Commonwealth of Massachusetts
Global Warming Solutions Act
5-Year Progress Report

Massachusetts
Global Warming
Solutions
www.mass.gov/eea/gwsa

Acknowledgements

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Barbara Kates-Garnick, EEA Undersecretary for Energy, and Maeve Vallely-Bartlett, EEA Undersecretary for Environment, co-chair the IAC and, together with Steven Clarke, Assistant Secretary for Energy, oversee GWSA implementation. Within EEA agencies, the GWSA is implemented and evaluated under the leadership of:

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- Mary Griffin, Commissioner, Department of Fish and Game (DFG)
- Jack Murray, Commissioner, Department of Fish and Game (DFG)
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The GWSA Team Leader Group coordinates strategy implementation and evaluation, and played a key role in providing the information and analyses needed to complete the 5-Year Progress Report.

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- Sharon Weber, MassDEP— Chair of the Non-energy Emissions Subcommittee
- Tina Halfpenny and Ian Finlayson, DOER— Co-Chairs, of the Energy Efficiency and Demand Side Management Subcommittee
- Kurt Gaertner, EEA and Steve Woelfel, MassDOT— Co-Chairs of the Transportation, Land Use, and Smart Growth Subcommittee
- Kathy Baskin and Vandana Rao, EEA— Co-Chairs of the Adaptation Subcommittee
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Letter from the Secretary

December 30, 2013

Dear Fellow Massachusetts Citizens,

I am pleased to present the first Massachusetts Global Warming Solutions Act (GWSA) Five Year Progress Report. This report fulfills an important mandate of the GWSA and highlights the significant, nation leading progress that Massachusetts has made under the leadership of the Patrick Administration with implementing the GWSA.

Governor Deval Patrick signed and the Massachusetts General Court passed into law the GWSA five years ago in 2008, committing the Commonwealth to the most ambitious greenhouse gas emission (GHG) reductions for a single state in the entire country in order to fully capture the economic, environmental and public health benefits of our shift towards a new clean energy economy.

As this report makes clear, the Commonwealth is already reaping the benefits of this historic commitment to reduce GHG emissions. Our clean energy economy is one of the most vibrant in the nation, and we have been ranked number one in the country the past three years for our leadership in energy efficiency. In 2014 we expect to surpass 600 megawatts (MW) of clean energy installed within the Commonwealth, marking exponential growth from the 34 MW installed when Governor Patrick assumed office in 2007, all of this while our most polluting and inefficient fossil fuel plants retire from operations and GHG emissions from our electricity sector have steadily fallen by more than 37 percent since 1990, even during periods of economic growth

Our progress towards a clean energy and zero GHG emission future has been historic and robust, but this report also highlights our continued commitment to further advance this progress and address future challenges. Recent mega storms like Typhoon Haiyan in the Philippines and super storm Sandy were powerful reminders of the human and economic cost of inaction and we remain focused on further enhancing the Commonwealth's resilience and adaptability to an already warming climate.

Massachusetts alone cannot halt climate change, and we continue to work closely with our partners in neighboring states and Canadian provinces on developing new regional policies to further reduce GHG emissions in a part of the nation which already has some of the lowest per capita energy-related carbon dioxide emissions in the US. Our recent leadership in lowering the Regional Greenhouse Initiative (RGGI) cap and the recent New England Governor's joint statement on energy infrastructure are perfect examples of this regional approach to lowering GHG emissions. Lastly, the Administration is keenly focused on further expanding smart growth, transit oriented development, and electric vehicle technology in order to accelerate the reduction of GHG emissions from our transportation and land use sectors, but much more work remains to sharply reduce the carbon intensity of these sectors.

In closing, I would like to acknowledge the significant undertaking that this report represents, and extend the Administration's gratitude to the Legislature, GWSA Implementation Advisory Committee (IAC) and all those who participated in the creation of this report for their time and valued input. Our progress has not happened by accident - leadership and hard work brought us here and both will remain critical to our collective generational commitment to enhance the quality of life and environment for future generations.

Executive Office of Energy and Environmental Affairs Secretary Richard K. Sullivan, Jr. views a new 2.1 MW rooftop solar installation in Franklin, MA.

Source: Art Illman, Courtsey of Milford Daily News

Regards,

Richard K. Sullivan, Jr. Secretary

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EXIT 1B
6 EAST
Hyannis
Provincetown
EXIT 1C
6A
Sagamore

Executive Summary

1.1 Summary of Global Warming Solution Act — Implementation and Recommendations

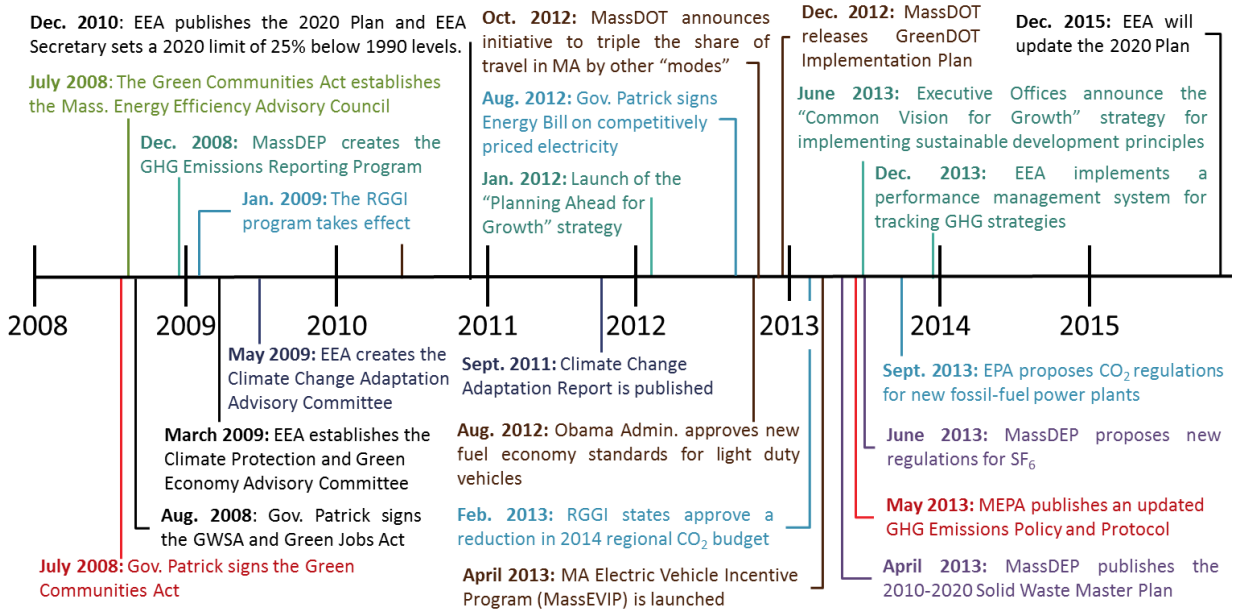
"The Global Warming Solutions Act means lower greenhouse gas emissions for the region and increased growth and opportunity in our clean energy economy, a major driver of job creation here in Massachusetts. It is also a strong statement that this region, which comprises nearly 20 percent of the national economy, is serious about being stewards of our environment and addressing climate change."

- *Governor Deval Patrick*
February 7, 2013

Massachusetts Governor Deval Patrick signed the landmark Global Warming Solutions Act (GWSA) in 2008, establishing the most aggressive set of measures to address climate change of any state in the country. Since that time, the Commonwealth has made impressive progress towards meeting the goals and requirements of the GWSA, and demonstrated an unwavering commitment to further expand its position as a national leader in innovative strategies to reduce global warming emissions, grow the clean energy economy, and prepare for climate change impacts already underway. In pursuing these goals, Massachusetts has created models for climate action which other states and jurisdictions have already started to emulate.

Figure 1 below shows that over the period 2008 to 2013, Massachusetts initiated a variety of legislative actions, executive orders, and new regulations addressing climate change and promoting clean energy. In addition, the Commonwealth is already planning specific activities for 2014 and 2015. As a result of this consistent commitment, a strong framework of laws and regulations is in place and guiding much of the state's current actions on mitigation and adaptation.

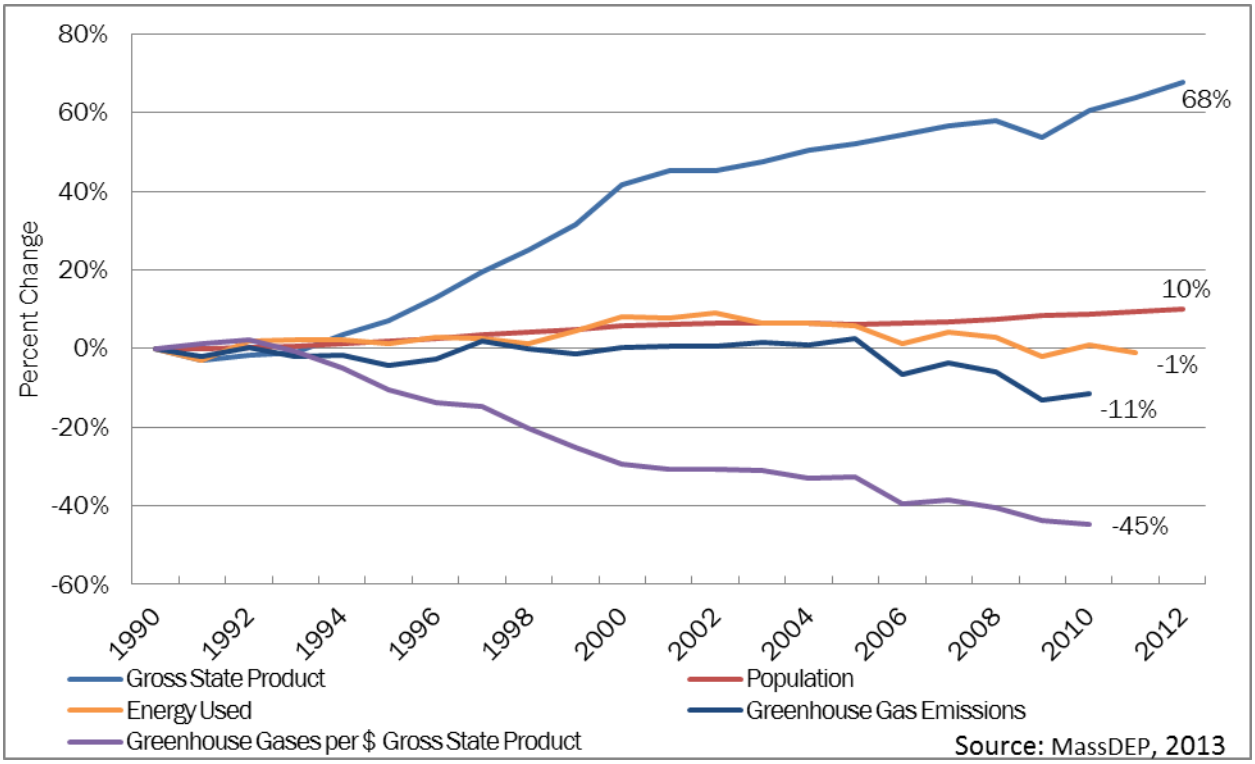
Figure 1: Key GWSA Legislative and Regulatory Milestones, 2008-2015



The involvement of the Commonwealth in these activities is comprehensive, and not limited to environmental agencies. The GWSA tasks the Executive Office of Energy and Environmental Affairs (EEA) Secretary with leading implementation of the GWSA, but the Executive Office of Housing and Economic Development (HED), the Department of Environmental Protection (MassDEP), the Massachusetts Clean Energy Center (MassCEC), the Department of Energy Resources (DOER), and the Department of Transportation (MassDOT) are all highly invested and involved in implementing climate and energy solutions and programs. In addition, many of the GWSA programs underway include creative incentives to encourage cities, towns, residents, and businesses across Massachusetts to take their own actions to mitigate and prepare for climate change, and they have taken advantage of these incentives and been our partners all along the way.

A key tenet of the Patrick Administration's vision on climate change is that aggressive action to reduce global warming emissions can *advance* economic growth, rather than hinder it. The performance of the Massachusetts economy has long shown that economic growth, greater efficiency in energy use, and environmental improvement are mutually reinforcing. As Figure 2 below shows, the state's economy has grown by 60 percent from 1990 to 2010, while total greenhouse gas (GHG) emissions dropped by 11 percent during the same timeframe.

Figure 2: Greenhouse Gas Emissions and Economic Growth, 1990-2011



The major accomplishments of the GWSA's first five years illustrate how leading on climate can be cost-effective and actually grow the economy. As the list below highlights, implementation of climate and clean energy strategies has spurred the growth of Massachusetts' clean energy economy. These bellwether programs have also jump-started action at other levels of government and across the private sector.

Cost-Effective Energy Efficiency—For the third year in a row, the American Council for an Energy-Efficient Economy (ACEEE) ranked Massachusetts #1 in its annual scorecard for state energy efficiency programs (ACEEE 2013). The state's first Three-Year Energy Efficiency Plan (2010 to 2012) delivered cost-effective savings of 2,393 GWh and 37.6 million therms, a return of $4 billion in net benefits on an investment of $1.5 billion (MA EEAC 2009). Cost savings from the second Three-Year Plan (2013 to 2015) are expected to be even higher, with net savings of over $6 billion.

(MA EEAC 2012b). EEA estimates that energy efficiency measures alone will reduce energy demand by approximately 17 percent from 2005 to 2015, lowering carbon dioxide emissions by 3 million metric tons in 2015. (Note that these numbers reflect total energy savings from energy efficiency, i.e., savings from the 2008 baseline in addition to incremental energy savings from the statewide Three-Year Plans).

