%
Division of Capital Asset Management	93.58	3%
Fitchburg State University	105.85	6%
Framingham State University	92.12	30%
Greenfield Community College	121.66	-33%
Holyoke Community College	66.50	10%
Holyoke Soldier's Home	112.08	6%
Massachusetts Bay Community College	74.25	17%
Massachusetts College of Art & Design	78.85	15%
Massachusetts College of Liberal Arts	95.46	30%
Massachusetts Maritime Academy (MMA)	74.64	-2%
Massachusetts Military Division	47.34	25%
Massasoit Community College	93.30	6%
Middlesex Community College	61.41	19%
Mount Wachusett Community College	113.06	-2%
North Shore Community College	63.83	9%
Northern Essex Community College	79.35	0%
Quinsigamond Community College	69.61	21%
Roxbury Community College	56.89	-8%
Salem State University	97.82	17%
Springfield Technical Community College	103.06	4%
Trial Court	84.44	1%
UMass Amherst	176.15	3%
UMass Boston	77.87	6%
UMass Dartmouth	145.89	11%
UMass Lowell	131.59	20%
UMass Medical School	556.61	11%
Westfield State University	119.44	13%
Worcester State University	77.79	27%

5 Increasing Renewable and On-Site Energy Generation

Overview

When Executive Order 484 was issued in 2007, wind and solar power were barely more than a novelty in Massachusetts. With just over 3 MW of each technology installed across the entire Commonwealth, seeing solar PV panels on the roof of a building or a wind turbine on the horizon were exceptions—interesting curiosities, but far from the norm.

Fast forward to today, and the picture has dramatically changed. Massachusetts is in the midst of a renewable energy revolution and, with the Patrick Administration's Executive Order 484 asking state agencies and public colleges and universities to "lead by example," public entities are important participants in this revolution

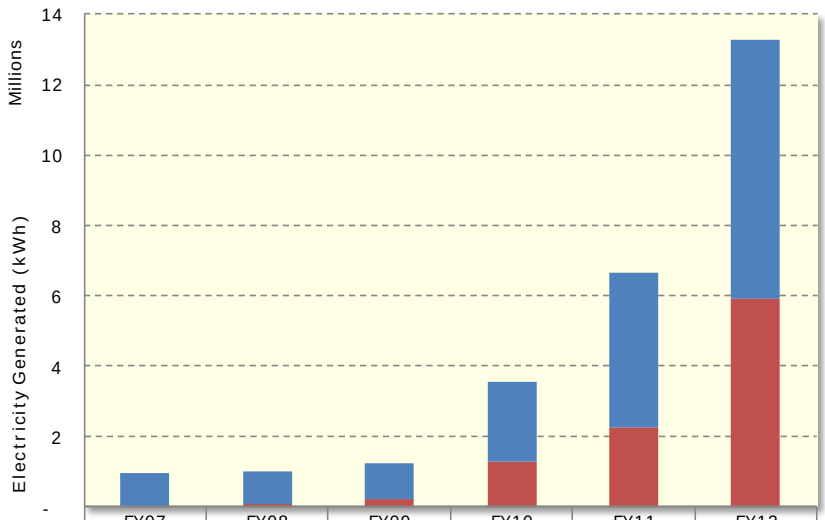
Results

In 2007, only a handful of solar PV arrays totaling some 100 kW and just one 660 kW wind turbine were installed on state properties—all told generating less than one million kWh of power for state agencies' use. Through a host of innovative financing efforts, ARRA funds, and the commitment of dozens of state facilities, installed solar PV has grown to some 7 MW and wind power has increased to more than 11 MW. On-site solar and wind power combined to provide state entities with more than 13 million kWh of electricity in 2012.

Agencies have also actively pursued on-site renewable generation from other sources including anaerobic digestion (at wastewater treatment plants) and small-scale hydro power. In fiscal year 2012, generation of on-site renewable power totaled 64,497,901 kWh (including 19.8 million kWh sold directly to the grid and not consumed by state facilities), equivalent to the electricity needed to power 8,487 Massachusetts homes.

In evaluating state government's progress toward LBE's renewable energy goals, it is important to consider the underlying purpose of the Executive Order's push toward renewable energy as well as changes in the clean energy landscape in the seven years since the order was signed. The Executive Order's call for renewable energy to comprise 15 percent of state government's total electricity consumption is intended to be part of an over-arching strategy to reduce reliance on fossil-fuel generated electricity, reduce GHG emissions associated with the inefficient production of electricity from the grid, reduce energy costs, increase energy self-reliance and security, and assure that state operations play a part in expanding the number of jobs and companies in the state's growing clean energy economy.

In 2007, achievement of those goals was envisioned to occur mainly through greater deployment of solar and wind power and, with a 70-fold increase in installed solar and 100-fold increase in installed wind, much progress has clearly been made in this area. In terms of the state's progress



	FY07	FY08	FY09	FY10	FY11	FY12
On-Site Wind	951,919	944,814	1,000,208	2,303,789	4,361,985	7,363,012
On-Site Solar PV	5,931	88,142	236,422	1,273,003	2,283,635	5,933,549

Figure 16: *Wind and Solar PV Generation, FY07 to FY12*
On-site wind and solar PV electricity generation at state facilities have increased by over 1000% since FY07.

towards realizing the fundamental intent of E.O. 484, however, these statistics tell only part of the story.

Commonwealth agencies and institutions of higher education have coupled installation of solar and wind power with deployment of another technology: combined heat and power (CHP). Largely absent from the state's arsenal of clean energy solutions in 2007, CHP (sometimes called co-generation), which generates both electricity and thermal energy from one fuel source, has emerged as a potent tool for achieving many of the benefits previously associated only with renewable power. At public universities, prisons, state hospitals and other locations, the Commonwealth has targeted replacement of antiquated heating plants with CHP facilities powered by cleaner natural gas, which improve the overall efficiency of energy systems while cutting GHG emissions and other air pollutants, reduce energy costs, and decrease reliance on grid electricity.

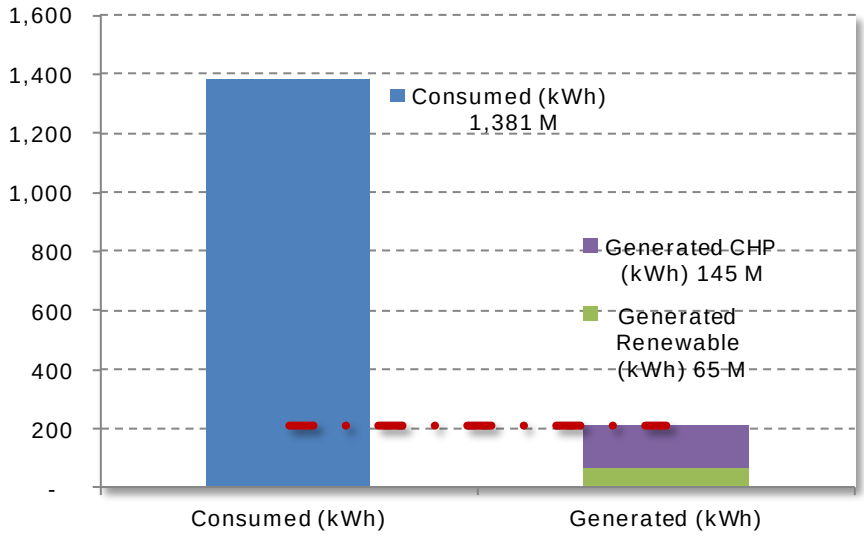


Figure 17: *Percent On-Site Generation vs. Total Consumption*
In FY12, with a total electricity consumption of 1.3 billion kWh, 210 million kWh were generated by on-site renewable power (green bar) and CHP (purple bar), just over 15% of state government's total electricity consumption. Red line represents E.O. 484 Target for FY12, 207.14 million.

Combined Heat and Power (CHP)

CHP, also called co-generation, generates both electricity and thermal energy from one fuel source. CHP was largely absent from the state's arsenal of clean energy solutions in 2007. It has emerged as a potent tool for achieving many of the benefits previously associated only with renewable power.

Along with the steady ramp-up of solar and wind power, this aggressive deployment of CHP has advanced the Administration's goals related to powering state government operations with cleaner sources of energy. The executive order sets a target for 15 percent of total consumed electricity to come from renewable sources. In FY12, with a total electricity consumption of 1.3 billion kWh, at least 207 million kWh would be required from clean sources to fulfill the E.O. target. When on-site generation from clean CHP, solar PV, hydro, wind, and anaerobic digestion are added together, some 210 million kWh of clean electricity are produced at facilities. This on-site generation comprises 15.21 percent of the total electricity consumption at state facilities, up from only 6 percent in 2007. When broken out in more detail, the electricity generation coming from renewable sources equaled 4.7 percent, up from 3.5 percent in 2007, while generation from on-site CHP totals some 10.5 percent of total commonwealth agency electricity consumption.

The move toward cleaner sources of electricity, along with efficiency efforts, has helped stop, even reverse the growth in grid electricity consumption taking place a decade ago. In fact, between FY06 and FY12, the Commonwealth actually reduced consumption of grid electricity by 8.6 percent, despite the growth in square footage and operating hours of many state

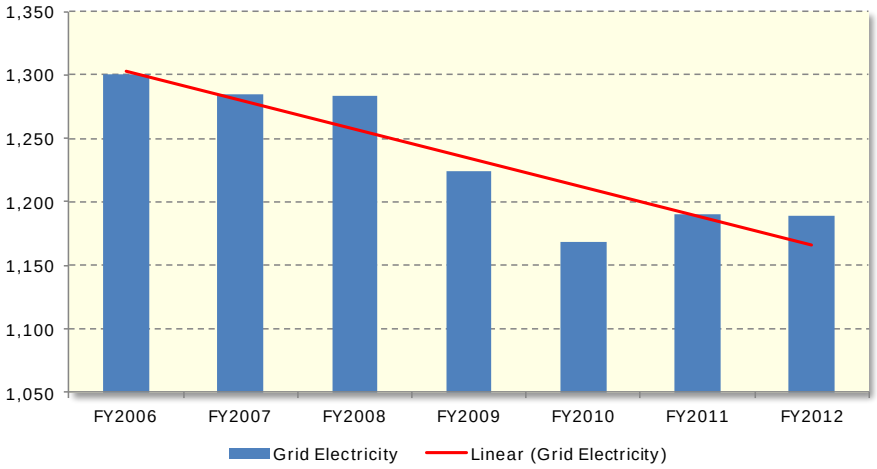


Figure 18: *Grid Electricity Consumption, FY06 to FY12*
Consumption (shown in millions of kWh) has been decreasing since FY06.

facilities (shown below). These efforts have helped to lower peak electricity demand in the region as a whole, thus reducing the need to build new power plants or to fire up fossil-fuel powered "peaking plants" during heat waves—a factor that contributes to lower emissions of GHG and other pollutants.