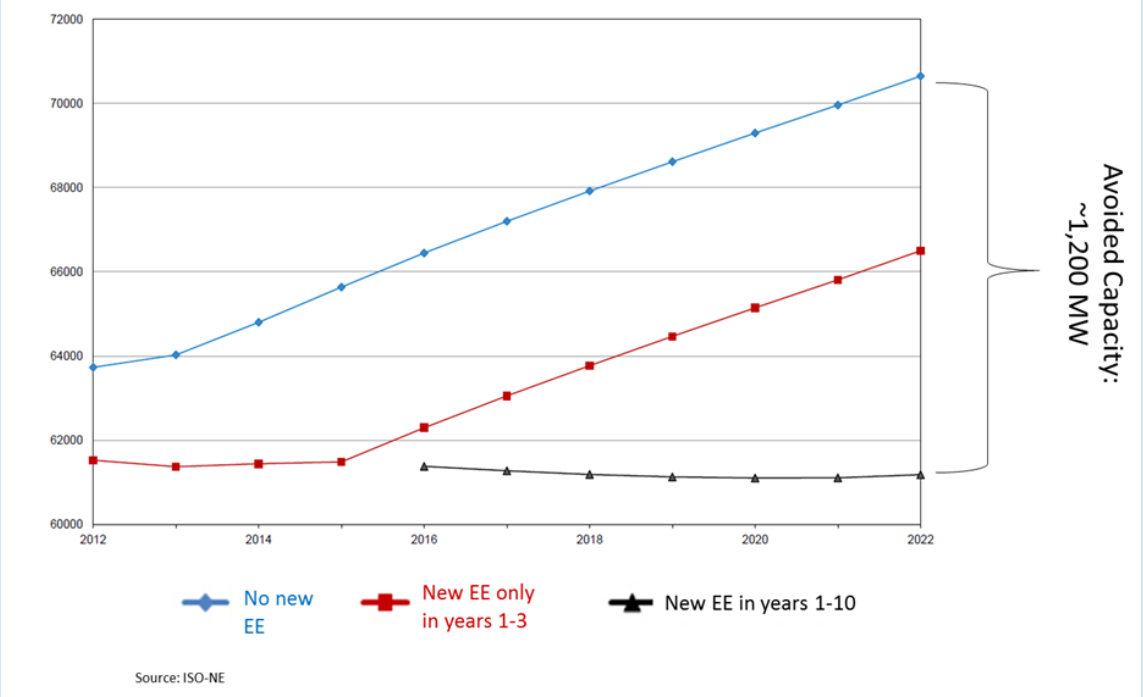
Renewable Energy—Solar and wind energy in Massachusetts have grown exponentially over the last five years, and interest in anaerobic digestion, small-scale hydropower and other RPS-eligible technologies continues to grow. Offshore wind energy areas in federal waters south of Martha's Vineyard with up to 4 GW in potential have been designated, and Cape Wind is expected to close on financing and move toward construction in 2014. Pilot renewable thermal programs have proven successful and are setting the stage for expanded efforts that will result in lower heating costs and increased environmental benefits for Commonwealth residents. And, the Commonwealth is working with other New England states to expand Massachusetts and the region's access to new grid-scale clean energy resources like large hydro and onshore wind energy.

Growth of the Clean Energy Economy—At a time when the US has struggled to find new job-creating industries, the clean energy economy in Massachusetts continues to grow. As of August 2013, the Commonwealth's clean energy sector employed nearly 80,000 workers, grew at an 11.8 percent increase from the previous year, and encompassed more than 5,500 firms (MassCEC 2013a).

Other Benefits of Sustained Investments in Energy Efficiency

Sustained, large-scale investments in energy efficiency provide other important benefits in addition to GHG reductions, and they can extend through an entire region. As Figure 3 shows, ISO-New England, the operator of the New England power grid, projects zero growth in electricity demand in Massachusetts because of the state's ongoing, large-scale investments in energy efficiency programs, an unprecedented outcome in a state with strong economic growth. Zero growth in Massachusetts' electricity demand means that the power grid avoids adding 1,200 MW in new generation capacity. This results in direct savings on bills for electricity customers throughout New England because system-wide demand for electricity is lower than it otherwise would have been, suppressing the wholesale price of electricity. And Massachusetts electricity customers benefit even further, by also avoiding costs for local transmission and distribution of electricity.

Figure 3: Massachusetts Annual Energy Forecast



Power Plant Emissions—GHG emissions from the use of electricity in Massachusetts have fallen dramatically since 1990, from 28 to 17 $MMTCO_2e$ in 2011, a drop of more than 37 percent (MassDEP 2013d) (see Figure 11). The decline of electricity generation by coal-fired power plants in Massachusetts is driving much of this decrease. Two coal-fired power plants have already shut-down some or all of their generating capacity.[1] Additional GHG reductions from the closure of a third coal-fired plant are possible in 2017. In addition, Massachusetts led the way in securing an historic commitment by the nine RGGI states to lower the cap on power plant emissions from 165 million short tons per year to 91 million short tons per year in 2014, with an annual reduction of 2.5 percent each year through 2020.

Green Communities—The Green Communities Program has become a national model, demonstrating how state government can assist towns and municipalities efforts to save energy and generate GHG emission reductions. Since its inception in 2011, 123 towns and cities, with over 48 percent of the state's population, have become Green Communities. These cities and towns have committed to total energy reductions equivalent to the annual energy consumption of over 15,000 homes. In GHG reduction terms, this is the equivalent of reducing emissions by 0.2 $MMTCO_2e$ or taking 34,000 cars off the road.

Building Capacity and Information Systems—The Commonwealth has made an unprecedented effort to build capacity for implementing climate solutions across all parts and functions of state government. Equally important, Massachusetts has invested heavily in information systems for measuring, reporting, and verifying GHG emissions and reductions. The state implemented a mandatory GHG reporting program for large sources in 2010, first completed an inventory in July 2009, and launched a Clean Energy and Climate Performance Management System for tracking GHG mitigation and adaptation activities in 2013.

The GWSA required the Secretary of Energy and Environmental Affairs to establish a statewide limit on greenhouse (GHG) emissions of between 10 percent and 25 percent below 1990 levels for 2020 and develop a plan for achieving that limit. In 2010, EEA released the *Massachusetts Clean Energy and Climate Plan for 2020* (the 2020 Plan) which described a broad portfolio of 27 major mitigation strategies across multiple sectors necessary for achieving that limit (MA EEA 2010a).[2] In tandem with the release of the 2020 Plan, EEA Secretary Ian Bowles established the most stringent limit possible of a 25 percent reduction in greenhouse gas (GHG) emissions below 1990 levels.

GWSA 2020 Limit:
25% below 1990 Emissions
(a 24 $MMTCO_2e$ reduction)

Comparable to the GHG emissions from lifetime energy savings (heating and cooling) associated with planting 48 million trees near buildings.

GWSA 2050 Limit:
80% below 1990 Emissions
(a 76 $MMTCO_2e$ reduction)

Comparable to the GHG emissions from combustion of diesel fuel needed to drive a tractor trailer from Boston to Pittsfield 7 million times.

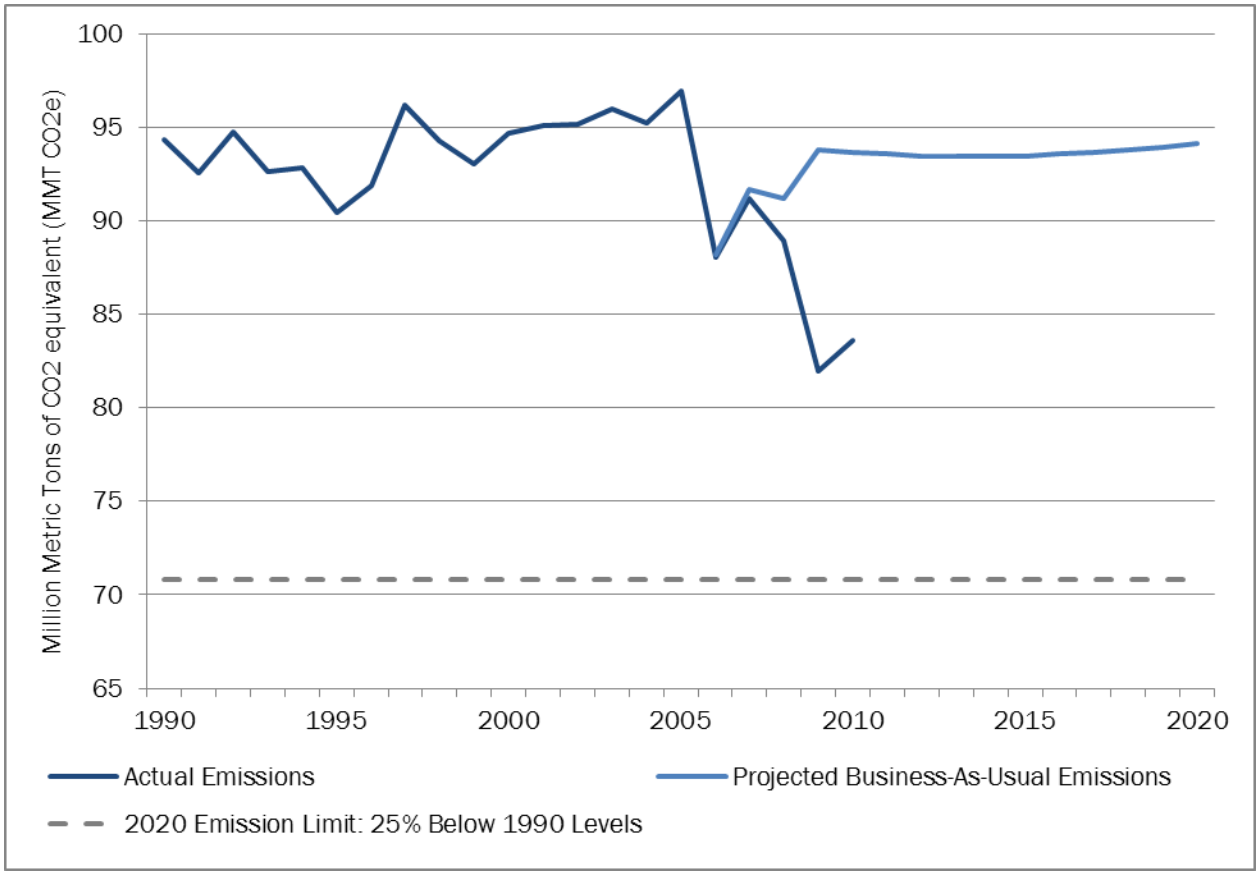
[1] Somerset Station shut down completely in 2010. Salem Harbor shut down two units in 2011; two remaining units are scheduled to shut down by June 2014. Owners of the Brayton Point coal-fired power plant recently announced the closure of that plant, expected in 2017.

[2] The 2020 Plan listed 28 strategies for reducing GHG emissions, but in this Progress Report, the "deep energy retrofit strategy" from the 2020 Plan is considered part of the "all cost-effective energy efficiency" strategy.

The 2020 Plan also presented quantitative estimates, ranging from low to high, for the likely GHG reductions by 2020 for each individual GHG mitigation strategy. Combining together the estimates of GHG reductions for all 27 strategies presented in the 2020 Plan, EEA's analysis found that if fully implemented, the strategies would deliver reductions ranging from 18 to 33 percent below 1990 emission levels. The "most likely" middle estimate would result in an emissions reduction of 27 percent below 1990 emission levels, or 24 $MMTCO_2e$.

Figure 4, based on the latest GHG inventory data for Massachusetts, shows that statewide GHG emissions in 2010 were 84 $MMTCO_2e$, an 11 percent reduction below 1990 levels of 94 $MMTCO_2e$. A combination of economic factors (especially the decline in natural gas prices), and public policies initiated before and after the GWSA have caused this downward trend, which will accelerate as the effects of new policies take hold, such as the lowering of the RGGI cap, greater investments in energy efficiency, and further growth in wind and solar energy.

Figure 4: Inventory of Massachusetts GHG Emissions, 1990-2010



Source: MassDEP, 2013f

As required by the GWSA, this Five-Year Progress Report (the Progress Report) assesses the Commonwealth's progress since 2008 on these GHG reduction strategies, describes key success stories, and identifies challenges that may limit further progress. When relevant information is available, it also provides a brief review of other GWSA requirements, including (but not limited to) the cost-effectiveness of strategies, their potential impacts on low-income communities, and whether actions minimize administrative burdens and contribute to progress on air quality goals and other environmental and public health goals. Finally, this Report makes recommendations on steps Massachusetts can take to increase the likelihood of achieving the 2020 and 2050 GHG emission limits as well as other GWSA objectives.

Below, Table 1 provides a summary of the Commonwealth's progress to date on the major areas of focus and key GHG mitigation strategies identified in the 2020 Plan. For each major category, the table provides a qualitative "score" (low/medium/high) of progress. The methodology behind the *qualitative* scoring is based, in large part, on the progress achieved for those strategies with greatest *quantitative* weight within each category. For example, the cost-effective energy efficiency strategy dominates the quantitative GHG reduction goal for the buildings sector, so progress on that strategy has the greatest influence on the qualitative score for the sector. That said, a qualitative evaluation of any kind obviously involves some subjective judgment. Quantitative estimates of progress for many GHG reduction strategies, discussed later in this Progress Report, are also presented on the Commonwealth's *Global Warming Solutions Act Dashboard,* launched in December 2013 (MA EEA 2013g).

Table 1: Summary Table of GWSA Progress: 2008-2013

Strategy	Key Accomplishments and Highlights	GHG Reductions Anticipated in 2020 Plan	Likelihood of Meeting Goals in 2020 Plan
Capacity Building and Information Systems	• Developed new Clean Energy and Climate Performance Management System to track and document progress on GHG reduction strategies • Enacted regulations in 2008 and 2009 requiring annual GHG reporting by large facilities and retail electricity sellers • Created the Implementation Advisory Committee to foster inter-agency collaboration and stakeholder participation	---	**High**
Buildings, Energy Efficiency & Demand-Side Management	• Approved utility-funded energy efficiency plans for 2013-2015, which are expected to save a total of 3,700 GWh of electricity and 69 million therms over the three years • Over 130 municipalities have adopted the stretch energy code • Secured initial $5M funding to plant 15,000 trees with anticipated lifetime savings of 1.8 MMTCO_2e from reduced energy use; full funding of program would more than triple these savings	9.8%	**Medium**
Energy Generation and Distribution	• Lowered the Regional Greenhouse Gas Initiative (RGGI) regional CO_2 budget from 165 million short tons to 91 million short tons per year • Solar PV sector grew from 3 MW to over 347 MW; wind energy sector grew from 3 MW to 103 MW; increased implementation of anaerobic digestion and small-scale hydro-electric project • Massachusetts' clean energy sector grew by 11.8% in 2012, higher than the overall MA economy, and employs nearly 80,000 people • Retirement of two major coal-fired power plants; third retirement expected soon • Funded several pilot programs in renewable thermal • Developed multi-year stakeholder process for identifying and designating MA Offshore Wind Energy Areas • Signed several long-term contracts for renewable energy • Launched a large hydro expansion initiative	7.7%	**Medium**

Strategy	Key Accomplishments and Highlights	GHG Reductions Anticipated in 2020 Plan	Likelihood of Meeting Goals in 2020 Plan
Transportation & Land Use	• Enacted new federal fuel economy standards for passenger vehicles and medium/heavy duty vehicles • Launched "Mode Shift" goal to triple the share of travel in MA by bicycling, public transit, and walking. • Launched the Massachusetts Electric Vehicle Incentive Program in 2013 and awarded 132 EV charging stations to municipalities and others • Signed onto multi-state ZEV agreement • Committed to hiring a new Assistant Secretary for GreenDOT to oversee implementation • Legislation reforming state planning and zoning statutes pending before the legislature • MassWorks and other infrastructure programs incorporate Smart Growth criteria in funding decisions	7.6%	**Medium**
Non-Energy Emissions	• Proposed new regulations on the emissions of SF_6 from gas-insulated switchgear, which are currently being finalized • Detailed necessary actions to reduce plastics combustion the *2010-2020 Massachusetts Solid Waste Master Plan*	2.0%	**High**
Cross-Cutting Programs	• Incorporated new GHG emissions protocols into MEPA • 123 communities enrolled in the Green Communities Act program, and over $20 million dollars invested in energy-saving projects • Leading by Example projects have reduced heating oil use at state facilities by over 50% in the past five years	---	**Medium**
Adaptation to Climate Change	• Outlined over 200 potential strategies to address the impacts of climate change in *The Massachusetts Climate Change Adaptation Report* • Convened the Adaptation Implementation Subcommittee in 2012 to prioritize and implement adaptation strategies outlined in the Adaptation report	---	**Medium**

Despite notable successes over the last five years, the Commonwealth's leadership recognizes that more can and must be done to position the state to achieve the 2020 emissions limit and move onto a trajectory consistent with a minimum 80 percent reduction in emission levels by 2050. Since the completion of the 2020 Plan, the Administration has identified 'supplemental' strategies which, if implemented, will enhance the chance for success on the GWSA's goals.

Investments in Capacity, Information Systems, and Cross-Cutting Programs

Since 2008, the Commonwealth built substantial institutional capacity, both within EEA and across state agencies, to enable smoother and more rapid implementation of climate and clean energy programs. Early successes in "cross-cutting" programs, such as Green Communities, the Massachusetts Environmental Policy Act's (MEPA) GHG requirements, and Leading by Example, provide encouraging signs, as these strategies, by their very nature, require a high degree of inter-agency communication, collaboration, and alignment among agency leadership.

In addition to building institutional capacity, Massachusetts has made a series of high-level investments in new information systems needed to measure, monitor, and transparently report on GWSA progress, ensuring that projects stay on-track and on-time. These investments include the completion of a credible, transparent GHG emissions inventory and implementation of a mandatory GHG reporting system for large facilities and retail electricity suppliers. Most recently, Massachusetts has developed and implemented a Clean Energy and Climate Performance Management System for tracking and reporting progress on GWSA measures and strategies (MA EEA 2013d).

Recommendations

Continue Investing in Information Systems to Support and Manage Effective Implementation of the GWSA

Initial progress on Massachusetts' new system for tracking, measuring, and verifying GHG mitigation and adaptation strategies—the Clean Energy and Climate Performance Management System (CCPMS)—is encouraging, but the system is not yet complete. To be most effective, the CCPMS database requires continued investment to ensure maintenance and improvement over time. This will require not only a commitment to consistent data entry, updates, and documentation of methods, but also the incorporation of the latest science and methodologies.

The process of gathering data describing progress on strategies and entering methodologies to calculate emission reductions in the CCPMS has made evident that some estimates of individual strategy's GHG reductions from the 2020 Plan may be out-of-date or otherwise in need of revisiting. In some cases, conditions on the ground may have changed since 2010 such that underlying assumptions are no longer valid. For example, GHG reductions associated with the use of electric vehicles may be even greater than initially estimated, due to improvements in battery performance and declining average grid GHG emissions. In other cases, there may be new methodologies available for estimating emission reductions.[3] Under the GWSA, EEA is required to update the 2020 Plan every five years, which will be provide an opportune window to revisit GHG reductions estimates and underlying methodologies from the 2020 Plan.

A related challenge to tracking progress on GHG reductions is designing methods for measuring strategies that transform energy use indirectly and/or over long time periods. For example, the Smart Growth Policy package includes strategies that have the potential to substantially transform transportation energy use by shifting travel from cars to other travel modes, but this type of shift is difficult to track through direct measurement. The CCPMS shows strong initial progress on developing quantitative and qualitative metrics and milestones for tracking these "indirect" and complex GHG reduction strategies. The database of metrics and milestones needs to be fully populated, and then maintained and updated over time.

The CCPMS provides data for the recently launched GWSA dashboard supporting the Commonwealth's commitment to providing annual updates to the public on its progress in implementing the GWSA. This is an important step to full transparency. The CCPMS enhances the Commonwealth's capability to communicate progress on GHG emission reductions and other measures to address climate change. The system will enable the Commonwealth to be more transparent on results, as well as the metrics and methodologies used and any uncertainties that affect the likelihood of meeting the 2020 and 2050 emission limits.

Increase the Pace of GWSA Implementation

The 2020 Plan included a wide array of strategies with ambitious goals for GHG reductions. Some of these measures have not proceeded as expected, in part, because of a reduction in state resources available to implement them. In other cases, however, GHG emissions reductions occurred much faster than initially anticipated. Emissions from energy generation, for example, fell as energy demand declined and natural gas prices dropped. The latter trend enabled an even faster reduction in coal-fired electricity generation than expected, but also slowed down implementation of natural gas efficiency projects.

As the economy and the Commonwealth's revenue situation continue to improve, there will be opportunities to increase the pace of GWSA implementation. Below are recommendations for how to focus efforts over the next five years.

- **Focus on VMT, Fuels, and Land Use.** Focusing on the implementation of strategies affecting transportation, the largest source of GHG emissions and energy use in the Commonwealth, will boost the likelihood of meeting the 2020 emissions limit. Federal fuel efficiency standards for passenger and medium/heavy duty vehicles will provide large GHG reductions, as will the implementation by a group of northeastern states of California's program for "zero emission" vehicles (ZEVs). However, vehicle miles traveled (VMT) and fuel used by Massachusetts drivers have increased substantially since 1990. More attention is needed to speed up strategies designed to reduce both VMT and fuel use, or to identify new policy alternatives. Land use is a key overarching issue that plays a critical role for both mitigation and adaptation purposes. Strategies that promote smart growth and patterns of development and resource protection that are consistent with the goals of GWSA will continue to be important areas of focus.

- **Accelerate the implementation of GreenDOT.** The Commonwealth's landmark strategy package for reducing energy use and miles traveled in the transportation and land use sectors will better position the state for meeting the 2020 and 2050 GHG emissions limits. While the GreenDOT Implementation Plan (and related Smart Growth and sustainable development policies) provide a strong vision and specific steps forward, the execution of these strategies will require continued commitment from the highest level of the state's leadership and collaboration across multiple agencies. Aspects of these plans also require additional funding sources which have yet to be identified. The funding issue should continue to be a primary focus for the remainder of the Patrick Administration and a foremost priority for the legislature and the Commonwealth's next Governor.

- **Continue aggressive implementation of energy efficiency**. This strategy has been a huge success story in Massachusetts in terms of both energy savings and economic growth, but has not yet reached its full potential of delivering all cost-effective savings. As low natural gas prices continue to reduce incentives for natural gas efficiency projects, there is a great opportunity to expand upon the scope of efficiency programs to include heating oil customers, a traditionally underserved part of the market. Advanced building codes should begin to have more effect, as new construction continues to rebound.

- **Expand access to new clean energy resources and imports.** This strategy is expected to provide a large contribution of GHG reductions. Massachusetts has been working closely and collaboratively with other New England states and neighboring Canadian provinces to enhance the region's energy infrastructure in order to expedite the development of large-scale clean energy resources in the region.

- **Continue to pursue offshore wind energy.** The Commonwealth's largest indigenous energy resource is the significant wind just off our coast, and its development can not only create a new clean energy industry, but realize tremendous reductions in GHG emissions. Efforts should focus on investing in infrastructure, ensuring responsible siting through marine wildlife surveys and stakeholder engagement, offshore wind transmission planning, and exploring incentives on the federal, regional, and state level.

- **Aggressively pursue 'supplemental' strategies.** Supplemental strategies have been identified to help fill any gaps where there might be shortfalls in fully achieving the emission reductions projected in the 2020 Plan. The contributions of new, "supplemental strategies," particularly in the transportation and land use sector, are very important to the prospects of meeting the 2020 GHG limit and will enhance the likelihood of success.

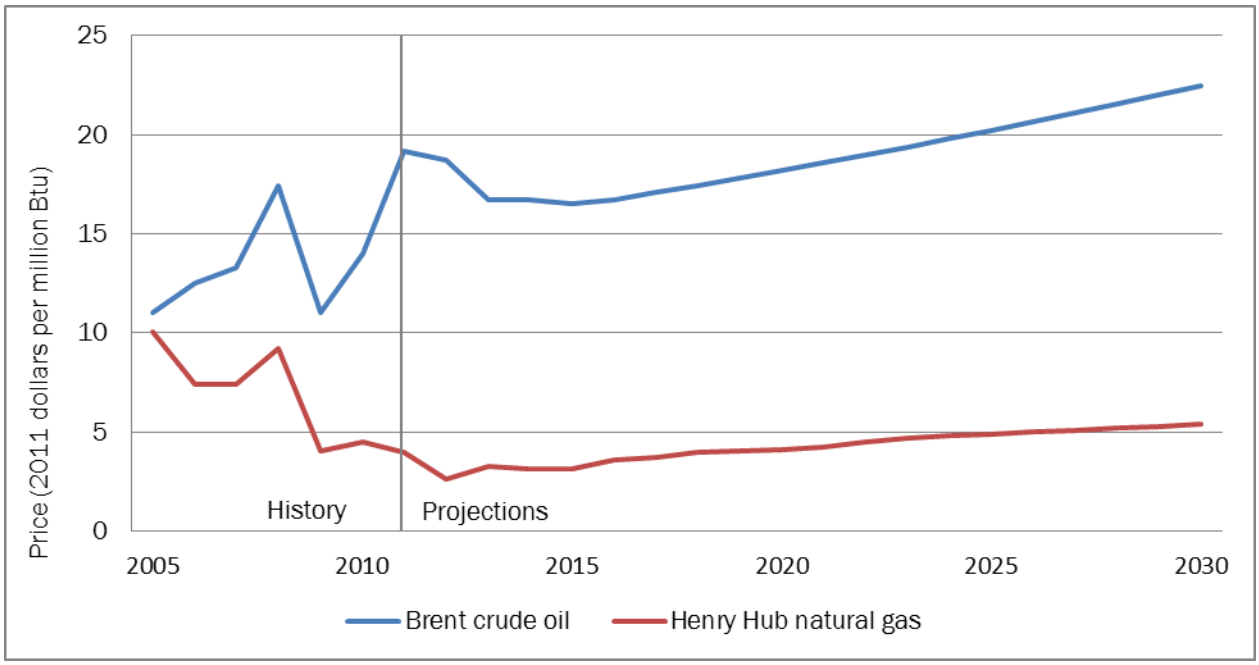
Conduct Additional Scenario Analysis to Support a 2050 Roadmap

The 2020 Plan described a few possible pathways for achieving the GWSA's ambitious 2050 emissions limit—an 80 percent reduction in GHG emissions below 1990 levels. Under this emissions limit, Massachusetts needs an additional 52 million metric tons in GHG emissions reductions above and beyond the 24 million metric tons of

reductions needed to meet the 2020 emissions limits. This translates to a very aggressive GHG reduction rate of 1.7 percent per year from 2020 to 2050, much faster than the 0.9 percent per year pace of emissions reductions needed from 2011 through 2020. Advances in energy and transportation technology will undoubtedly provide additional carbon reductions over this timeframe, and any federal (or international) policies which put a price on carbon would also spur development of low-carbon technologies. Given that the pace of reductions needed to achieve the 2050 limit must accelerate, the Commonwealth should further develop a 2050 "Roadmap" based on additional scenarios which include an analysis of possible increases in electricity use by vehicles and building as well as changes in patterns of land use. Major variables to consider in developing scenarios include population, economic growth, changes in energy demand, development patterns, and the cost and availability of low-carbon technologies— factors which will influence the likelihood of meeting the 2050 emissions limit. These probabilistic scenarios can then be updated in successive GWSA five-year progress reports and plans for 2030, 2040, and 2050, as new information becomes available.

The Commonwealth's approach to the 2050 Roadmap should explicitly account for the GHG implications of an increased role for natural gas, in addition to other policy considerations like fuel diversification, local economic development, and long-term price risks (Energy Modeling Forum 2013). Exceptional growth in the supply of natural gas from shale-bed resources has transformed North America's energy markets. As shown in Figure 5 below, historically-low natural gas prices are providing cost savings for consumers and businesses that shift to natural gas from higher-price heating and transportation fuels (EIA, 2013). It is important that the Commonwealth continues to review the interplay of natural gas with energy efficiency and renewable energy and its impact on meeting the Commonwealth's 2050 GHG emissions goals.

Figure 5: Natural Gas vs. Crude oil Prices



Source: Energy Information Administration, 2013

1.2 Highlights — Building Capacity for 2020 and Beyond

Since 2008, the Commonwealth has built substantial institutional capacity, both within EEA and across state agencies, to enable smoother and more rapid implementation of climate and clean energy programs. Early successes on "cross-cutting" programs that draw on contributions from EEA and other agencies, such as Green Communities, GHG requirements under the Massachusetts Environmental Policy Act (MEPA), and GreenDOT implementation, are an encouraging sign that the state's newfound capacity is being used effectively. By their very nature, these strategies require a high degree of inter-agency communication, collaboration, and alignment among agency leadership. Equally important, Massachusetts has made a series of high-level investments in new information systems needed to measure, monitor, and report transparently on progress towards the GWSA goals.