Strategies

Clean Energy Investments & Projects

LBE partners across the Commonwealth are contributing to the E.O.'s renewable energy goals. Twenty-eight state agencies and colleges in the Commonwealth receive power from cleaner on-site sources. The MWRA leads the way with more than 4 MW of installed wind and solar PV across multiple facilities along with many other hydro and anaerobic digestion systems (see Agency Spotlight below).

Further examples of the LBE Program's successful efforts to transition the Commonwealth from polluting forms of grid-based electricity to on-site generated renewable and other clean energy alternatives are myriad. They include:

- Investment of approximately $7 million in federal Recovery funds to install 37 solar PV systems between 2010 and 2012, totaling 2.8 MW at 19 state-owned facilities and projected over 30 years to generate 94 million kWh of renewable power, reduce energy bills by $12 million and eliminate over 38,000 metric tons of GHG emissions;
- Two wind turbines with combined capacity of 3.3 MW, 100 kW of solar PV, and a wood chip-powered heating plant at Mt. Wachusett Community College, enabling the campus to run nearly entirely on renewable energy;
- The DOC's installation of over 4.3 MW of solar PV and wind across multiple facilities, the largest amount of renewable energy at any Executive branch agency, with on-site generation from renewable energy and clean CHP accounting for 18 percent of the agency's total electricity consumption in FY12; and
- Numerous other renewable energy projects at state colleges and universities including: a 600 kW wind turbine and 369 kW of roof-mounted solar PV at UMass Dartmouth; a 394 kW solar installation at Berkshire Community College; a 379 kW rooftop solar array at Massasoit Community College; and 345 kW of solar power along with a ground source heat pump system at North Shore Community College.

Powering with Wood, Department of Conservation and Recreation

The Department of Conservation and Recreation (DCR) is offsetting the use of tens of thousands of gallons of #2 heating oil each year at two of its western Massachusetts properties, showcasing the clean energy potential of wood. DCR installed a wood chip heating system at its 53,952 square foot Quabbin Reservoir Administration Building in Belchertown in 2008. Initially powered with sawmill chips but eventually envisioned to be fueled entirely with sustainably harvested wood from the surrounding DCR-managed forest, the Quabbin boiler burned 312 tons of wood chips during the 2012–13 heating season, offsetting the use of 23,400 gallons of #2 fuel oil and over 200 tons of fossil-fuel derived carbon emissions, while supporting the local economy and saving DCR some $75,000 in annual heating costs. A display panel in the building's visitor center monitors the heat produced, carbon offset, and the fossil fuels displaced.

Meanwhile, two wood pellet boilers at DCR's Mt. Holyoke Range State Park in Amherst have offset an average of over 3,600 gallons of #2 heating oil per year since they were installed in 2010. Combusting an average of over 30 tons of pellets per year combined, the OkoFEN boilers provide locally-sourced heating for the park's 3,140 square foot Notch Visitors Center and 4,158 square foot Moore House and Garage.

Deer Island Wastewater Treatment Plant, Mass. Water Resources Authority

Long credited with helping to achieve a dramatic cleanup of Boston Harbor through its deployment of state-of-the-art wastewater treatment technologies at the Deer Island Wastewater Treatment Plant, the Massachusetts Water Resources Authority (MWRA), in recent years, has expanded its environmental stewardship to include clean energy, embracing a plethora of on-site and renewable energy options that serve as a model for similar facilities across the country. A recipient of the U.S. Environmental Protection Agency's Energy Leadership Award and two LBE Awards, MWRA's Deer Island facility—the country's second largest sewage treatment plant—now gets 25 percent of the energy needed to treat its daily average wastewater volume of 350 million gallons from on-site and renewable power generation facilities.

Deer Island is among the largest electricity users in the Northeast, responsible for handling wastewater from 43 Eastern Massachusetts communities and shouldering an annual energy demand of 18 MW and yearly electric bill of about $16 million. These statistics were powerful incentives for the Authority's investment in a suite of energy alternatives ranging from ground- and rooftop- solar PV systems and wind turbines to anaerobic digesters (AD) and hydro-electric generators that capture water as it drops from the plant into the outfall tunnel shaft. The island's renewable energy generation now offsets 25 percent of its Deer Island energy bill, a $3.4 million value.

In addition to all the measures implemented at Deer Island, MWRA has installed solar PV, wind, and hydro at several other water and wastewater locations, resulting in significant decreases in grid electricity and an increase in renewable energy generation. MWRA has decreased use of grid electricity by 17 percent between fiscal years 2006–2012 and increased renewable energy generation by 38 percent over the same timeframe. In fiscal year 2012, MWRA generated 27 percent of its total electricity consumption from onsite renewable sources.

Deer Island at a Glance

Wind—Two 600 kW "conventional" turbines, generating approximately 2 million kWh of electricity per year, and one 100 kW FloDesign prototype turbine.

Solar PV—736 kW producing 850,000 kWh of clean electricity generation per year.

Anaerobic Digesters**—Co-generation using methane from on-site digesters saves approximately five million gallons of fuel oil annually; saving some $2.6 million per year (pictured left).

Hydro—Two 1 MW hydroelectric generators producing almost 6 million kWh per year (pictured bottom left).

*** In addition to generating energy, AD produces sludge that is pelletized to become fertilizer, and then given to cities and towns served by the Authority and sold to turf farms.*

Continuing this trend, the LBE Program last year provided grants to support renewable and on-site power projects at state-owned facilities. Totaling nearly $1.3 million, the LBE grants include:

- $75,514 for a ground source heat pump at Middlesex Community College that will save an estimated 27,695 kWh of electricity and 5,392 therms of natural gas, resulting in $10,000 in energy costs annually;
- $38,300 for a solar thermal system at Quinsigamond Community College; and
- $387,000 for a power plant cooling system at UMA to further boost the efficiency of its CHP system.

Additionally, two UMass campuses are leading the way in generating clean on-site power from large-scale CHP power plants. In 2009, UMA installed a 10 MW natural gas fired CHP system that provides the vast majority of electricity and heat needed to operate the 10 million square feet of buildings that comprise the state's largest higher educational campus. The new power plant eliminated the need to burn over 30,000 tons of coal, which had previously constituted some 40 percent of the campus' energy use. By 2012, UMA was generating 68 percent of all electricity use on campus from its CHP plant.

Largest CHP Plant at State Facilities, UMass Medical School

The University of Massachusetts Medical School (UMMS) is a 2010 Leading By Example Award winner based on the dozens of energy efficiency innovations it has implemented, in addition to its very successful CHP energy system. Recently, UMMS opened its new Albert Sherman Center, a 512,000-square-foot facility for biomedical research and education, which achieved LEED Gold certification, making it the greenest building on campus (pictured bottom right). With its on-site CHP system offsetting grid electricity use and many other initiatives, UMMS's greenhouse gas emissions have decreased by 25 percent since the LBE Baseline. Further, leveraged incentives through a partnership with National Grid provided an additional $5.6 million to UMMS for CHP expansion, which meant the project had a 2.4-year return on investment.

UMMS is served by a combined heat and power system (CHP) which uses energy byproducts of on-site electricity generation for 100 percent of the campus's heating and air conditioning (pictured top right). The on-site electricity generation saves up to 30 percent of fuel that would have been lost in the transport of energy from an off-site location, plus emits no greenhouse gases, since the steam produced for heating and cooling is used a second time to produce almost half of the electricity used on campus.

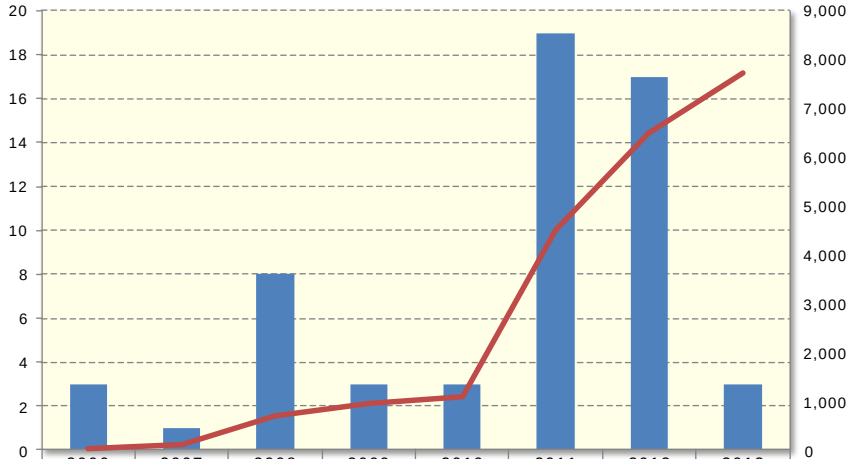
UMMS by the numbers:

- A 94 percent reduction in oil usage since 2007, eliminating more than 1.9 million gallons of #6 fuel oil
- 40,079 additional metric tons of CO2 reduction expected with CHP plant expansion
- 17.5 MW CHP power plant is the largest at any state facility
- $5.6 million in leveraged incentives from National Grid

Meanwhile, at the UMMS in Worcester, a recently expanded co-generation plant is expected to supply all campus heating/cooling demands, as well as most of the electricity needed to run the campus.