GHG Performance Tracking and Measurement

Aided by funding and collaboration from the Barr Foundation, EEA launched the Massachusetts Clean Energy and Climate Performance Management System (CCPMS) in late 2013. Designed to provide a cost-effective means to monitor, evaluate, and communicate progress on the 2020 Plan, this Web-based data management system is designed to track performance information for emission reduction strategies identified in the 2020 Plan, supplemental emission reduction strategies, and climate change adaptation strategies. The CCPMS contains hundreds of quantitative metrics and qualitative milestones used to track performance, which can be updated and validated annually. When these tracking data are updated, the system converts quantitative metrics (e.g. British thermal units (Btu) of natural gas reduced) to GHG mitigation estimates and updates output reports that summarize progress made under each strategy.

Data collection and entry for all 27 GHG reduction strategies, which are critical for tracking the Commonwealth's progress in meeting the GWSA's emissions limits, began in mid-2013 and are not yet complete. The system is far from fully populated for nearly 150 GHG reduction strategy elements, which themselves have more than 400 metrics and project milestones. Upon completion of the CCPMS database, Massachusetts will be able to access and present consistent, timely, and reliable information on progress made toward the 2020 Plan.

Interagency Collaboration and Implementation Advisory Committee

The emission reduction strategies identified in the 2020 Plan include a diverse set of activities to be implemented in multiple sectors. To successfully implement the 2020 Plan, eleven state agencies with a broad range of expertise and oversight have come together to execute the strategies, and have been aided by additional input from universities, federal partners, advocates, and private corporations. The Implementation Advisory Committee (IAC) provides guidance to the Administration on GWSA implementation. Convened in May 2012, the IAC membership includes a broad base of representatives from the business, energy, environmental, and academic communities in Massachusetts. Over the last year, the IAC has provided input to EEA on the assessment of progress on the 2020 Plan, helped to identify supplemental GHG emission reduction strategies, and is helping to further develop the climate change adaptation process.

GHG Inventory and Reporting Systems

The GWSA requires Massachusetts to establish a GHG emissions registry and reporting system, and publish a state-wide GHG inventory with comprehensive estimates of GHG emissions by sector. To date, Massachusetts has met its obligations to publish the statewide GHG emissions inventory. In July 2009, MassDEP published the first GHG inventory and projection for "business-as-usual" 2020 emissions.[3] Since then, MassDEP has completed annual updates to the GHG emissions inventory.

In 2008 and 2009, MassDEP promulgated mandatory greenhouse gas reporting regulations which require large facilities and retail electricity suppliers to report their GHG emissions annually. Facility managers have been reporting their emissions via MassDEP's electronic reporting system, the Climate Registry Information System (CRIS). With CRIS, MassDEP has collected and published emissions information from approximately 300 of the state's largest emitters.

MEPA GHG Process

The Massachusetts Environmental Policy Act (MEPA) requires that proponents of large projects undertake an assessment of project impacts and alternatives in an effort to avoid, minimize, and mitigate damage to the environment to the maximum extent feasible. In 2007, the EEA Secretary determined that the phrase "damage to the environment" includes the emissions of greenhouse gases. In response, MEPA issued the Greenhouse Gas Emissions Policy and Protocol, which requires project proponents to undertake an analysis of a project's primary sources of GHG emissions at an early stage of project planning, and examine all feasible alternatives that may have lower GHG emissions potential. Project proponents then make mitigation commitments which become conditions for the project if it requires permits.

Since the MEPA GHG Policy was established, 58 projects have submitted estimates of project-related GHG emissions and proposed alternatives with lower GHG emissions. These projects have demonstrated that considerable GHG emissions reductions can be achieved through MEPA review; additional emissions reductions from the MEPA process are expected in the future.

1.3 Highlights — Climate Mitigation Strategies in Massachusetts

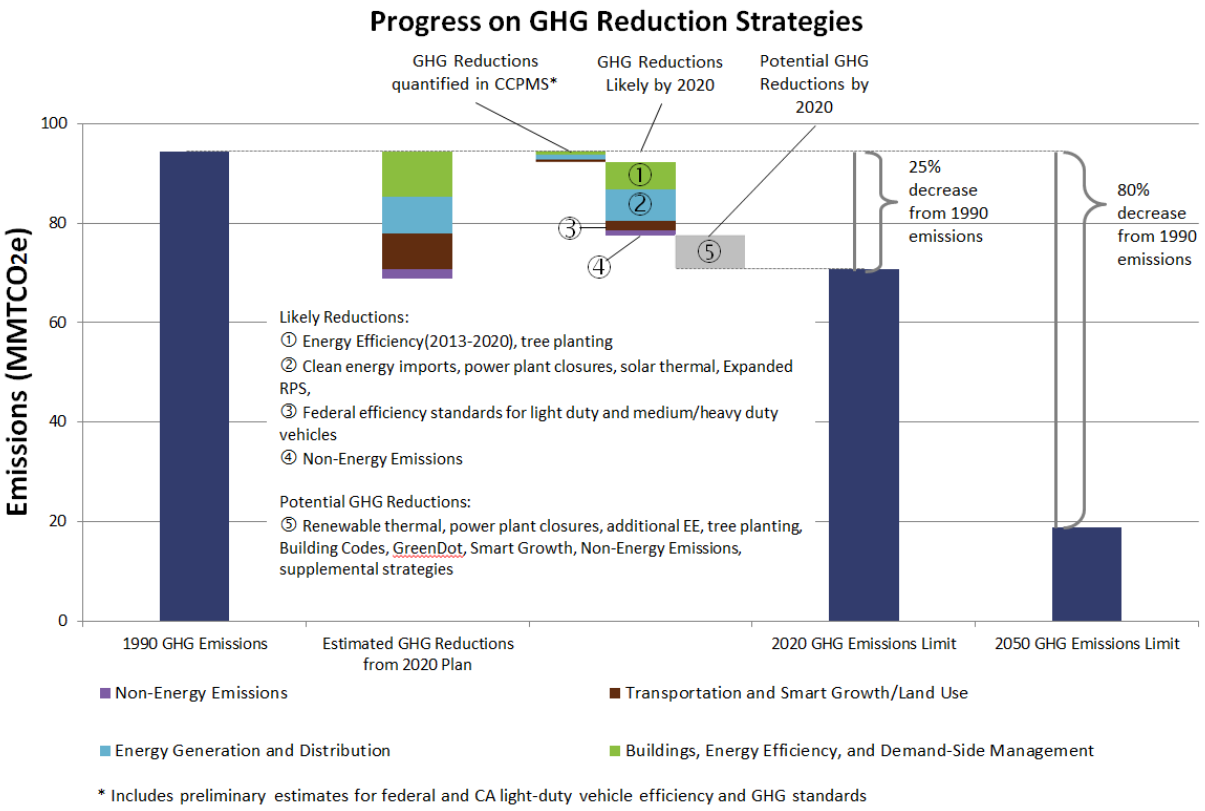
Since the publication of the 2020 Plan, EEA, key agencies, and other executive offices in the Commonwealth have been implementing in earnest many of the Plan's key GHG reduction strategies. In other cases where strategy implementation is not yet underway, EEA and agencies have initiated other activities necessary to achieve the strategy, such as developing strategic plans, securing funding, and drafting enabling legislation. In a more limited set of cases, where impediments have prevented strategies from moving forward, EEA and the agency staff are developing and planning supplemental strategies.

As mentioned earlier, EEA is in the process of developing quantitative estimates in the CCPMS for all GHG reduction strategies currently being implemented. Of the 27 strategies described in the 2020 Plan, quantitative estimates for four strategies have already been developed and validated with the CCPMS, and quantification of other strategies is underway but not yet complete.

Figure 6 below shows the magnitude of progress to date from these strategies towards the 2020 goal, juxtaposed against the 2020 Plan's estimates of GHG reductions which would result from the 27 strategies. Progress on the 2020 Plan's GHG reduction strategies is differentiated into three different categories, described below:

1. **GHG Reductions Quantified in the CCPMS**: This block represents progress towards the 2020 goal contributed by strategies which have been quantified and validated in the CCPMS to date, including (1) expanded cost-effective energy efficiency from 2010 to 2012, equal to 0.8 $MMTCO_2e$; (2) expanded RPS, equal to 0.1 $MMTCO_2e$; (3) federal light-duty fuel economy standards from 2009 to 2011, equal to 0.4 $MMTCO_2e$; and (4) recent power plant closures, equal to 0.8 $MMTCO_2e$.
2. **GHG Reductions Likely by 2020**: This block of GHG reductions represents strategies which are underway or in the late stages of planning, and in EEA's judgment are highly likely to be realized at or near their full potential by 2020.These include (1) energy efficiency and tree-planting, totaling 5.5 $MMTCO_2e$ (2) clean energy imports, power plant closures, solar thermal, and expanded RPS, totaling 6.4 $MMTCO_2e$, (3) Federal efficiency standards for light– and medium/heavy duty vehicles, totaling 2.0 $MMTCO_2e$, and (4) Non-energy emissions, totaling 1.0 $MMTCO_2e$.
3. **Potential GHG Reductions by 2020:** This block illustrates potential GHG reductions associated with strategies which could generate needed GHG reductions by 2020 to meet any remaining gap, but which are either in very early stages of planning or have not yet been implemented. By definition, these strategies are generally subject to a higher level of uncertainty than strategies in the other two categories. The magnitude of this block is 6.7 $MMTCO_2e$.

Figure 6: Progress on GHG Emission Reduction Strategies and the 2020 Limit



The next section describes progress on mitigation strategies for each of the major sectors, as well as challenges to implementation.

Buildings, Energy Efficiency, and Demand-Side Management

The Commonwealth's commitment to implement *all cost-effective energy efficiency* is arguably the single-most influential decision influencing progress towards the goals of the 2020 Plan over its first five years. This signature piece of the 2008 Green Communities Act (GCA) also played a leading role in earning Massachusetts a #1 ranking in the U.S. in state energy efficiency programs from the American Council for an Energy Efficient Economy (ACEEE) for the third straight year. Efficiency programs administered by electricity and natural gas providers have doubled the annual level of benefits delivered within the last three years, resulting in over $4 billion in net benefits from an initial $1.5 billion investment. Now into its second Three-Year Plan (covering 2013-2015), the plans continue to grow incrementally, with net benefits from energy efficiency for the second period now projected at over $6 billion. *Deep energy retrofits* have been absorbed into the energy efficiency plans and as such are no longer being tracked as a distinct strategy. These will be included in estimates of energy efficiency in future estimates of progress.

Under the umbrella of the GCA, a number of other important policy innovations have been made. The *Green Communities Program* is now a national model for engaging municipalities and communities in efforts to implement energy efficiency, and renewable energy efforts that reduce GHG emissions and fuel costs to consumers and businesses. Since 2008, 123 communities have been designated as Green Communities, 133 have adopted the stretch building energy code, and more than $28 million in municipal building energy-saving projects have been deployed, at substantial savings equivalent to the annual energy consumption of over 15,000 Massachusetts homes and a GHG emissions reduction of 0.2 $MMTCO_2e$.

Other programs targeting communities designed to complement the Green Communities Program have also been highly successful in increasing clean energy education and adoption. For example, the SolarizeMass Program's unique group purchasing model and grassroots approach has resulted in tremendously competitive pricing and caused a surge of solar energy installation by Commonwealth residents and businesses, totaling to 1,250 new solar contracts at capacity of 9.4 megawatts.

Requirements for *advanced building energy codes* have led to an acceleration of advanced building energy code adoption relative to historical levels; however, despite two baseline energy code updates and the wide adoption of the nation-leading stretch energy code, to date this sector has not delivered the expected GHG reductions. The economic recession had serious effects on the construction sector, and indicators such as new housing starts and commercial construction and retrofits were for several years well below historical levels. Low construction rates reduce GHG emissions in a given year, but also reduce the aggregate savings from advanced energy codes. Construction indicators are now recovering, and aggregate savings can be expected to improve.

Tree-planting and retention pilot projects to reduce building energy use for heating and cooling are moving forward. With an initial $5 million in funding, the Commonwealth expects to plant 15,000 trees and create emissions reductions of 1.8 $MMTCO_2e$ resulting from avoided energy use over these trees' lifetime (MA EEA 2013). Full funding of the tree planting and retention program ($24 million) would result in planting of 53,000 additional trees for a total of 68,000 trees, and would more than double the energy savings and emission reductions from the first 15,000 trees.

Heating oil efficiency programs for commercial and industrial customers have not moved forward, and require legislation. Efforts are underway to work with the commercial real estate industry and identify opportunities for greater uptake of energy efficiency in that sector. Moreover, DOER continues to evaluate and consider ways to incorporate oil heat efficiency into its existing programs.

Energy Generation and Distribution

In the 2020 Plan, *imports of clean energy* were expected to deliver substantial GHG reductions—5.3 percent below 1990 emission levels.[4] Massachusetts has played a key leadership role working with the other New England states on a regional initiative to expand access to new, large scale, clean energy resources like large hydro and both onshore and offshore wind energy. This included the development of a regional coordinated procurement process for renewable energy with The New England States Committee on Electricity (NESCOE) and the launch of a regional large hydro expansion initiative.

In April 2013, Massachusetts and eight other states participating in the *Regional Greenhouse Gas Initiative (RGGI)* completed a review of the first three years of the RGGI program, which caps CO_2 emissions from large power plants. The RGGI states revised the emissions cap downwards, from 165 to 91 million short tons. Under the new cap, allowance revenues for Massachusetts are expected to increase by $350 million from 2012 to 2020, and will be made available for cost-effective energy efficiency programs (MA EEA 2013).

As expected, *federal rules for power plants* combined with low natural gas prices have resulted in announcements of closures of two of Massachusetts' coal-fired power plants—Somerset and Salem Harbor Stations. Emissions reductions associated with these plant closures will meet estimates from the 2020 Plan. The owners of Brayton Point Station have announced a plan to close the facility in 2017; if that facility indeed closes, it would achieve another 3.5 $MMTCO_2e$ in GHG reductions that were not anticipated in the 2020 Plan.

Growth in wind, solar, anaerobic digestion, and small-scale hydropower energy spurred on by the *expanded Renewable Portfolio Standard (RPS)* has been highly successful—over five years, installed solar photovoltaics (PV) grew from 3 to 347 megawatts (MW), meeting the Governor's goal four years ahead of schedule. Over the same period, wind energy grew from three to 103 MW of installed capacity. In addition, construction on the 468 MW

[4] the 2020 Plan, GHG reductions from this strategy were estimated at 5.4 percent below 1990 levels; this has since been adjusted to 5.3 percent to account for double-counting.

Cape Wind project is expected to begin in 2014, if final financing is secured. Other progress related to offshore wind energy includes the completion of a multi-year stakeholder process to identify new offshore Wind Energy Areas in federal waters south of Martha's Vineyard, a leading Wind Technology Testing Center in Charlestown, and the development of the New Bedford Marine Commerce Terminal, a first-in-the-nation facility designed to deploy offshore wind projects along the Atlantic Coast.

Transportation and Land Use

New *federal vehicle efficiency standards* adopted by the Obama Administration in 2012 require the largest increase in corporate average fuel economy standards for passenger vehicles in decades, and will increase the efficiency of the state's vehicle light-duty fleet. Massachusetts has adopted California's even more aggressive standards for the model years 2017 to 2025, which will deliver substantial GHG reductions as anticipated in the 2020 Plan. Massachusetts implements these reductions by promulgating amendments to the existing *Low Emission Vehicle (LEV)* program, making the regulation consistent with California's GHG tailpipe and refrigerant leakage standards for passenger vehicles.

Massachusetts has made some early progress on promoting the adoption of electric vehicles (EVs). In 2013, EEA launched the *Massachusetts Electric Vehicle Incentive Program* (MassEVIP), with $2.5 million in funding for municipalities to purchase hybrid electric and battery electric passenger vehicles and install electric charging stations. Funded in part by the state, Massachusetts currently has over 390 public EV charging stations, more than any other New England state. The Commonwealth is also participating in a multi-state program to increase the market share of "zero-emission vehicles," as well as joining other regional efforts to plan for greater deployment of EVs and charging infrastructure in the Northeast. With $11.7 million in Federal Highway Administration funds, MassDOER's Alternative Transportation team is launching a Clean Vehicle Program to replace a variety of fleet vehicles across the Commonwealth with cleaner alternatives such as natural gas and propane, battery and hybrid electric vehicles, solar electric vehicles and hydraulic hybrids.

MassDOT released the *GreenDOT* implementation plan in December 2012. GreenDOT's mode shift goal—to triple person-miles traveled by transit, foot, and bicycle—is currently being translated into performance metrics for future tracking. Similarly, the state is developing metrics and indicators for tracking progress on the *Smart Growth Policy Package* and related *Sustainable Development Principles.* However, absent additional funding for the infrastructure and other investments needed to implement these plans, progress may be limited.

In 2013, the U.S. EPA proposed a revision to the 2014 requirements for traditional ethanol and advanced cellulosic biofuels under the *Federal Renewable Fuel Standard* (RFS) because of challenging market conditions which have limited the availability of biofuels. As a result, estimated GHG reductions from the federal RFS program for Massachusetts are likely to be lower than estimated. The regional *Clean Fuels Standard*, under consideration by ten Northeast states, has not moved forward.

Similarly, legal challenges have slowed progress on a pilot of the *Pay-as-You-Drive (PAYD)* program. Even the pilot program will be difficult to launch in 2014. Moreover, a statewide PAYD program is unlikely to result in the GHG reductions initially estimated in the 2020 Plan.

Non-Energy Emissions

Strategies to reduce GHG emissions from the non-energy sector are progressing well, with new legislation and grants providing support to strategy implementation. In June 2013, MassDEP proposed draft regulations aimed at reducing *emissions of sulfur hexafluoride (SF_6) from gas-insulated switchgear*. The regulations are currently being finalized, and would require owners of gas-insulated switchgear to reduce leakage rates of existing equipment, or if purchasing new gas-insulated switchgear, to purchase only equipment with a low emissions rate.

In the 2020 Plan, a strategy to *reduce leaks from stationary equipment* has the largest possible GHG reduction in this sector, at 1.3 percent of 1990 emissions. To achieve this, MassDEP has gathered information from stakeholders and develop draft regulations for leak detection and repair in facilities with large refrigeration units. Other efforts to advance this strategy include engaging with stakeholders on transitioning to refrigerants with lower global warming potential (GWP), and incorporating refrigeration guidelines into the MEPA GHG Protocol.

Reducing GHG emissions from plastics combustion is also a key strategy in this sector. The Massachusetts 2010-2020 Solid Waste Master Plan (SWMP), published in 2013, sets a goal of reducing solid waste disposal by 30 percent by 2020. To achieve this reduction and also garner the accompanying reductions in GHG emissions, the Commonwealth is launching programs to decrease the rate of disposal and incineration of plastics. To help launch highly effective programs for reducing waste and increasing recycling, such as the Pay-As-You-Throw program, MassDEP's Sustainable Materials Recovery Program is providing grants to municipalities which otherwise lack capital to start these efforts. In addition to reducing GHG emissions, a key co-benefit of this strategy is that it helps municipalities reduce their overall expenditures on waste disposal.

1.4 Highlights — Climate Adaptation Strategies in Massachusetts

Over the last five years, Massachusetts has taken important steps to plan for effective adaptation to a changing climate. In 2009, EEA established an Adaptation Advisory Committee to review potential approaches to help Massachusetts become more resilient in the face of growing evidence of climate change impacts. This advisory committee, composed of a broad range of stakeholders across state agencies, non-governmental organizations, academia, and local governments, led the publication of the Climate Change Adaptation Report (the Adaptation Report). This Report, released in 2011, includes an overview of the observed and predicted changes to Massachusetts' climate and the anticipated impacts, key vulnerabilities to climate change, and adaptation strategies that could increase resilience and preparedness.

The development of the Massachusetts Climate Change Adaptation Report focused state agency attention on the growing issue of climate change impacts, and facilitated the initiation of research and implementation projects across the state. In 2012 EEA formed an adaptation subcommittee, with representation from state agencies as well as stakeholders outside of government, to begin planning for implementation of the 200-plus recommendations within the report. Information on climate science, research, project outcomes and other climate-related efforts are also being shared through the subcommittee.

The Commonwealth's accomplishments and ongoing efforts made by various entities comprising the subcommittee include:

- Implementation of a pilot project by Department of Transportation to analyze coastal asset vulnerabilities and adaptive capacity relative to climate change and sea level rise;
- Assessments of community preparedness to respond to public health impacts by Department of Public Health;
- Assessments of natural resource vulnerability to climate change by Department of Fish and Game and protection of over 5,600 acres of high priority habitat;
- Adaptation training provided by the Department of Environmental Protection to managers of small drinking water systems located within 100– and 500-year flood plains and areas identified as vulnerable to sea level rise;
- The division of Fisheries & Wildlife and Division of Ecological Restoration's efforts to restore "Century Bog" to maximize ecosystem resiliency;
- Incorporation of climate change in the newly updated state hazard mitigation plan; and
- Development of climate plans by various regional and local entities.

Events like Hurricane Sandy highlight the need for the Commonwealth to develop clear priorities among the various programs and policies identified in the Adaptation Report. Earlier this year, Governor Patrick announced that climate change adaptation will be one of EEA's top three priorities through the end of his Administration. To help implement the Governor's priority Secretary Sullivan added a full time staff member – a Policy Advisor for climate change adaptation – and each Secretariat designated a point of contact on adaptation to identify and advance adaptation activities that reflect Administration- and Commonwealth-wide priorities. While prioritization of activities is ongoing, EEA anticipates accelerating adaptation related work over the next year.

Introduction

In 2013, the Intergovernmental Panel on Climate Change (IPCC), the world's leading scientific body of expertise on climate change, released the findings of their fifth and most recent assessment of the state of climate change science. While media outlets seem intent upon spurring continuing debate over the science of climate change, the IPCC's findings on the latest climate science and the role of human contributions to those changes are unambiguous and conclusive. In their 2013 "Summary for Policymakers," the IPCC stated with the highest level of confidence that "…it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century," (IPCC 2013).

Under the leadership of Governor Deval Patrick, the Commonwealth is leading the nation in state-level efforts to reduce GHG emissions and identify, plan for, and mitigate the potential impacts of climate change to the Massachusetts economy and its most vulnerable populations, infrastructure, habitats, and coastlines. The *Global Warming Solutions Act of 2008* has been the primary catalyst for many of these efforts.

2.1 Background on the GWSA

In August 2008, Governor Patrick signed the Global Warming Solutions Act (GWSA), thereby making Massachusetts one of only three states in the US with legally binding limits on statewide greenhouse gas emissions.[5] The GWSA created a regulatory framework for actions to reduce global warming emissions to levels which scientific evidence indicates are needed to avoid the most damaging impacts of climate change. The Act itself laid out requirements for EEA to engage in specific activities, including the creation of a GHG inventory and business-as-usual projection to 2020, setting a limit for GHG emissions in 2020, requiring mandatory GHG reporting by large sources of emissions, and proposing and implementing measures and strategies for reducing emissions (Commonwealth of Massachusetts 2008a). Table 2 below summarizes the key requirements of the GWSA and the actions taken by EEA and other state agencies to respond to those requirements.

[5] In 2006, Governor Schwarzenegger signed California's Assembly Bill 32, which requires an economy-side GHG cap-and-trade program. Connecticut passed global warming solutions legislation in April 2008.

Table 2: Summary of Major GWSA Requirements and EEA Activities

Major Requirement of the GWSA	EEA and State Agency Progress on Key GWSA Requirements
Establish regulations requiring reporting of GHG emissions by large sources, by Jan. 1, 2009. Establish regulations for voluntary GHG emission reports and requiring reporting of GHG emissions by retail electricity sellers, by July 1, 2009.	**December 2008:** MassDEP issues initial GHG reporting regulations (*310 CMR 7.71*); **March 2009:** EEA establishes the Climate Protection and Green Economy Advisory Committee, focused on the development of the 2020 Plan. **June 2009:** Mass DEP amends reporting requirements to address verification, voluntary reporting, and reporting by retail electricity sellers.
Establish a 1990 baseline and a projection of statewide GHG emissions for a likely **"**business-as-usual" case to 2020, by July 1, 2009.	**July 2009:** Mass DEP publishes "Statewide GHG Emissions Level: 1990 Baseline and 2020 Business-As-Usual Projection."
Establish emission reduction limit that must be achieved by 2020, and a plan for achieving it, by January 1, 2011.	**December 2010:** The EEA Secretary sets a statewide limit on GHG emissions of 25% below 1990 levels by 2020. EEA releases the "Massachusetts Clean Energy and Climate Plan for 2020" outlining 27 strategies for GHG reductions.
Create an Advisory Committee to analyze strategies and recommendations for adapting to climate change, and report back to the Legislature, by December 31, 2009.	**September 2011:** EEA publishes "Massachusetts Climate Change Adaptation Report." Adaptation Advisory Committee continues to study and make recommendations on adaptation strategies.
Monitor implementation of regulations and every 5 years, report on measures undertaken and recommendations for future policy actions, by January 1, 2014.	**December 2013:** EEA publishes first Five-Year GWSA Progress Report, including recommendations for future policies.

2.2 Purpose and Scope of the Five-Year Progress Report

The purpose of this Five-Year Progress Report on the Global Warming Solutions Act (the Progress Report) is to meet several objectives. First, as described above, it is designed to comply with Sections 5 and 18 of the GWSA. These sections of the GWSA require that: 1) the Secretary of Energy and Environmental Affairs monitor implementation of regulations relative to climate change and report every five years on measures undertaken; and 2) publish the first report of progress by January 1, 2014. In addition, Section 5 of the GWSA requires EEA to consider how measures and strategies taken to reduce GHG emissions will affect other criteria and public policy considerations which are important to the Commonwealth, including:

- Equity, cost benefits
- Potential impacts on low-income communities
- Treatment of early emission reductions
- Interaction with federal and state air quality standards
- Other societal benefits
- Potential administrative burden
- Leakage
- Relative contribution to statewide GHG emissions
- Whether GHG reductions are "real, permanent, quantifiable, verifiable and enforceable"

The scope of this Progress Report does not include new analysis addressing how specific GHG mitigation strategies outlined in the Massachusetts Clean Energy and Climate Plan for 2020 (the 2020 Plan) meet these criteria. However, this Progress Report does provide qualitative discussion of possible effects of the 2020 Plan's implementation on these criteria and policy considerations whenever feasible.

The remainder of this Progress Report is organized as follows:

- Section 3—-Capacity Building for GWSA Implementation and Related Programs
- Section 4—-Progress on Climate Change Mitigation
- Section 5—-Progress on Climate Change Adaptation

Capacity Building for Implementation of GWSA

Substantial institutional capacity is needed to implement climate and clean energy programs under the GWSA. Programs span a broad range of sectors, so multiple state agencies with a complementary range of expertise are needed to oversee and implement programs. Since 2008, Massachusetts has fostered the inter-agency communication and collaboration needed for the successful implementation of climate and clean energy programs. In addition, the state needs to be able to assess the effectiveness of programs for meeting future GWSA emission limits. Over the last year, the Commonwealth has invested in major information systems to track progress for each climate and clean energy program, aggregate progress across programs, and evaluate impacts on statewide emissions reductions.

Table 3: Summary of Progress on Capacity-Building

Strategy	Key Accomplishments and Highlights	Reductions below 1990 levels anticipated in 2020 Plan	Likelihood of Meeting 2020 Goals
Collaboration and Coordination	• Created the Implementation Advisory Committee to foster inter-agency collaboration and stakeholder participation • Created five Implementation Subcommittees to implement and monitor strategies identified in the 2020 Plan	- -	High
Assessment of Climate and Clean Energy Programs	• Developed systems to track, evaluate, and report on climate change and clean energy programs	- -	High
Investments in GHG Measurement, Reporting, and Verification Systems	• Published statewide GHG emissions inventories • Enacted regulations in 2008 and 2009 requiring annual GHG reporting by large facilities and retail electricity sellers • Developing a Clean Energy and Climate Performance Management System to track progress on GHG reduction strategies	- -	Medium to High

3.1 Collaboration and Coordination

Since 2008, the Commonwealth has built substantial institutional capacity, both within the Executive Office for Energy and Environmental Affairs (EEA) and across state agencies, facilitating implementation of climate and clean energy programs. Multiple agencies are working together under the GWSA and their early success on "cross-cutting" programs is encouraging.