With co-generation systems proving both fiscally and environmentally effective, additional installations have taken place through DCAMM oversight at UMass Dartmouth, Dept. of Correction Bridgewater, and the Wrentham Development Center, all of which will be operating in fiscal years 2013 to 2014.

State agencies have played a significant role in helping to grow solar installations. Between 2006 and 2013, solar installations at state owned facilities have grown from just 100 kW to more than 7MW, an impressive 7,400 percent increase.



	2006	2007	2008	2009	2010	2011	2012	2013
Installations	3	1	8	3	3	19	17	3
kW Installed	37	118	692	952	1,100	4,519	6,504	7,714

Figure 19: *Growth in Solar PV Installations at State Facilities since FY06*
Solar PV installations have multiplied throughout the Commonwealth since the executive order was signed, with over 53 installations to date.

The LBE Program and its partners have taken advantage of an array of state, federal and utility grants and incentives to finance these projects. Clean Renewable Energy Bonds provided no and low interest financing for renewable projects, while ARRA funds supported a good portion of installations in 2011 and 2012. Renewable energy projects at state facilities have also benefited from the sale of Renewable Energy Certificates (RECs)—especially Solar Renewable Energy Certificates (SRECs), which alone have generated over $1.4 million in FY12 revenue for state agencies to help offset the costs of renewable power. Utility incentives have been critical to funding large CHP projects—National Grid provided $5.6 million to UMMS's new CHP plant- and many projects are financed in part by CEIP, which uses low-interest state bonds to finance energy projects, which are then paid for through savings.

A growing number of state facilities are moving forward with power purchase agreements (PPA), where third party owned systems get built with minimal or no public monies and generated electricity is then sold to the state at a discounted price. There are some 1.6 MW of solar PV PPAs in operation, with many additional MWs planned.

Financing Renewable Projects

- Clean Renewable Energy Bonds
- ARRA Funds
- Renewable Energy Certificates
- Utility Incentives
- Purchase Power Agreements

Solar Leaders, Two Community Colleges

Community colleges have become leaders in the effort to enhance renewable energy across Massachusetts. Collectively, the fifteen Massachusetts community colleges have installed 3.6 MW of solar PV under the LBE Program. Berkshire Community College and Massasoit Community College (pictured) are standouts in this category—with a combined solar capacity of nearly 765 kW, enough electricity to power approximately 115 typical Massachusetts homes for a year.

The Massasoit Community College 370 kW rooftop solar PV array, positioned on five buildings of the Brockton campus, similarly provides multiple benefits. The array is expected to meet 8 percent of the college's current electricity needs and to save up to $60,000 annually in energy costs. College members and visitors can learn about the project through the real-time energy generation monitors displayed in the five buildings.

At Berkshire Community College, the 394 kW solar array is expected to generate enough electricity to meet 20 percent of the schools demand, but another benefit is that rooftop systems inverters and panels were all manufactured and installed by businesses in Lawrence, Devens, and Worcester.

Bioheat

As part of the Administration's efforts to increase the sustainability of Commonwealth operations, E.O. 484 directed state agencies to move, by 2012, toward a minimum blend of 10 percent bio-based fuel for all heating applications previously using #2 heating oil. While barriers such as lack of fuel supply and blending facilities and insufficient local infrastructure have delayed progress toward this original target, increased reliance on bioheat remains an LBE goal.

A new state contract in 2010 for heating fuels provided access to fuel oil that contains waste grease, oils, and fats, a greener option than the previous soy based biofuel available to agencies. But, due to fuel supply and delivery constraints, this waste oil blend is only available in three of the eight state delivery zones. In 2012, approximately 18,000 gallons of bioheat were purchased by state agencies through the statewide contract.

Many vehicles in the state fleet are currently using a 5 percent blend of biodiesel. In 2012, by using approximately 832,000 gallons of B-5 fuel instead of diesel, state agencies reduced GHG emissions in the transportation sector by over 430 metric tons.

6 Energy Costs

Although the executive order did not require an analysis of energy costs, any examination of clean energy programs would be incomplete without an attempt to determine the impacts on energy expenditures. In this section, we examine the actual energy costs borne by the state over the past decade and the impact LBE efforts have had on avoiding energy costs based on a projected business as usual analysis.

As most have experienced across the country, energy costs for the forty-nine LBE partners tracked for this report have increased over the past decade from FY02 to FY12. The good news is that these costs actually reached their peak in 2008 and have steadily declining over the past four years, with actual energy costs $32 million less in 2012 than they were four years earlier.

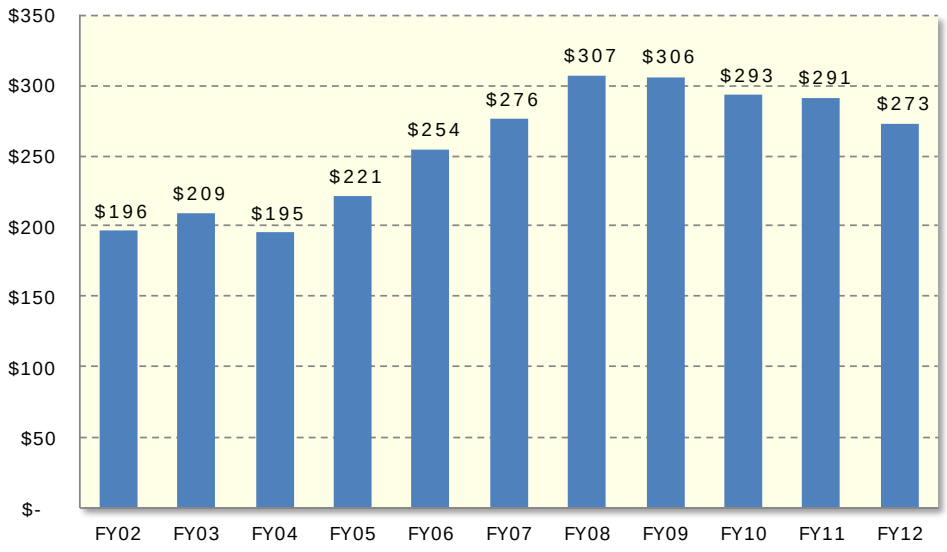


Figure 20: *Annual Energy Costs, LBE Baseline to FY12*
Actual annual energy expenditures, shown in millions, for all LBE Partners.

Some of this decrease in energy expenditures in recent years can be attributed to the drop in natural gas prices and slightly lower electricity prices. However, since many LBE efforts since 2006 have focused on building efficiency, the switch to cleaner and less expensive fuels, and installation of renewable power, we can examine the impacts of these efforts on actual energy expenditures versus a business as usual scenario. In other words, how do the actual energy costs compare with what the state's energy costs would have been had no investments been made in new equipment, efficiency improvements, and renewable energy?

To conduct this analysis, LBE staff looked at five years of weather normalized energy use and cost data from FY02 through FY06 (the Baseline for the Energy Cost Avoidance section) and created two different Business As Usual (BAU) scenarios for FY07 through FY12. By beginning the scenarios in FY07, the cost impacts related to the work done by the Patrick Administration could be observed. These scenarios assumed that the weather normalized baseline energy use would continue to change at the same rate over the next six years for each of the fuels consumed by Commonwealth agencies.

Under the first BAU scenario, LBE assumed that all energy consumption other than electricity would continue to change at the same rate as during the baseline years. This scenario then assumed that electricity use at state agencies would grow in line with the 2006 ISO-New England electricity forecasts for regional electricity use from 2007 to 2012. The second BAU scenario assumed that all energy consumption would continue to change at the same pace as during the baseline years. These two differing scenarios are used to capture the varying assumptions, recognizing that forecasting energy use can be difficult to predict.

Under both these scenarios, the actual fuel rates paid by each LBE Partner (e.g. $/gallon of oil or $/kWh) were then applied to the BAU estimates for fuel use to determine overall costs. In other words, the two BAU scenarios are based on historic, weather normalized projected consumption rates but with actual fuel costs applied to develop BAU costs for each fuel. (See Appendix C for more details on this methodology.) This calculation was done for each fuel used by LBE Partners.

As can be seen in Figure 21 below, the two BAU scenarios result in total projected BAU energy costs in FY2012 total between $279 to $295 million, some $36 million to $51 million more than the actual costs in that same year. Calculating the annual variance between each year's BAU and actual costs yields total cumulative avoided energy costs between $93 million and $166 million during the years 2007-2012, for an average annual avoided energy cost of between $18 and $33 million.

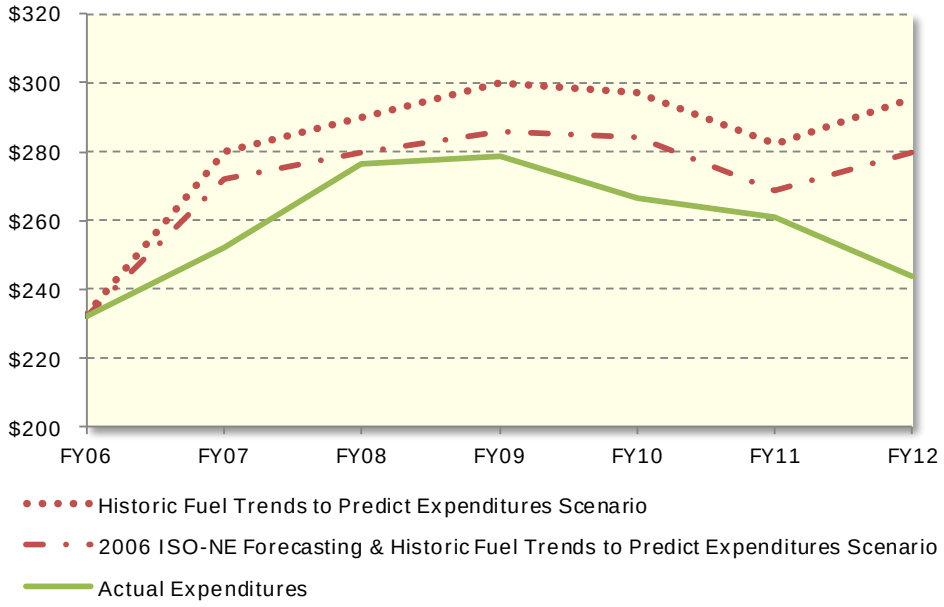


Figure 21: *Actual Energy Costs vs. Business as Usual, LBE Baseline to FY12* An analysis of actual fuel costs as compared to the Business as Usual (BAU) costs shows a variance between $36 million to $51 million in FY12 for building energy consumption. Energy costs shown in millions of dollars.

Through a host of energy and equipment investments, the Commonwealth has achieved total cumulative avoided energy costs of between $93 million and $166 million from 2007 to 2012.

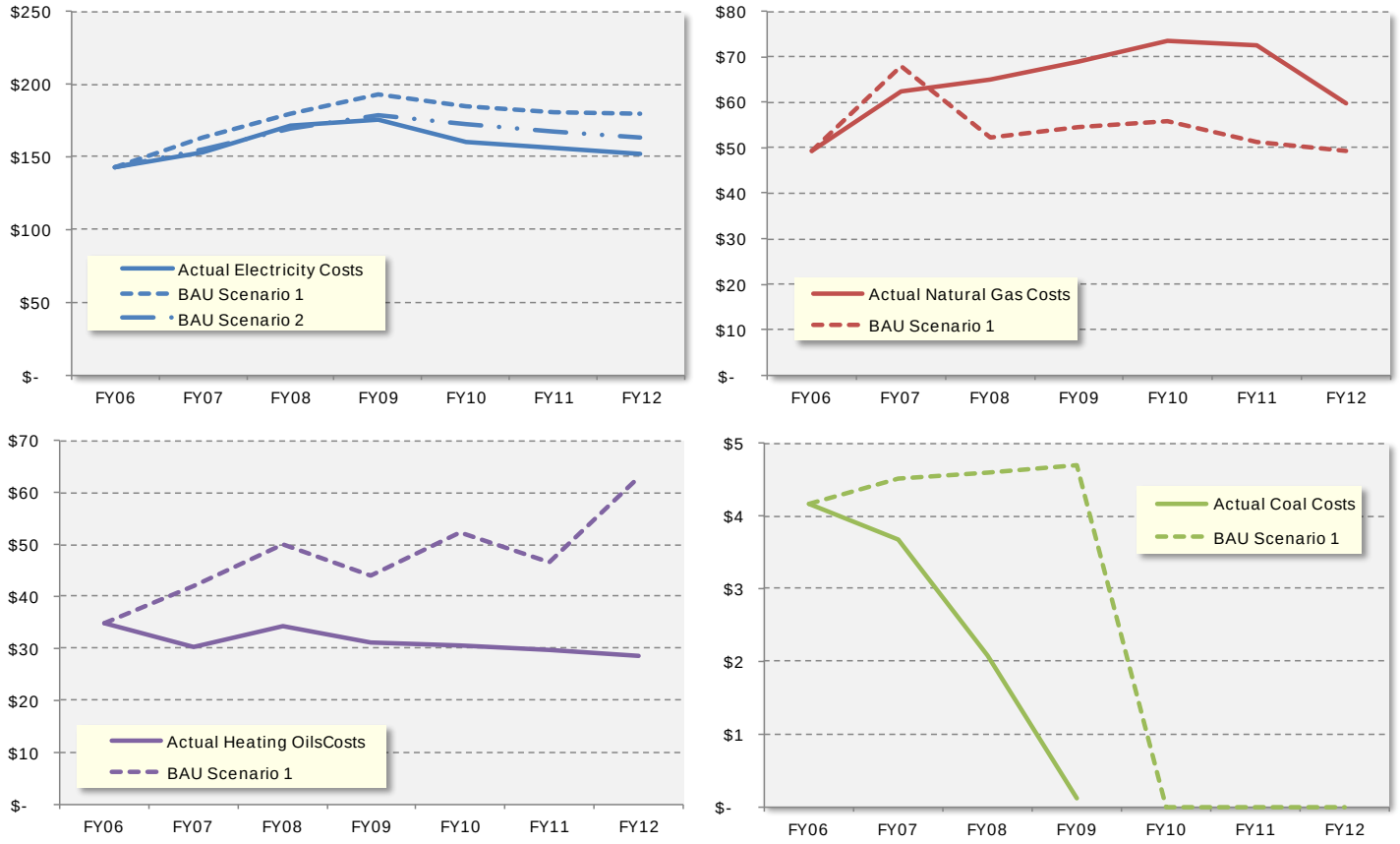
To determine more specifically where these avoided costs are derived, LBE staff examined the data associated with the consumption of grid electricity, and natural gas, fuel oil, and coal for heating. Between 2006 and 2012, the LBE analysis shows that while expenditure on heating oil decreased by only 14 percent, actual use of heating oil decreased by 62 percent. At the same time, natural gas prices increased by 30% while consumption grew by 80 percent. This makes clear that the significant investment in high efficiency equipment that moved agencies from dirtier, more costly oil to cleaner, less expensive natural gas has clearly played a key role in avoiding dramatically higher energy costs.

	Actual Energy Costs	Business As Usual (Scenario ISO-NE forecast + Historic Trends)	Business As Usual (Scenario Historic Trends)	Cumulative Avoided Energy Costs (Scenario ISO-NE forecast + Historic Trends)	Cumulative Avoided Energy Costs (Scenario Historic Trends)
FY02	$184,807,672	n/a	n/a	n/a	n/a
FY03	$196,000,510	n/a	n/a	n/a	n/a
FY04	$182,347,668	n/a	n/a	n/a	n/a
FY05	$204,310,079	n/a	n/a	n/a	n/a
FY06	$232,325,863	n/a	n/a	n/a	n/a
FY07	$251,834,304	$272,210,851	$280,057,828	$20,376,547	$28,223,524
FY08	$276,363,063	$279,932,483	$289,923,057	$23,945,966	$41,783,518
FY09	$278,706,948	$285,818,073	$299,652,525	$31,057,091	$62,729,094
FY10	$266,229,467	$284,377,211	$296,932,354	$49,204,835	$93,431,981
FY11	$260,841,945	$268,407,172	$282,331,605	$56,770,062	$114,921,641
FY12	$243,515,413	$279,859,274	$295,304,297	$93,113,923	$166,710,524

Table 2: Cumulative savings in FY12 reflect a difference of between $93.1 million to $166.7 million between actual costs and those from the BAU case.

As seen in the graphs and chart below, the BAU analysis demonstrates that the vast majority of avoided energy costs between 2006 and 2012 stem from projects that affected primarily grid electricity and natural gas, fuel oil and coal for heating. While the dramatic increase over this time period in the use of natural gas resulted in a $70.8 million increase in expenditures as compared to the BAU scenario, the avoided costs associated with eliminating coal total $7.9 million, avoided costs of fuel oil $113.3 million, and avoided expenditures of grid electricity between $37.9 million to $111.6 million. In sum, the cumulative avoided costs associated with these four sources of energy over this six year period total $88.4 million to $162 million.

The story told by these data is clear. By moving away from heating oil to cleaner burning natural gas, and installing of on-site renewable and CHP technologies, LBE partners have helped to dramatically slow the growth in energy expenditures, avoiding between $93 million to $166 million in higher energy costs that would have resulted had these investments not been made.



Figures 22: *Actual Energy Expenditures vs. BAU Projected Costs, FY06 to FY12*
Cost comparison between actual expenditures and the BAU Scenarios 1 and 2, the scenario using historic fuel trends to predict expenditures and the scenario using 2006 ISO-NE forecasting and historic fuel trends to predict expenditures, respectively. Expenditures are shown in millions of dollars. Note that the BAU Scenario 2 is only available for electricity.

Fuel Type	Actual Expenditures	Scenario 1	Scenario 2
Coal	$ 5,869,724	$ 13,811,606	Same
Electricity	$ 968,386,896	$ 1,079,965,963	$ 1,006,369,361
Heating Oils	$ 184,494,094	$ 297,796,031	Same
Natural Gas	$ 401,906,675	$ 331,102,634	Same
Other	$ 990,491	$ 1,624,087	Same
Steam	$ 15,843,262	$ 19,901,345	Same
Grand Total	$ 1,577,491,141	$ 1,744,201,665	$ 1,670,605,064
Difference between Actual and Scenario		$ 166,710,524	$ 93,113,923

Table 3: Comparison for all Fuel Types, Actual Cost and BAU Scenarios 1 and 2
When comparing the actual cumulative fuel expenditures to the BAU cumulative fuel expenditures, the total avoided energy costs are between $93 million and $166 million.

LBE and ARRA

Federal funding received under the 2009 American Recovery and Reinvestment Act (ARRA) allowed Leading By Example (LBE) to significantly expand its energy efficiency and renewable energy initiatives at a time when the national recession was restricting the ability of Massachusetts, and all states, to invest in public buildings and facilities. LBE leveraged about $24.6 million from ARRA to procure $133.5 million in additional public and utility investments for state facility improvements estimated to produce greenhouse gas emission reductions equivalent to removing 139,802 cars from the road. In addition, LBE project investments generated 1,162 construction-related jobs.

ARRA funding supported LBE in five project categories: comprehensive energy projects, low emissivity rink ceilings (pictured right top), small-scale efficiency projects, LED light bulbs, and real-time energy metering (pictured right middle and bottom). The majority of Leading By Example's ARRA funds, $9.7 million, went toward supporting the Enterprise Energy Management System (EEMS) Program, which installed 1,291 real-time energy meters at 469 buildings to enhance energy efficiency planning. EEMS is the largest project of its kind in the United States.