Interagency Collaborations

The emission reduction strategies identified in the 2020 Plan include a diverse set of activities to be implemented across multiple sectors. To implement and monitor these strategies, EEA created five Implementation Subcommittees:

- Buildings, Energy Efficiency and Demand-Side Management;
- Energy Generation and Distribution;
- Transportation, Smart Growth and Land Use;
- Non-Energy Emissions; and
- Climate Change Adaptation.

Each subcommittee is led by experts who collaborate closely with climate scientists and policy experts both within and beyond the Commonwealth. This approach ensures a high level of internal coordination among the EEA agencies and extends leadership to other Secretariats, including the Executive Office of Housing and Economic Development (HED), Massachusetts Department of Transportation (MassDOT), and the Massachusetts Clean Energy Center (MassCEC) (2013a). In total, two Executive offices and nine state agencies with a broad range of expertise and oversight have come together to execute these strategies, as shown in Table 4. The EEA, MassDOT, and HED Secretaries collaborate closely and communicate regularly on GWSA implementation.

Table 4: State Agencies Implementing Emission Reduction Strategies Identified in the 2020 Plan (MA EEA 2013d)

2020 Plan Strategy	Participating State Agencies
Buildings, Energy Efficiency, and Demand-Side Management	
Advanced Building Energy Codes	DOER, DPS
All Cost Effective Energy Efficiency (now includes Deep Energy Efficiency Improvements)	DOER, DPU, HED, MassDEP
Building Efficiency Rating and Labeling	DOER
Expanding Energy Efficiency Programs to Commercial/Industrial Heating Oil	DOER
Federal Appliance and Product Standards	DOER
Green Communities Designation and Grant Program	DOER
Leading by Example	DOER (All State Agencies)
Tree Retention and Planting to Reduce Heating and Cooling Loads	EEA, DOER, DHCD

2020 Plan Strategy	Participating State Agencies
Energy Generation and Distribution	
New Clean Energy Resources/Clean Energy Imports	EEA, DEP, DOER, DPU
Clean Energy Performance Standard	EEA, DOER, DPU MassCEC, MassDEP
Developing a Market for Solar Thermal & Space Heating	DOER, MassCEC
Expanded RPS and APS	DOER, DPU, EEA, MassCEC MassDEP
More Stringent EPA Power Plant Rules	MassDEP
Regional Greenhouse Gas Initiative (RGGI)	DOER, MassDEP
Transportation and Smart Growth/Land Use	
Clean Car Consumer Incentives [now Clean/Electric Vehicle Incentives, Fleet & Individual supplemental strategy]	DOER, MassDEP
Federal and California Vehicle Efficiency and GHG Standards	MassDEP
Federal Emissions and Fuel Efficiency Standards for Medium and Heavy-Duty Vehicles	MassDEP
Federal Renewable Fuel Standard (RFS)	MassDEP
Regional Low Carbon Fuel Standard (LCFS)	MassDEP
GreenDOT	MassDOT
Pay As You Drive Auto Insurance (PAYD)	MassDOT, DOI
Smart Growth Package	DHCD, EEA, EOHED, MassDOT
Non-Energy Emissions	
Reducing Emissions from Plastics	MassDEP
Stationary Equipment Refrigerant Management	MassDEP
Reducing SF6 Emissions from Gas-Insulated Switchgear	MassDEP
Other Cross-Cutting Policies	
MEPA GHG Policy and Protocol	All EEA Agencies, MassDOT, MHC, Regional Planning Agencies
Leading by Example	All EEA agencies, DCAMM
Green Communities	MA DOER, All EEA Agencies
Abbreviations:	
Department of Energy Resources (DOER), Department of Housing and Community Development (DHCD), Department of Public Safety (DPS), Department of Public Utilities (DPU), Executive Office of Energy and Environmental Affairs (EEA), Executive Office of Housing and Economic Development (HED), Division of Capital Asset Management and Maintenance (DCAMM), Massachusetts Clean Energy Center (MassCEC), Massachusetts Department of Environmental Protection (MassDEP),Massachusetts Department of Transportation (MassDOT), Massachusetts Division of Insurance (DOI), Massachusetts Historical Commission (MHC)	

Implementation Advisory Committee

The GWSA requires the Commonwealth to establish an advisory committee composed of representatives from the business, energy, environmental, government and academic communities in Massachusetts to advise EEA on implementation of the GWSA. In May 2012, EEA convened the Implementation Advisory Committee (IAC) (MA EEA 2013e). Co-chaired by the EEA Undersecretaries for Energy and Environment, the IAC has focused on assessing progress toward the goals of the 2020 Plan, identifying supplemental GHG emission reduction strategies, and further developing the climate change adaptation process. The IAC replaces its predecessor, the Climate Protection and Green Economy Advisory Committee (CPGEAC), which was focused on the development of the 2020 Plan, and met for the last time in January 2012.

Organizations Represented on the Implementation Advisory Committee

- A Better City
- City of Boston
- Conservation Law Foundation (CLF)
- Environment Northeast
- Environmental League of Massachusetts
- Fraunhofer Center for Sustainable Energy Systems
- Jiminy Peak Mountain Resort LLC
- Massachusetts Audubon Society
- Massachusetts Executive Office of Energy and Environmental Affairs
- Massachusetts Institute of Technology
- Metropolitan Area Planning Council
- National Grid
- The Nature Conservancy
- New England Clean Energy Council
- Next Step Living
- R.E. Hill & Company
- Tufts University
- Woods Hole Oceanographic Institution

Source: EEA, 2013

MEPA Greenhouse Gas Emissions Policy and Protocol

The Massachusetts Environmental Policy Act (MEPA) process illustrates how cross-cutting programs requiring interagency collaboration can successfully achieve emissions reductions. In 2007, the EEA Secretary determined that the phrase "damage to the environment" included the emissions of greenhouse gases (MA EEA 2010c) and introduced the MEPA GHG Policy and Protocol. The GHG Policy requires project proponents, at an early stage of project planning, to identify a project's primary sources of GHG emissions, and examine all feasible measures to avoid, minimize and mitigate GHG emissions (MA EEA 2010b).

The MEPA Office coordinates the review of projects and GHG analysis. Agencies that typically participate in this review include MassDEP, MassDOT, the DOER, MHC, regional planning agencies, and municipal agencies (MA EEA 2013f). From 2008 to 2012, 58 projects that were subject to the MEPA GHG Policy have completed MEPA review. When these projects are completed, their mitigation measures will avoid the generation of 83,000 metric tons CO_2e per year (MA EEA 2013l). These projects have demonstrated that considerable GHG emissions reductions can be achieved through application of the MEPA GHG Policy. MEPA review is ongoing for more than 100 projects that are subject to the MEPA GHG Policy which will contribute to additional emissions reductions over the next five years .

3.2 Assessment of Clean Energy and Climate Programs

Massachusetts has numerous systems in place to track, evaluate, and report on its climate change and clean energy programs. These systems document progress made toward program goals, identify program impacts, inform program planning and management decisions, and provide transparent information to the public. This section highlights assessment systems for three programs:

- The Massachusetts Energy Efficiency Advisory Council (EEAC) Three-Year Electric and Gas Energy Efficiency Plan and Reports;
- The Renewable Energy Portfolio Standard (RPS) and Alternative Energy Portfolio Standard (APS); and
- The Regional Greenhouse Gas Initiative (RGGI).

EEAC Three-Year Electric and Gas Energy Efficiency Plan and Reports

The EEAC was created under the Green Communities Act of 2008 to guide the development of energy efficiency plans by the state's investor-owned gas and electric utilities and energy providers and monitor the implementation of these plans (MA EEAC 2013). The EEAC works with Program Administrators (PAs) from the utilities and energy providers to develop three-year plans with goals for electricity and gas savings, which lead to considerable greenhouse gas emissions reductions. The PAs are then responsible for implementing the programs to achieve the plan goals.

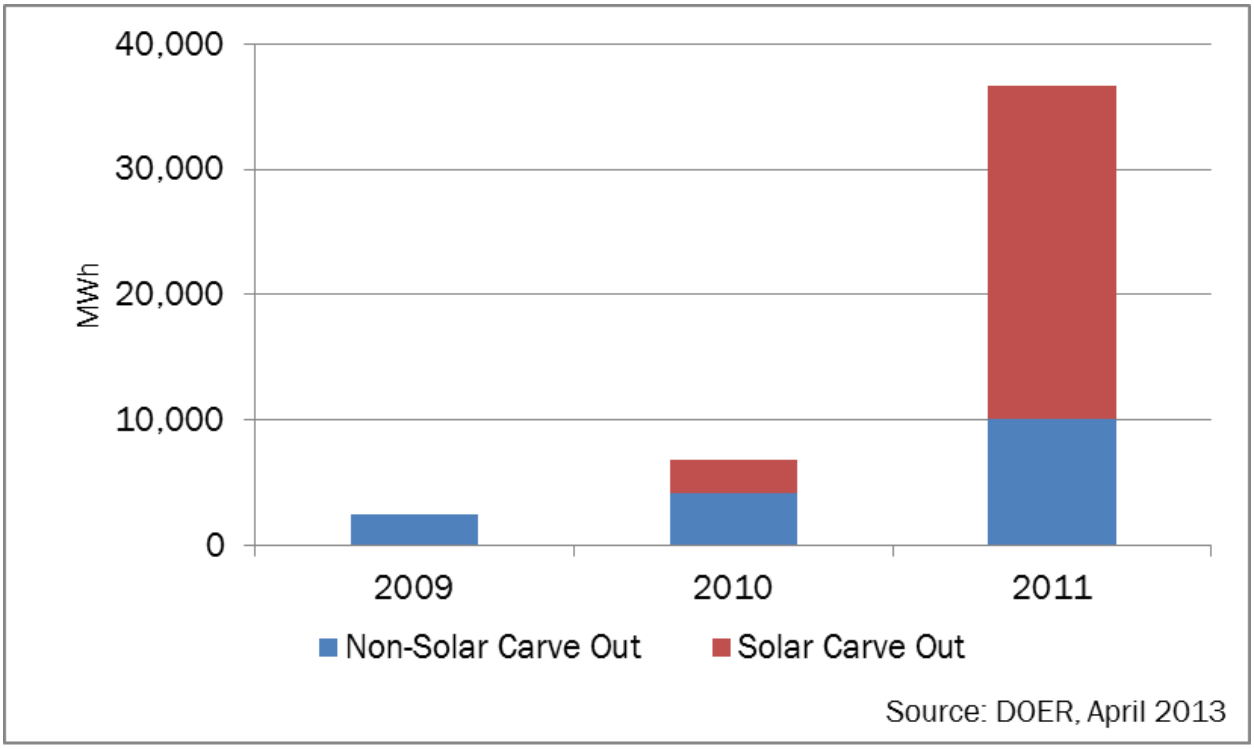
To track savings from the program investments, the three-year plans established an Evaluation, Measurement, and Verification (EM&V) framework, under which PAs administer studies to verify, document, and improve energy efficiency program performance and to enhance the program offers and services (MA EEAC 2012a). Annual energy efficiency reports document the progress made toward plan goals and highlight achievements made during the year (MA EEAC 2010; MA EEAC 2013). With information from these evaluations and reports, the EEAC, and ultimately the DPU, can determine the impact of its energy efficiency programs relative to program goals and can refine efforts to push for further savings.

RPS/APS Annual Reports

The Massachusetts Renewable Energy Portfolio Standard (RPS) requires utilities and competitive retail electricity suppliers to buy a percentage of their portfolio of electricity sales from renewable energy (e.g., solar photovoltaic, solar thermal electric, wind energy, etc.) and waste energy (e.g., garbage incineration). Similar to the RPS, the Alternative Energy Portfolio Standard (APS) requires a certain percentage of the state's electric load to be met by efficient non-renewable technologies (e.g., combined heat and power, flywheel storage, etc.).

These Massachusetts retail electricity suppliers are required to submit annual compliance filings to demonstrate that they met their RPS and APS obligations. DOER uses these filings to produce Annual RPS & APS Compliance Reports, which summarize the RPS-affected portion of the Commonwealth's retail sales of electricity, the supply of renewable and alternative energy to retailers, retailers' compliance with their obligations under RPS and APS, and proceeds from alternative compliance payments (MA DOER 2013c). This information allows state regulators to determine how the RPS and APS programs have affected the availability of renewable and alternative electricity and to project retailers' future obligations to purchase renewable and alternative electricity. For example, the Massachusetts RPS and APS Annual Compliance Report for 2011 highlights a rapid increase in availability of solar photovoltaic energy since 2009 (shown in Figure 7 below) (MA DOER 2013c).

Figure 7: Solar Photovoltaic Energy Generation Qualifying for RPS Renewable Energy Certificates



RGGI COATS

In January 2007, Massachusetts joined the Regional Greenhouse Gas Initiative (RGGI), an agreement between northeastern states to jointly limit emissions of CO_2 from large electric power plants. RGGI sets a limit on the total CO_2 emissions through a cap and trade program and allows trading of CO_2 allowances to achieve compliance. Massachusetts uses proceeds from the sale of allowances to fund energy efficiency programs, such as MassSave® and the Green Communities Designation and Grant Program for cities and towns. The ten partnering states use an electronic platform, the RGGI CO_2 Allowance Tracking System or COATS, to track and facilitate CO_2 trading (RGGI Inc. 2013a). RGGI COATS allows:

- Power plants and other market participants to receive, transfer and hold $C0_2$ allowances;
- Offset project sponsors to register and verify offsets; and
- The public to access RGGI program data and information on $C0_2$ allowance market activity through a series of customizable reports.

With RGGI COATS, Massachusetts can efficiently determine power plant operators' compliance with CO_2 budget trading regulations, review how CO_2 emissions from power plants in the state have changed under RGGI, and provide timely data to regulated entities, the public, and carbon allowance market stakeholders.