Other LBE projects supported by ARRA funding and money leveraged through ARRA include: 238 energy conservation measures by the Division of Capital Asset Management and Maintenance, low emissivity ceilings at five public ice skating rinks, 86 small-scale energy efficiency and lighting projects, and the purchase of 7,464 LED light bulbs for 58 state facilities. Overall, LBE's investment of ARRA funds helped reduce energy use and GHG emissions at more than 200 state-owned facilities.

7 Other LBE Efforts

Demand Response Program and Forward Capacity Market

State agencies have made great strides in expanding enrollment into Demand Response programs sold into the Forward Capacity Market, resulting in significant revenue for the Commonwealth and lower energy costs through reduced peak demand. These programs enable state (and other) entities to commit to ISO New England, the regional grid operator, that in times of extreme conditions and high demand on the grid, they will be able to curtail their electric demand and, as a result, be paid an agreed upon amount for making such commitments.

Participation in grid demand response programs has generated $4.7 million in revenue over 6 years.

From 2006 to 2012, the number of sites enrolled in demand reduction programs grew significantly from 10 to 98, an increase of 840 percent. Correspondingly, the number of MW of clean energy installed in these programs swelled from 7.8 MW to 44 MW, a 465 percent increase. During this time frame, participation in these programs resulted in close to $4.7 million in revenue paid to the state through ISO New England, the region's electricity

grid operator. The majority of those funds were returned to the agencies participating in demand response to be used for maintenance and energy needs, as well as funding energy efficiency efforts.

Energy Training and Maintenance Program

Over the past six years, a number of facility management trainings have been offered to state employees across the Commonwealth. Through the DCAMM Massachusetts Association of Facility Managers, over 1,000 state employees have been trained in a wide range of building and facility operational areas, from fire safety to indoor air quality to snow blower safety. Many of these trainings included sessions related to energy using equipment, including:

- Building control systems
- Demand response
- Infra red cameras
- Lighting solutions
- HVAC systems

- Motor management
- Operations and maintenance efficiencies
- Preventative maintenance
- Steam traps
- Chiller servicing

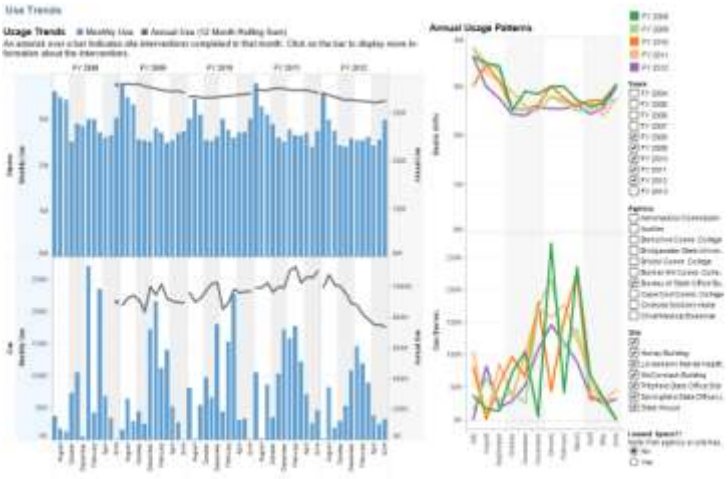
Additionally, between 2007 and 2012, 142 state employees received comprehensive building management and maintenance training by attending 75 hours of intensive training over a three month period and receiving Building Operator Certification (BOC). The BOC training is a nationally recognized, competency-based training and certification program that offers facilities personnel the improved job skills and knowledge to transform workplaces to be more comfortable, energy-efficient and environmentally friendly.

Recently, from 2011 through 2013, over 40 on-site trainings and webinars have been held to support agency staff in analysis of real-time energy consumption data being obtained through EEMS, the

ARRA funded project that installed some 1,300 meters across 25 million square feet of state buildings. The trainings have offered an overview of the power of EEMS to identify and address energy issues and have helped facilities target specific energy anomalies at specific buildings.

Energy Information System for Tracking Use

Collecting energy use data in order to track facility, agency and statewide progress toward meeting the goals of the Executive Order is critical to ensuring success of the LBE Program. With thousands of state electric and gas accounts, and state procurement of fuels such as heating oil, propane, gasoline, and diesel through various channels from various vendors, however, this is also a complicated and difficult undertaking.



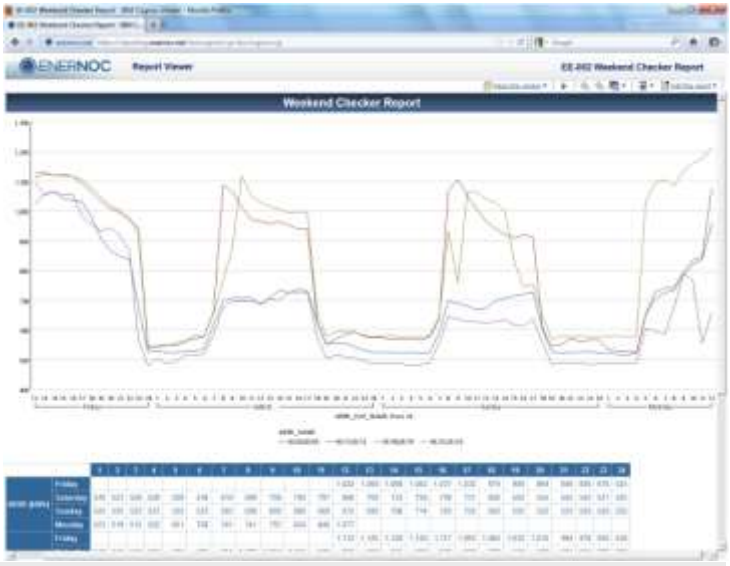
MassEnergyInsight (MEI) use trends report allows LBE partners the ability to compare utility account usage for different years.

Since adoption of E.O. 484, the Commonwealth has developed a number of means and tools to track the data necessary for measuring progress toward its goals. In 2010, the DOER's Green Communities Division created MassEnergyInsight (MEI), a web-based tool that loads usage and cost data related to various state facility accounts directly from electric and gas utilities, and then allows DOER and state agencies to easily access and compare energy use, costs and associated GHG emissions across years for all operations, by department, or for individual facilities. Some 8,500 electricity and gas accounts have now been loaded in MEI, providing a wealth of billing information related to state energy use.

The LBE partners who have installed EEMS at their facilities are:

- Division of Capital Asset Management and Maintenance
- Chelsea Soldiers' Home
- MassDEP Wall Experiment Station
- Department of Public Health
- Berkshire Community College
- Department of Correction
- Bunker Hill Community College
- Fitchburg State University
- Cape Cod Community College
- Massachusetts College of Art and Design
- Quinsigamond Community College
- Massachusetts Maritime Academy
- Northern Essex Community College
- Salem State University
- Bristol Community College
- Westfield State University
- Greenfield Community College
- Bridgewater State University (dormitories)
- Holyoke Community College
- Framingham State University (dormitories)
- Massasoit Community College
- UMass Lowell
- North Shore Community College
- Trial Courts
- Mount Wachusett Community College

Parallel to the MEI effort, DOER invested $9.7 million of ARRA funding to deploy EEMS. Through installation of this real-time metering program, EEMS produces data that enables agency and building managers to make swift adjustments to cut energy waste and maximize efficiency. EEMS has identified over $2.4 million in annual savings that could result



EEMS weekend checker report allows sites to compare how buildings are shutting down on different weekend.

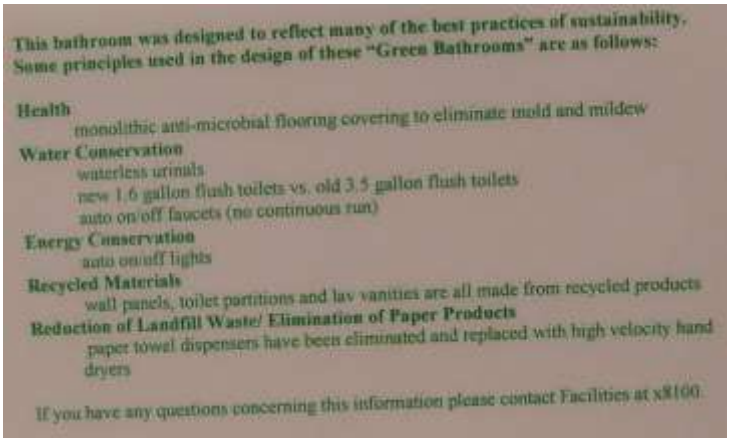
from addressing peak electricity demand and usage spikes to reducing night baseloads, maximizing weekend setbacks, and improving heat optimization. For example, UMass Lowell saw over $45,000 in savings by comparing the current and past energy usage at particular facilities and adjusting the building management systems at these facilities to previous schedules.

Innovative Technologies at State Facilities	
Technology: Advanced Energy Panels Company: Advanced Energy Panels, a division of Windo-Therm, LLC. http://www.advancedenergypanels.com Facility user(s): Berkshire County Sheriff's Department Prison	Description: Indoor mounted, double-pane, insulating window panels. Reduce building energy loss by eliminating air leaks around windows. May be used in historic buildings without compromising building architecture.
Technology: Autoflame Combustion Management System Company: George T. Wilkinson, Inc. http://www.gtwilkinson.com/autoflame.htm Facility user(s): Massachusetts College of Art and Design	Description: Autoflame® Combustion Management System is a microprocessor based, linkage-free control system that eliminates the use of 'old style' cams, rods and mechanical linkages, improves existing boiler combustion efficiency and reduces fuel use by up to 12%.
Technology: The Burner Booster Company: Energy Efficiency Solutions, LLC http://www.theburnerbooster.com/ Facility user(s): Department of Correction, Massachusetts Correctional Institution—Plymouth; Department of Youth Services, Metropolitan Youth Service Center—Dorchester	Description: The Burner Booster is a higher-efficiency replacement oil pump and nozzle system that works with a specially designed oil burner to create ultra-efficient combustion that reduces oil use, by as much as 30 percent.
Technology: Electric Vehicle Charging Station [Level 2] Company: Multiple Companies Web: search for *Electric Vehicle Charging Station [Level 2]* Facility user(s): Massachusetts Bay Transit Authority (7 locations); Massachusetts Port Authority—Logan Airport; Massachusetts Department of Transportation	Description: Alternative fuel technology—Level 2 (240 volt ac) charging stations with universal J1772 connector; provide electricity to all electric and hybrid electric vehicles currently on the market. Level 2 charging station reduces the charge time by 50 percent over a Level 1, (120 volt ac) charging station.
Technology: Energy Avenger Series™ Company: Integrated Systems International, LLC http://www.isienergycontrols.com/ Facility user(s): Massachusetts Department of Transportation, Highway Division, HOV facility; Massachusetts Bay Transit Authority—Alewife Station	Description: The Energy Avenger® is designed for HID (High Intensity Discharge) lighting fixtures; Metal halide, high pressure sodium, mercury vapor, etc. The technology reduces power being delivered to HID ballasts, reduces energy consumption, prolongs life of lamps and fixtures, Estimated energy savings: 20% to 35%.
Technology: FloDesign Wind Turbine Company: FloDesign Inc. http:/flodesign.org/ Facility user(s): Massachusetts Water Resources Authority—Deer Island	Description: In 2011 an engineering prototype 100kW vertical wind turbine, developed by FloDesign Inc., a MA company, was installed on Deer Island. The FloDesign Wind turbine is projected to produce higher efficiency results over traditional wind turbines.
Technology: Geothermal Energy and Water Systems Company: Multiple Companies Web: search for *Geothermal Energy and Water Systems* Facility user(s): North Shore Community College, Middlesex Community College, Mass. Maritime Academy	Description: Ground Source Heat Pumps (GSHP) extract heat or cooling stored in the upper layers of the Earth and delivers it into buildings for heating or cooling needs. Such systems can potentially reduce the energy costs for a facility by 25% to 40%.

The LBE Program collates data collected through MEI and EEMS, into a comprehensive MS Access database that tracks all state energy usage data. Additionally, the Program works closely with the Commonwealth's Operational Services Division to regularly obtain data on a variety of fuels purchased through state contracts to heat state buildings and fuel state vehicles. These data are also incorporated into the LBE database.

Reducing Potable Water Use

A number of state agencies have initiated water conservation measures in response to E.O. 484's call for state government to reduce potable water use by 10 percent from 2006 levels by 2012 and 15 percent by 2020. However, as the data tracking effort began, DOER realized that it was not possible to centrally track water data for a variety of reasons, including a lack of centralized usage information and the absence of consumption figures at many state sites using well water. That being said, water conservation has been and continues to be an important component of LBE efforts. The Department of Correction, for example, has undertaken an aggressive conservation and compliance program for the water supply system that serves the Norfolk and Walpole correctional complex. Utilizing measures such as water conservation devices and flow restrictors, this project has reduced daily water use by approximately 100,000 gallons—a 25 percent savings.



Meanwhile, an annual energy and water conservation competition between student residence halls at Framingham State University saved the school 434,130 gallons of water. Water conservation is also a major component of DCAMM's comprehensive energy projects, which include water conservation measures such as installing low-flow toilets and faucet aerators, repairing underground water leaks, and a variety of other measures. Since 2007, eleven projects with water conservation measures are expected to save 132 million gallons of water annually.

8 Conclusion and Future Efforts

Conclusion and Future Efforts

Since Governor Patrick signed E. O. 484, state government has made huge strides to improve energy efficiency, advance renewable and on-site power generation, and reduce GHG emissions associated with state operations. With the state remaining committed to meeting all the specific targets laid out in the Executive Order, two points, in particular, are important to note:

1. A suite of clean energy bills passed in the wake of the Administration's adoption of E.O. 484 have combined to transform the overall energy landscape in Massachusetts in the years since the Order was signed. While still dependent on fossil fuels for electricity generation, the Commonwealth has taken giant steps away from the fuels of the past, and policies are in place that promise to keep us on that forward-looking path. By putting energy efficiency, renewable energy, on-site energy generation, and concern about GHG emissions front and center for state government, E.O. 484 has contributed to the Commonwealth's clean energy revolution and plays a significant role in ensuring its momentum.
2. Through prudent economic policies implemented by the Patrick Administration—including the swift and smart investment of approximately $70 million of ARRA funding in energy-related projects—Massachusetts emerged from the recent national recession faster and stronger than most other states and continued to invest in important public sector projects such as expansion of state institutions of higher education. This means that efficiencies in energy usage and reduction of GHG emissions have in many cases occurred simultaneously with expanded square footage of state facilities.

In signing E.O. 484, the Governor envisioned that state government would lead the way toward a sustainable future. State agencies and employees rose to this challenge enthusiastically, rapidly embarking on programs to conserve energy and water, reduce GHG and other pollutants, and move government entities toward cleaner sources of electricity. The past several years have seen a palpable shift toward sustainability—and the energy cost savings that come with it.

In addition, aware that good intentions alone would not be enough, the Patrick Administration through the LBE Program has devised and relied upon smart financing mechanisms to achieve the Governor's goals. These include both astute investment of ARRA dollars, and the new Commonwealth Clean Energy Investment Program (CEIP), which utilizes general obligation bonds—the least expensive source of state financing—to support projects that pay off their financing debt through energy savings and thereby provide funding for more energy projects.

The work of the LBE Program to date has set the stage for a large volume of additional projects and programs that are in process, or will be shortly, as this report goes to press. These include:

- The DCAMM's Accelerated Energy Program (launched January 2013) to complete energy efficiency retrofits at 700 buildings (two thirds of state government building space) in 700 days, targeting energy use reduction of at least 25 percent across 50 million square feet of buildings by the end of 2014 and resulting

in more than $40 million dollars in annual energy cost reductions

- LBE grants totaling several million dollars to state agencies for renewable energy projects including solar thermal, biomass-pellet boilers, and efficient heat pump technology
- Grants to agencies to support large-scale parking lot solar PV arrays that will generate clean power as well as provide shade for vehicles and reduce the heat island effect of large asphalt parking lots
- Convening of an Enterprise Energy Management System (EEMS) Advisory Committee to guide continued implementation of real-time energy metering across over 25 million square feet of state facilities
- Implementation of plans to eliminate most heating oil use by state facilities by 2020, with projects now underway to replace the remaining sites that use #6 fuel oil with cleaner-burning natural gas
- Efforts underway to install up to three anaerobic digestion systems at state facilities that will take organic waste and turn it into electricity and heating fuel
- Promotion of several behavioral strategies designed to help facilities engage employees and visitors in reducing energy consumption
- Development of new high performance buildings standards that will set the stage for a new generation of green buildings
- Use of capital funds to support efficiency programs at non-building applications that will help to reduce energy use associated with street, tunnel, bridge, and parking lot lights, the operation of dams, as well as many other critical state functions

As the successes—both environmental and economic—of the LBE Program mount, they feed off of each other, with additional agencies and

employees across state government inspired to do their part. Thanks to E.O. 484 and the LBE Program's implementation of it, state government is on the cusp of further innovation and transformation that will continue to advance the growth of our clean energy economy while benefitting the Commonwealth's taxpayers, environment, and quality of life.

Appendix A: Greenhouse Gas Emissions (GHG)

The LBE staff developed a GHG inventory for 49 state agencies and authorities for fiscal years 2002-2012 (please see Fact Sheet II for a complete list of all agencies included in our analysis). The inventory consisted of annual energy consumption and cost data by fuel for a given agency for each fiscal year. LBE tracked fiscal year data rather than calendar year data to be consistent with agency budgets.

Data Collection

The consumption and cost data for the fuels tracked by the GHG inventory came in a variety of formats and from a variety of sources. The majority of the dataset came directly from state agencies through LBE tracking forms submitted with annual data for given fuels, including historic data back to FY02. LBE staff worked closely with agencies that directly submitted the tracking forms to get the most accurate energy consumption and costs.

With the help of the Operational Services Division (OSD), LBE tracked fuel purchases through the OSD statewide contracts. Fuels that are purchased through a statewide contract include heating oil, gasoline, diesel, propane, and vehicle fuels purchased at the pump. For some fuels, such as fuel oil and propane, LBE uses the purchase date as it is not generally possible to track the actual consumption of these fuels unless they are separately metered. While not an exact metric of consumption, LBE believes that the long-term trends in purchases also reflect the energy consumption trends.

Energy Cost data were also reported through the state accounting system (MMARS). In some cases, where actual consumption data were not available, LBE used MMARS cost data as a proxy for energy consumption. With the help of a consultant, LBE developed an adjusted U.S. Energy Information Administration (EIA) price that reflected historic electricity and natural gas for Massachusetts. All data points that used MMARS as a proxy for consumption are noted in the GHG inventory.

As tracking technologies have improved in the past few years, LBE has been at the forefront of energy tracking systems. Through two very different tracking systems, LBE is able to monitor energy consumption data for building level and account level detail. LBE used the real-time energy consumption data from the Enterprise Energy Management System (EEMS) to track and verify reported data where such data was available. Through MassEnergyInsight (MEI), LBE was able to track account level electricity and natural gas consumption data for agencies that are unable to track their agency usage. Renewable installations are tracked separately from most other fuels, with renewable energy generation at a majority of sites reported directly to LBE by state agencies. LBE also used the Production Tracking System (PTS)—the central portal that tracks virtually all renewable energy generation in the state—to verify reported generation and calculate generation when not reported directly.