3.3 Investments in GHG Measurement, Reporting, and Verification Systems

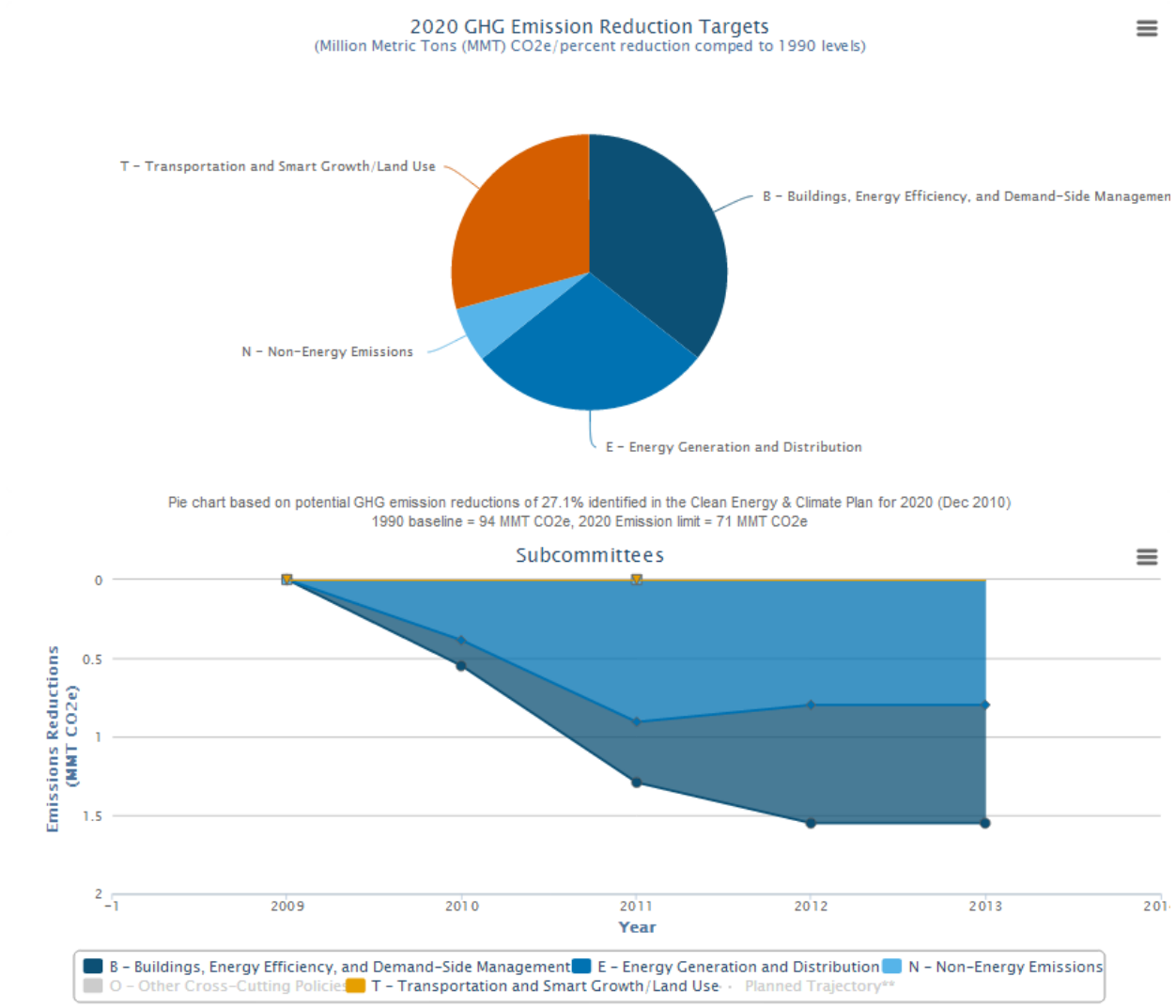
To assess mitigation progress toward achieving the GWSA's 2020 limit of a 25 percent reduction in emissions below 1990 levels, the state needs to know current total emissions levels, how emissions have changed since 1990, and how emissions reduction strategies have impacted and are expected to further impact the state's emissions (MA EEA 2010a). Massachusetts has developed three information systems to gather and consolidate this information. The Massachusetts Greenhouse Gas Emissions Inventory and Massachusetts GHG Registry quantify statewide emissions over time and the Clean Energy and Climate Performance Management System (CCPMS) tracks progress made on the State's emissions reduction strategies and estimates resulting GHG reductions.

Clean Energy and Climate Performance Management System and Dashboard

In September 2013, with the help of a grant from the Barr Foundation, EEA launched the Massachusetts Clean Energy and Climate Performance Management System (CCPMS). Designed to provide a cost-effective means to monitor, evaluate, and communicate progress on the 2020 Plan, this Web-based data management system can track performance information for emission reduction strategies identified in the 2020 Plan, supplemental emission reduction strategies, and climate change adaptation strategies. This system contains hundreds of quantitative metrics and qualitative milestones used to track performance, which can be updated and validated annually (MA EEA 2013d). When these tracking data are updated, the system converts quantitative metrics (e.g. British thermal units of natural gas reduced) to GHG mitigation estimates and produces output reports that summarize quantitative and qualitative progress measures under each strategy (Figure 8).

Data collection, and entry into the CCPMS, for all 27 GHG reduction strategies from the 2020 Plan is critical for tracking the Commonwealth's progress in meeting the GWSA's emissions limits and has only recently begun. The CCPMS has been configured and tested, and metrics have been developed to track most strategies. However, quantitative data on GHG reductions is currently available for only a few strategies As of November 2013, the system housed enough data to estimate GHG mitigation for four strategies and to track milestone completion, on a qualitative basis, for other strategies (MA EEA 2013d). Figure 8 below provides a depiction of progress on GHG reduction limits. To fully populate the database, Massachusetts will need to continue developing data sources to populate metrics, identifying accurate methods to estimate carbon mitigation, and obtaining data to be input into the system. Upon completion of the CCPMS database, Massachusetts will be able to capture data in a simple, clear and transparent way. The CCPMS will enable agencies to access and present consistent, timely, and verifiable information on progress made toward the 2020 Plan and to improve transparency as data is shared through the public-facing, web-based GWSA "Dashboard." The GWSA Dashboard was recently launched in December 2013 to provide updates on GWSA performance to all stakeholders.

Figure 8: Screenshot of CCPMS Aggregate Progress Report (MA EEA 2013d)



Source: EEA, Nov. 2013.

GHG Registry and Inventory

The GWSA requires Massachusetts to establish systems to track GHG emissions, including:

1. A state-wide GHG inventory with comprehensive estimates of GHG emissions by sector, and
2. A GHG emissions registry and reporting system that collects emissions information data from individual GHG emitters.

To date, Massachusetts has met its obligations to publish the statewide GHG emissions inventory. In July 2009, MassDEP published the first GHG inventory and projection for "business-as-usual" 2020 emissions (MassDEP 2009). The 1990 emissions level established in this inventory will serve as the baseline against which Massachusetts' future GHG emissions reductions limits will be planned and measured.

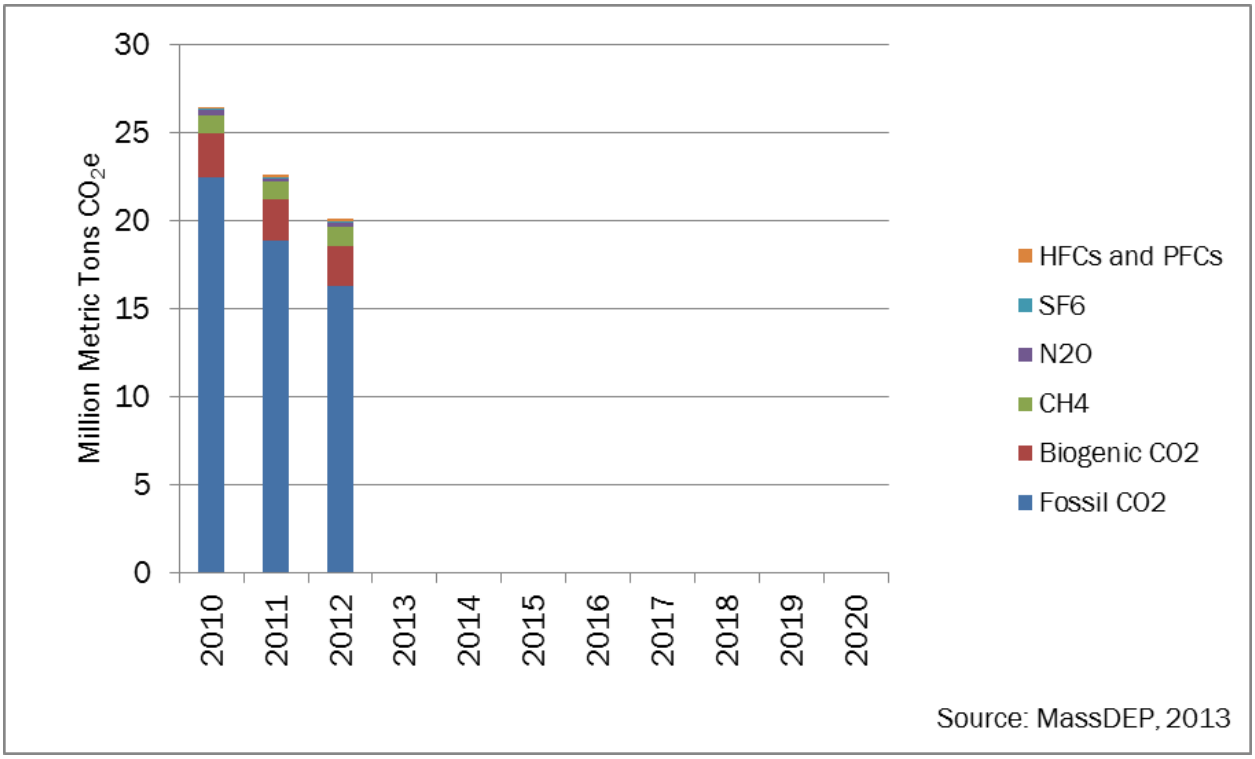
The GWSA further requires Massachusetts to publish a triennial state greenhouse gas emissions inventory to update the first GHG inventory. The triennial inventories contain comprehensive estimates of the quantity of greenhouse gas emissions in the Commonwealth for the last three years in which the data are available. To meet this obligation, MassDEP works to release updated inventories without delay. MassDEP publishes updated annual draft emissions data as they become available and publishes full three-year inventories as full data for the three-year period are complete. These updates have been expedited with funding from the Barr Foundation. As of November 2013, MassDEP has published a final GHG emissions inventory for years 1990 to 2008 and a draft inventory with full data through 2010 and partial data for years 2011 and 2012 (MassDEP 2012a; MassDEP 2013d). These updated inventories are compared against the 1990 baseline to track progress toward GHG emission reduction limits.

Massachusetts also has met its obligations to establish a GHG registry and reporting system. In 2008 and 2009, MassDEP promulgated mandatory greenhouse gas reporting regulations which require large facilities and retail electricity suppliers to report their GHG emissions to the Massachusetts GHG Registry annually (MassDEP 2013f). MassDEP has partnered with The Climate Registry (TCR) to ensure that reported data are consistent among facilities and that reporting is streamlined. Facility managers are required to take the following steps:

- Use estimation methods in TCR's General Reporting protocol to calculate their GHG emissions;
- Verify calculated GHG emissions using TCR's General Verification Protocol; and
- Report GHG emissions via TCR's electronic reporting system.

Using these protocols and TCR's system, MassDEP efficiently collects and publishes reliable emissions information from approximately 300 of the state's largest emitters (MassDEP 2013e).
Figure 9 illustrates how, from 2010 to 2012, the registry has shown a trend of reduced emissions of CO_2 from the combustion of fossil fuels (MassDEP 2013e). This trend is largely attributable to reduced emissions from coal combustion at power plants in Massachusetts.

Figure 9: Trend in Emissions (Metric Tons of CO_2e) by Gas Reported to The Massachusetts GHG Registry



Case Study: Who are the 2012 Massachusetts GHG Registry Reporters?

The Massachusetts GHG Registry collects GHG emissions information from large stationary facilities in Massachusetts, including all facilities that emit more than 5,000 tons CO_2e per year or are regulated under the air "operating permit" provisions of the federal Clean Air Act Amendments. In 2012, 295 facilities reported 20,097,762 metric tons CO_2e of GHG emissions to the registry (MassDEP 2013e).

A small number of facilities reported the majority of emissions in the registry; the twenty-five largest reporters emitted 77 percent of the total emissions. These facilities with the highest emissions include electric power plants, two large natural gas distribution systems, an academic institution, and a manufacturer (MassDEP 2013e).

Facilities reported estimates of emissions for six greenhouse gases (Table 5). Nearly all facilities reported emissions of fossil carbon dioxide (98%), methane (98%), and nitrous oxide (98%). Few facilities reported biogenic carbon dioxide (18%) or sulfur hexafluoride (6%) (MassDEP 2013e).

Table 5: 2012 Massachusetts GHG Registry Reporting by Gas (MassDEP 2013e)

Gas	Facilities	Emissions (Metric Tons CO_2e)	Facilities with Highest Emissions
Fossil Carbon Dioxide (CO_2)	288	16,308,345	Electric power plants
Biogenic Carbon Dioxide (CO_2)	54	2,213,558	Waste-to-energy facilities One wood-fired power plant Water treatment facilities
Methane (CH_4)	290	1,137,432	Natural gas systems Landfills One waste-to-energy facility
Nitrous Oxide (N_2O)	289	200,606	Electric power plants One water treatment plant Waste-to-energy facilities
Sulfur Hexafluoride (SF_6)	17	76,780	Electronics manufacturers One academic institution One electric switching station One electricity transmission facility One research and development facility
Hydrofluorocarbons (HFCs) and Perfluorocarbons (PFCs)	140	143,294	Manufacturers Research institutions

There is considerable overlap between the facilities in the Massachusetts GHG Registry and facilities that reported under the federal Greenhouse Gas Reporting Program (GHGRP)--nearly all of the 91 direct emitters that reported under the federal GHGRP in 2011 also reported to the Massachusetts GHG Registry in 2012 (US EPA 2013a; MassDEP 2013e). However, the 2012 Massachusetts GHG Registry includes over 200 facilities that were not required to report to the federal GHGRP in 2012. The differences in the universe of facilities reporting to each system is driven by the reporting requirements that determine who must report to each program.