LBE staff verified and analyzed information as the data were received through the various sources and formats, and worked directly with all agencies to make sure all fuels consumed were adequately reported and assessed.

Emissions Factors

GHG emissions included in the E.O. 484 analysis are expressed in carbon dioxide equivalents (CO2e), which include emissions associated with carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) for the various fuels listed below. LBE tried to include all Scope 1 and Scope 2 emissions for each of the agencies that were tracked. Scope 1 emissions, as defined by the EPA, are "direct GHG emissions from sources that are owned or controlled[4]" by the site where fuels are consumed. Fossil fuels burned on-site, as well as from owned and leased vehicles, and other direct sources of emissions tend to be included in Scope 1 emissions. Scope 2 emissions are the result of indirect GHG emissions from the generation of electricity, heating cooling, and steam generated off-site and purchased by an agency, and all the transmission and distribution losses associated with these purchased utilities. LBE partners submitted energy consumption for all fuels relating to scope 1 and scope 2 emissions, and the emissions factors used by LBE encompass both. LBE worked with MassDEP to determine the correct grid electricity emissions factors for the state's portfolio. The grid electricity emissions factors used by LBE in this report reflect the true emissions associated with energy consumed in the Commonwealth. The MassDEP-calculated factors change each year based on the mix of fuels actually used to generate electricity used in

[4] http://www.epa.gov/greeningepa/ghg/

Massachusetts, and therefore best represent the true emissions associated with the Commonwealth's energy consumption. For other building fuels and for vehicle fuels, the emissions factors were based on EIA CO_2e emissions factors. For vehicles, LBE added an annual percentage to the CO_2 to incorporate other GHG emissions based on total transportation emissions compiled by MassDEP.

Fuels in the GHG inventory include:

- B100 Equivalent
- #2 Oil
- Bituminous Coal
- #4 Oil
- Compressed Natural Gas
- #6 Oil
- Diesel
- On-Site Anaerobic Digestion Electricity
- Electric Vehicle
- On-Site CHP Electricity
- Ethanol Fuel Blend of 85 percent (E85)
- On-Site Hydro Power Electricity
- Excess Electricity Produced (Renewable Energy)
- On-Site Solar PV Electricity
- Gasoline
- On-Site Wind Electricity
- Grid Electricity
- Paper Cubes
- Jet Fuel
- Propane
- Liquid Natural Gas
- Purchased Steam
- Natural Gas
- Wood Chips

Calculations & Highlights

LBE performed GHG calculations for this report to avoid any discrepancies among agencies. LBE used the energy consumption reported to LBE in native fuel units and multiplied the emissions factor related to the fuel for a given year. A Microsoft Access database was developed to track fuel consumption and allow for specific calculations, including GHG emissions and energy usage intensity (kBtu/SF). The calculations for GHG emissions are not weather normalized.

- E.O. 484 states that the GHG baseline should be set for a fiscal year 2002. However, after a review of the data and in recognition of the difficulties associated with energy data collection in the earliest years, LBE determined that a more accurate representation of the baseline fuel consumption would be a three-year average of fiscal years 2002-2004. This averaging also enables the baseline to more accurately reflect variations in weather and avoid skewing the baseline year to be extremely high or low. LBE consulted with the U.S. Department of Energy (DOE) with regard to tracking energy consumption and GHG emissions for combined heat and power to avoid double counting emissions for the electricity produced on-site. Through U.S. DOE guidance, LBE tracked emissions for natural gas and other input fuels for the CHP systems. The on-site electricity generated and the thermal outputs were also tracked to analyze overall electricity consumption at a site.
- Agencies track biofuels in various ways. LBE created a B100 equivalent to avoid incorrectly calculating the GHG emissions attributed to the diesel or petroleum fuel portion of the biofuel/bioheat. The B100 equivalent was considered emissions neutral, as per the calculation used by the U.S. Environmental Protection Agency (EPA). Biomass GHG emissions were calculated as zero as is done by the EPA. Two agencies included biomass in their fuel portfolio.
- Renewable energy sources were tracked independently and confirmed through various sources. All emissions from renewable energy generation were calculated as zero. Renewable Energy Certificates (RECs) and Alternative Energy Credits (AECs) associated with all renewable generation were accounted for to ensure transparency.
- LBE worked closely with state agencies and campuses to understand how certain fuels were used in order to attribute the correct building and vehicle emissions. Fuels were categorized in three sections: building, vehicle, and other. LBE determined that although the fuels in the "other" category were not attributed to buildings or vehicles, it was necessary to track these other fuels to accurately account for GHG emissions. Changes in agency square footage have been tracked each year in order to accurately track progress toward the energy reduction target. Such metrics are based on the weather normalized energy use per square foot. LBE requested square footage information for each agency by fiscal year. Throughout the fiscal years, some state buildings may have been acquired by other agencies. The GHG emissions were calculated for the given square footage in a particular fiscal year. If buildings transferred ownership, the future GHG emissions would be associated with the new owners. For state buildings owned by one agency and leased by another, energy usage was attributed to the agency that purchased the fuels, as consumption data for specific buildings is not always available.

Adjusted calculations are all noted to reflect the nature of the energy consumption at a given agency.

Appendix B: Energy Usage Intensity & Weather Normalization

One of the metrics E.O. 484 identifies is an overall energy consumption measurement on a kilo British Thermal Unit (kBTU) per square foot basis. As per E.O. 484, this metric identifies FY04 as the baseline.

Data Collection & Weather Normalization

While standard weather normalization procedures call for monthly consumption data by location to reflect heating and cooling degree days for a given site, LBE received annual, agency-wide consumption and cost data for a majority of the state agencies tracked. As such, using monthly data by location to normalize for weather was not possible. Because of the data limiting factors, LBE worked with Peregrine Energy Group (Peregrine) to develop a formula that would take into account a fuel's weather dependency and geographic location.

In order to determine weather-dependency in the state building utility data set, Peregrine's analysis determined that electricity was 5% weather dependent and natural gas was 50% weather dependent. Peregrine's analysis took a look at building fuel data from FY08-12, identifying the approximate base loads for each fuel. LBE performed a similar analysis using a subset of data (the OSD Competitive Supply contract data) and also determined the same weather dependency percentages for electricity and natural gas. For heating oil, a weather dependency of 90% was attributed as we determined that virtually all heating oil use is dependent on the weather to provide heating, with a small amount providing hot water and other non-heating needs.

To account for geographic location, Peregrine provided LBE with Heating Degree Days (HDD) and Cooling Degree Days (CDD) information by municipality and weather station. For LBE partners such as colleges and universities or agencies with one primary location, LBE applied the HDD and CDD associated with the main location of the LBE partner. For the LBE partners that have facilities located in multiple municipalities, a statewide HDD and CDD was determined. The state wide degree days were derived from the average of 16 weather stations. The weather stations in the following table were used for both regional HDD and CDD as well as developing the statewide average for weather normalization.

City	Station Name		City	Station Name
Boston	Boston Logan International Airport		Norwood	Norwood Memorial Airport
Lawrence	Lawrence Municipal Airport		Worcester	Worcester Regional Airport
Fitchburg	Fitchburg Municipal Airport		Beverly	Beverly Municipal Airport
Westfield	Barnes Municipal Airport		Hyannis	Hyannis Barnstable Municipal Airport
Taunton	Taunton Municipal Airport		Orange	Orange Municipal Airport
Plymouth	Plymouth Municipal Airport		North Adams	North Adams Harriman Airport
Bedford	Bedford Hanscom Field		Pittsfield	Pittsfield Municipal Airport
New Bedford	New Bedford Municipal Airport		Nantucket	Nantucket Memorial Airport

Through Peregrine's weather normalization analysis the following formula was determined to be most suitable for heating and cooling fuels:

$$\textbf{Heating Fuel WeatherNormalized Use} = \left(Weather\ Dependent\ Use \times \left(\frac{HDD_{average\ \ year}}{HDD_{actual\ \ year}}\right)\right) + Nonweather\ Dependent\ Use$$

$$\textbf{Cooling Fuel WeatherNormalized Use} = \left(Weather\ Dependent\ Use \times \left(\frac{CDD_{average\ \ year}}{CDD_{actual\ \ year}}\right)\right) + Nonweather\ Dependent\ Use$$

Calculations for weather and non weather dependent usage were determined through the following formulas:

$$\textbf{\textit{Weather Dependent Use}} = (Annual\ Use) \times (Weather\ Dependent\ Percentage)$$

$$\textbf{\textit{Nonweather Dependent Use}} = (Annual\ Use) \times (1 - Weather\ Dependent\ Percentage)$$

LBE applied the weather normalization formula to electricity, natural gas, and heating oil consumed for building usage. Other fuels, particularly those used in vehicles were not weather normalized. The natural gas consumption at UMA and UMMS were weather normalized slightly differently as the two LBE partners consume large amounts of natural gas for their CHP operations. Weather normalizing all of UMA and UMMS natural gas at 50 percent would provide inaccurate information as a significant amount of gas is used to generate electricity on-site.

For UMA and UMMS, LBE identified the input and output ratios through the 2012 CHP Performance Results that include a summary of the actual CHP Performance Results by quarter along with the net electrical output, useful thermal output, fuel consumption, and full load equivalent operating hours. The output ratios were applied to the natural gas input to determine what percentage of natural gas input into the system would be weather normalized for electric load and which percentage of natural gas would be weather normalized for thermal load.

Calculation for Baseline & Energy Usage Intensity

The energy reduction target in E.O. 484 is based on an FY04 weather normalized baseline. The weather normalized energy consumption and actual square footage for each fiscal year was used to determine a weather normalized EUI. For example, for FY05, the weather normalized energy consumption was divided by the actual square footage of FY05. LBE applied the weather normalization formula to each fuel by agency when analyzing agency level EUI. The total, overall weather normalized energy consumption and overall square footage was used when analyzing changes to the statewide EUI.

EUI calculations for the LBE Progress Report reflect building energy consumption data over the square footage of the agencies included in the calculations. Since the EUI metric is based on the impacts associated with square footage of buildings, EUI calculations were conducted only for agencies where the majority of electricity, gas and oil consumption are for building operations. Based on operating characteristics, six agencies were not included in the EUI calculations. LBE determined that the following agencies do not lend themselves to EUI analysis because much of their energy consumption does not center on building usage:

- Department of Conservation and Recreation—operations occur at a variety of locations that include campgrounds, state parks, dams, and seasonal sites.
- Department of Fish and Game—operations occur at a variety of outdoor locations including fish hatcheries and campgrounds.
- Environmental Police—operations center on environmental enforcement and natural resources, primarily at outdoor sites.
- Massachusetts Water Resources Authority—operations center on drinking and wastewater treatment facilities whose work is related to water flow instead of square footage.
- Department of Transportation (MassDOT), Highway and Turnpike Divisions—operations focus on transportation needs for the Commonwealth, with majority of energy use for roadway operations such as tunnels, bridges, etc.
- Massachusetts Port Authority (MassPort)—operations deal with airport and transportation needs.

Appendix C: Business As Usual Analysis

As part of an effort to determine avoided costs from FY07-12 associated with a range of energy investments at state facilities, LBE determined that a Business as Usual (BAU) scenario could be used to establish a comparison of projected expenditures without investments and the actual expenditures incurred by LBE partners. In developing this avoided costs analysis, multiple weather normalized BAU scenarios were developed to better understand the impacts of various assumptions. Through the analysis, LBE compared fuel consumption trends before FY07 and extrapolated consumption and expenditures from FY07 to FY12.

Focus on Building Usage

With the majority of overall energy consumption coming from the building portfolio rather than the vehicle fleet, building energy consumption has been a key priority for the LBE Program and its partners. At the present moment, the majority of the energy investments are focused on buildings. The LBE Program is now taking a closer look at the Commonwealth's vehicle fleet and fuel consumption through initiatives such as solar parking canopies and vehicle fleet standards and efficiencies. When considering the various BAU scenarios, LBE selected one that provided greater focus on the clean energy investments by LBE partners. The scenarios selected focused on building fuels, removing all vehicle fuel consumption and expenses.

Background & Scenario Development

The LBE dataset consists of annual agency level data by fuel for every fiscal year from FY02–13. The current data set is a good representation of the overall, diverse Commonwealth energy consumption portfolio. The LBE dataset consists of 49 LBE partner agencies and campuses located throughout the Commonwealth. Building energy across LBE partners varies from operations at universities and community colleges to continuously run facilities such as hospitals.

After consulting with other DOER divisions and consultants, LBE took a closer look at fuel trends at state facilities and ISO-New England (ISO-NE) past forecasts. LBE developed two BAU scenarios that demonstrate the most accurate representation of avoided costs at state facilities. The two trends that were considered for the BAU dealt with the LBE fuel trends and past forecasts from ISO-NE. Both scenarios used the FY02-06 timeframe as the basis for the trends used in the analysis. Together, these two scenarios provide a defensible range of energy avoided costs at state facilities.

Calculation

In order to form the projected calculations from FY07–12 for the BAU, LBE established a methodology that could be applied to any given scenario. The FY07–12 energy consumption and cost calculations would determine the comparison between the BAU and the actual costs incurred by the Commonwealth.

The methodology included three main steps to both calculate the consumption and costs of the BAU and then to determine the costs avoided by the LBE partners. First a growth rate was calculated for a time period and used to estimate the potential fuel consumption from FY07–12. Then, the expenditures associated with the fuel consumption from FY07–12 were determined. Once the BAU potential is determined from FY07-12, the difference between the potential expenditures and the incurred expenditures are calculated.

The first scenario used fuel trends by LBE Partner from the FY02-06 baseline to extrapolate consumption from FY07–12. In using the LBE Partner fuel trends, the BAU usage projections would express the potential fuel consumption at an agency based on past experience.

[5] The scenario that incorporated the ISO-NE electricity forecast used FY07–12 forecast growth.

The second scenario that LBE determined adequate to calculate avoided costs took into consideration the past 2006 ISO-NE forecast[5]. The ISO-NE forecast provided Massachusetts specific information for net energy load as well as for economic scenarios from 2006–2015. LBE calculated a rate of growth for electricity using the base economic forecast from FY07–12. Through this scenario, the BAU could focus electricity consumption on forecasts developed for all of Massachusetts's potential consumption, adjusting for industry knowledge that ISO-NE had in 2006.

LBE determined that calculating avoided costs for LBE partners should take into consideration both ISO-NE electricity forecasts and LBE fuel trends based on the type of facilities involved in the dataset. With electricity being a large portion of state facility consumption, a closer look at the forecasting trends was needed.

Results

The LBE cumulative avoided cost for buildings was determined to be between $93.1M and $166.7M from FY07–12. LBE feels confident that the efforts undertaken during this time period are reflected in the cumulative avoided costs range. The range incorporates specific historical fuel trends as well as past MA-specific ISO-NE forecasts into the BAU projections. These trends are specific to LBE Partners' consumption needs for state operations.

Photograph Credits

Front Cover:
Top, North Shore Community College's (NSCC) Health and Student Services Building, first state owned zero net energy building, completed 2013. Middle: Ribbon cutting on Energy Improvement Project at Hogan Regional Center (DDS). Bottom: Solar thermal at Hogan Regional Center

Page 1: Turbine at MWRA; Lyndon P. Lorusso Applied Technology LEED Gold certified building, Cape Cod Community College; electric vehicle getting powered by an EV charging station, and hot water heater tanks, Hogan Regional Center

Page 2: Governor Deval Patrick; Albert Sherman Center, UMass Medical School (UMMS), former EEA Secretary Richard K. Sullivan, Jr. speaking at Mt. Wachusett Comm. College (MWCC)

Page 5: Ground-mounted solar PV array, Greenfield Community College

Page 6: Solar energy monitoring gauge, Massasoit Community College; real-time wind energy dashboard elements for Mass. Maritime Academy (MMA) turbine

Page 7: Treehouse Dormitory exterior, Mass. College of Art and Design

Page 8: State House dome, Boston

Page 10: Roof-mounted solar PV arrays, MCI Norfolk Wastewater Treatment Facility and Solar PV array, South Middlesex Correctional Center (DOC)

Page 11: North Hall a residence hall opened in 2011, Framingham State University

Page 13: Campus view with two 1.65MW turbines and biomass plant, MWCC

Page 15: Biomass plant equipment, MWCC

Page 16: Signing of a Memorandum of Understanding between the university's Chancellor and Northeast Utilities, UMass Amherst (UMA)

Page 17: Biomass pellet storage, Notch Visitor Center, Mt. Holyoke Range State Park (DCR)

Page 18: New high efficient natural gas boilers, Wrentham Developmental Center (DDS)

Page 22: Staff from DOC, DCAMM, and the project contractor celebrate the awarding of the Accelerated Energy Program Certified Plus plaque for efficiency projects at NCCI Gardner; new piping for solar thermal system installed at the Hogan Regional Center

Page 24: Combined Heat and Power plant, UMA

Page 25: Albert Sherman Center interior, UMMS

Page 26: Waquoit Bay National Estuarine Research Reserve's main building and a student upgrading building windows (DCR)

Page 27: Artist rendering of LEED Gold certified new library building, MMA; photograph of new LEED Platinum MassDEP Wall Experiment Station building

Page 28: Health Professions & Student Services building, NSCC; Governor Patrick joined by other officials breaking ground; completed new Field Headquarters facility in Westborough, Department of Fisheries and Wildlife

Page 29: Turbine blade being lifted into place, December 2010, MWCC

Page 32: Pellematic boiler and biomass pellet storage, Mt. Holyoke Range State Park's Notch Visitors Center

Page 33: View of solar PV array, 600 kW turbine, and two anaerobic digesters; close-up of turbine blades; another view of the anaerobic digester; and hydroelectric generators, MWRA

Page 34: On-site CHP system; Albert Sherman Center exterior, UMMS

Page 35: Rooftop solar PV array, Massasoit Community College

Page 36: Exterior LED fixture

Page 38: Electricity transmission lines; 660kW wind turbine at MMA in Bourne, the first wind turbine installed at a state facility; heating oil delivery truck; and wood pellet silo installed as part of ARRA funded biomass projects in western Massachusetts

Page 39: Low-e ceiling, DCR rink; installation of EEMS infrastructure and close-up of gauge; installation of interior high efficiency lighting

Page 40: Building energy code training; training session on real-time EEMS system

Page 43: Signage about restroom environmental initiatives and installed efficient water fixtures, Cape Cod Community College; roof-mounted solar PV array

Page 44: Roof-mounted solar PV arrays at Logan International Airport (MassPort)

Page 45: Top left, installation of solar PV, Terminal A-Logan International Airport; swimming pool covers, Hogan Regional Center; and 62 kW solar PV array at Chickatawbut Hill, the largest solar installation at any state park

Page 46: Solar energy monitoring meter, Massasoit Community College

Page 49: National Grid representative presents incentive check to DCAMM's Jenna Ide for energy conservation measures implemented at the Gardner Trial Court

Page 50: LBE Director Eric Friedman highlights the ongoing partnership between DOER, DCAMM, Program Administrators, and state agencies in implementing energy efficiency across state government

Page 51: State officials celebrate state government's first LEED Platinum building, MassDEP's Wall Experiment Station; green roof, same building; installation of solar PV on rooftop, Worcester State College and MWCC

Back Cover:
Top, Wind turbine installed in 2014, NCCI Gardner. Middle, Pittsfield Armory receiving certificate with former DOER Commissioner Sylvia. Bottom, completed new Field Headquarters facility, Department of Fisheries and Wildlife

Photo Credit: Most photographs were taken by the DOER team during site visits

Commonwealth of Massachusetts

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