3.4 Conclusions and Recommendations

Since 2008, the Commonwealth has built substantial institutional capacity, both within EEA and across state agencies, that is increasing the pace and effectiveness of climate and clean energy program implementation. . The Commonwealth has made a series of high-level investments in new information systems needed to measure and communicate overall progress under the GWSA. Multiple information systems are now in place to plan, evaluate, and report on progress made under these programs. Continued investment will more fully populate the systems with relevant data, and also ensure that the systems incorporate the latest science, methodologies, and emissions factors.

A key challenge to tracking progress on GHG reductions is designing methods for measuring strategies that transform energy use indirectly or over long time periods. For example, the Smart Growth Policy package includes strategies that have the potential to reduce transportation energy use by shifting travel from cars to other travel modes; however, this type of shift is difficult to track through direct measurement. The CCPMS shows strong initial progress on developing qualitative metrics and milestones for tracking these "indirect" and complex GHG reduction strategies, but the database of metrics and milestones is not yet fully populated.

The Commonwealth has also committed to providing annual updates to the public on its GWSA performance, an important step to full transparency. The GWSA dashboard includes documentation of data sources and methodologies for calculating GHG emission reductions for some strategies. Work is ongoing to complete documentation for all strategies and this will continue to be an important activity going forward to clarify assumptions and uncertainties and support the evaluation of progress in meeting the Commonwealth's GHG emission limits.

Progress on Climate Change Mitigation

4.1 Buildings, Energy Efficiency, and Demand Side Management

4.1.1 Overview

Energy use in buildings accounts for more than half of Massachusetts's energy use and is its largest contributor to GHG emissions. The 2020 Plan outlines a variety of strategies to reduce energy use and GHG emissions from the buildings sector. The primary strategy for reducing building energy use is implementation of all cost-effective energy efficiency as laid out in the Green Communities Act of 2008. Other strategies for managing energy demand include improving building energy codes and tree planting and retention programs to reduce demand for heating and cooling. The 2020 Plan set an emissions reduction goal for these strategies of 9.8 percent below 1990 emission levels.

Progress to date on these strategies is described below in Table 6. In addition to implementing these strategies, the Commonwealth has also identified possible supplemental strategies to further boost energy savings in the buildings sector.

4.1.2 Emission Reduction Strategies: Results and Recommendations

Table 6: Progress on Buildings, Energy Efficiency, and DSM Strategies from the 2020 Plan

Strategy	Key Accomplishments and Highlights	Estimated GHG Reductions Anticipated by 2020 Plan	Likelihood of Meeting Target in 2020 Plan
All Cost Effective Energy Efficiency (*Now includes Deep Energy Efficiency Improvements, 0.2% goal)	• Net savings of $4 billion on $1.5 billion investments in natural gas and electric efficiency under first Three-Yr Plan (2009-2012); second Three-Yr Plan (2013-2015) estimates net savings of over $6 billion • Low natural gas prices are slowing the pace of gas efficiency projects • Electricity sacings ranged from nearly 1% of annual sales in 2009 to over 2% in 2012. natural gas savings ranged from 0.5% to over 1% of annual retail sales • DOER established working group on commercial	7.3%*	**Medium**
Advanced Building Energy Codes	• Sharp decline in residential construction during recession limited penetration of advanced codes • 2012 IECC stretch code adopted in 2013; implementation in the field expected to start in mid-2014	1.6%	**Medium**

Building Energy Rating and Labeling	• Commercial building asset rating pilot now in Phase II with a broad sample of commercial buildings • Residential integration of "HomeMPG" energy scorecards into MassSave in the great Springfield area showing increased savings with over 2,500 homes scored to date	-	**High**
Expanding Energy Efficiency Programs for C&I Heating Oil	• New legislation is required to move heating oil programs in Commercial & Industrial sectors forward	0.1%	**Low**
Tree Retention & Planting to Reduce Heating and Cooling Loads	• With initial $5M in funding, projects are underway to plant 15,000 trees, with lifetime energy savings of 1.8 $MMTCO_2e$; • Additional 53,000 trees planned for Holyoke, Fall River, and Chelsea • Still identifying remaining funding for full implementation of strategy (total of $24 million)	0.1%	**Medium**
Federal Appliance and Product Standards	• Federal standards for new furnaces delayed by up to 7 years	0.6%	**Low**

All Cost-Effective Energy Efficiency and Deep Energy Retrofits

The Patrick Administration has long recognized that energy efficiency is a win-win strategy which provides substantial economic benefits to consumers and businesses, retains more capital in the local economy, and results in other environmental benefits (e.g., improvements to air quality) in addition to GHG reductions. The strategy to implement all cost-effective energy efficiency (EE) also has the highest goal for GHG reductions of all strategies in the 2020 Plan, at 7.1 percent below 1990 levels. This strategy represents *additional* GHG reductions which are due to the expansion of the state's energy efficiency programs under the Green Communities Act (GCA) since 2008.

Under the requirements of the GCA, investor-owned natural gas and electric utilities in Massachusetts are required to acquire all cost-effective energy efficiency, i.e., energy efficiency which is less costly than securing additional energy supply. The utilities' Program Administrators (PAs) begin the implementation of natural gas and electricity efficiency programs by submitting a Three-Year Plan to the Department of Public Utilities for approval.[6] In these plans, the PAs outline their plans for the types of energy efficiency programs (e.g., high-efficiency lighting) and customer classes (i.e., residential, commercial, and industrial) they expect to reach, the expected costs to implement the programs, and the target energy savings. These plans also indicate anticipated challenges to success.

Table 7 below, taken from the 2020 Plan, shows the anticipated GHG reductions, fuel savings, and economic benefits to consumers and businesses from all cost-effective energy efficiency.

[6] The Cape Light Compact is also an energy efficiency provider and participates in the development of the Three-Year plans.

Table 7: Anticipated Savings from All Cost-Effective Energy Efficiency (MA EEA 2010a)

GHG Reductions in 2020	6.7 $MMTCO_2e$ (7.1% of 1990 Levels)
Electricity Savings in 2020 (GWh)	9,500
Natural Gas Savings in 2020 (MMBTU)	36 million
Heating Oil Savings in 2020 (MMBTU)	7.7 million
Cumulative Net Savings, 2010 to 2020 (discounted)	$17.5 billion

Based on the successes of the first Three-Year Plan (2010 to 2012), Massachusetts earned a No. 1 ranking for state -based energy efficiency programs from the American Council for an Energy-Efficient Economy (ACEEE) three years in a row. Results from investments in electric and natural gas efficiency under the first Three-Year plan are impressive. Electric efficiency programs funded under the Green Communities Act equaled 1,228 GWh in savings, or 83 percent of the goal for that period. Although electric savings fell short of the annual goals implied by the 2020 Plan (shown above), the recent performance trend was very encouraging.

As Table 8 below illustrates, progress on natural gas efficiency programs was somewhat slower than anticipated. Natural gas prices currently pose a challenge to gas efficiency programs because low prices dampen the magnitude of energy savings from efficiency, thereby resulting in longer "pay-back" periods on a given investment. Natural gas efficiency programs under the first Three-Year plan delivered almost 38 million therms in savings, or nearly 60 percent of the goal. Annual gas savings grew from 0.5 percent of annual sales in 2009 to over 1 percent of annual sales by 2012.

Residential heating oil and propane efficiency efforts were quite successful. This success is attributable in part to the high costs of these fuels, which results in short payback periods for investments in projects reducing oil and propane use (in comparison to longer payback periods for natural gas efficiency projects under current prices).

Table 8: Incremental Energy Efficiency Savings Above 2008 Baseline, 2010 to 2012[7]

Efficiency Program	Actual Energy Savings	Energy Savings Goal
Electricity (GWh)	1,228	1,466
Natural gas (therms)	23,582,276	40,574,821
Residential Heating Oil (MMBTU)	682,618	745,433
Propane (MMBTU)	66,555	71,232

[7]The energy savings numbers in Table 8 show the level of incremental savings from the first MA statewide Three-Year Plan, above and beyond the Business as Usual (BAU) projections (based on energy savings in 2008). The 2020 Plan only counts incremental savings above the 2008 baseline towards the "All Cost-effective energy efficiency" measure to avoid double-counting in our statewide inventory. Total energy efficiency savings are reflected in the Executive Summary.

In 2013, MA DPU ratified the PAs' second Three-Year plan (2013 to 2015). When implemented, the efficiency plan is expected to generate $6 billion in net energy savings. This plan includes annual retail electricity savings targets of 2.5, 2.55, and 2.6 percent through 2015, and annual saving targets of 1.0, 1.4, and 1.6 percent of natural gas sales through 2015 (MassSave, 2013). As next steps, the PAs describe their plans to expand programs to include more businesses and homeowners, especially those in harder-to-reach neighborhoods.

Deep energy retrofits were a separate strategy from all cost-effective in the 2020 Plan, and have been folded into the cost-effective EE strategy.

As a supplemental strategy to boost efficiency gains in the commercial sector, MA DOER established a Commercial Real Estate (CRE) working group in 2013 which is co-chaired by the energy utilities. This working group, which includes many representatives from the commercial real estate sector, will identify opportunities and a roadmap to improve penetration of efficiency efforts in commercial buildings, especially during retrofitting. In addition, the City of Boston has adopted and a number of other municipalities are considering energy disclosure ordinances which would apply to commercial buildings greater than 25,000 square feet. One goal of these ordinances is to inform property managers to induce greater participation in the state's efficiency programs.

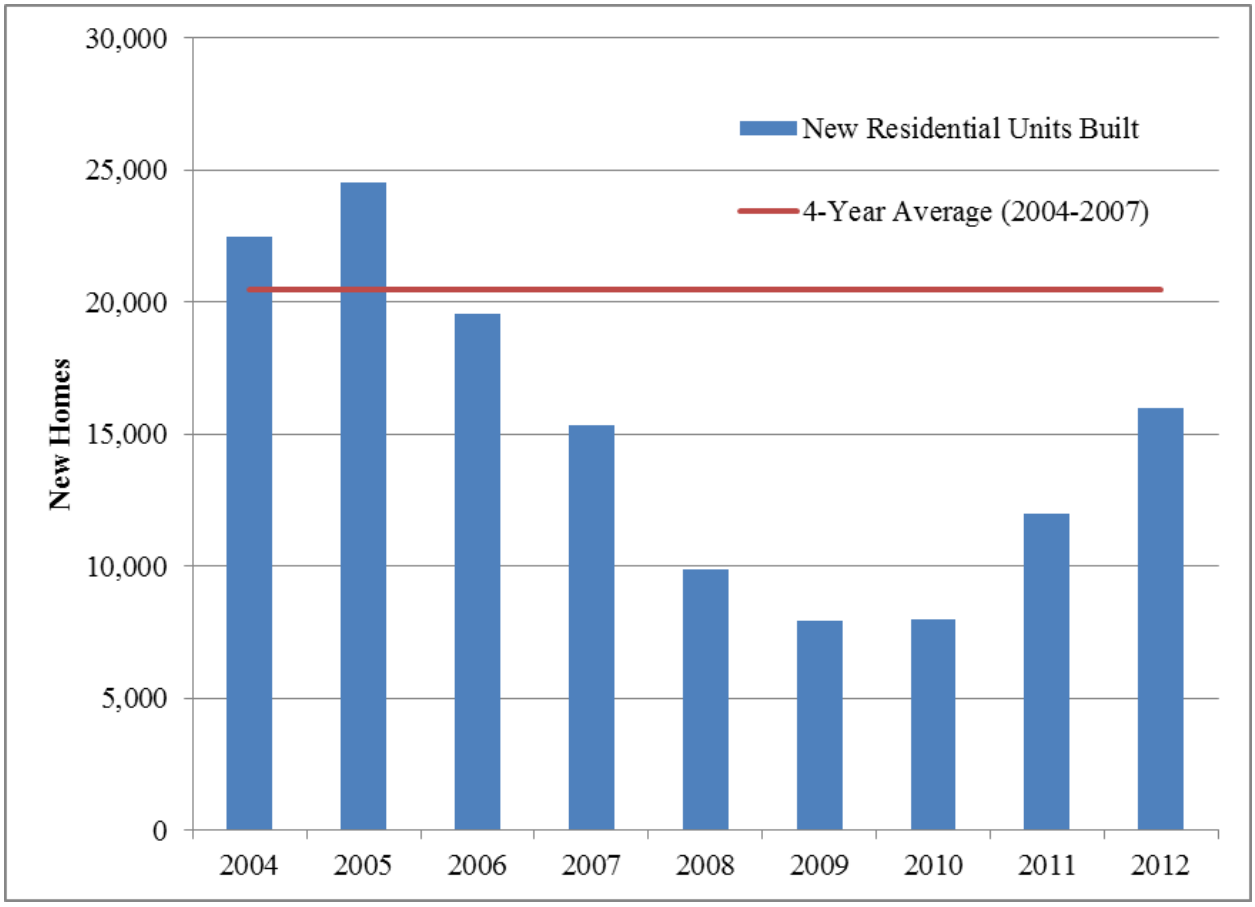
Advanced Building Energy Codes

The 2020 Plan makes clear that a strategy requiring advanced building energy codes is one of the lowest-cost options for reducing GHG emissions. In the 2008 Green Communities Act, Massachusetts adopted a requirement that building energy codes meet or exceed the International Energy Conservation Code (IECC) and stay current with the IECC's three-year update cycle. The most recent update to the base energy code is based on the 2012 International Energy Conservation Code (IECC2012) which represents a 15 percent improvement on average over the IECC2009 based code (MA EEA, 2013). Potential GHG reductions of 1.5 $MMTCO_2e$ (or 1.6 percent below 1990 levels) from this strategy are estimated in the 2020 Plan, with annual GHG reductions growing cumulatively over time.

In addition, Massachusetts is a pioneer in the use of the concept of a "stretch" energy code, and has used the stretch code to accelerate the transition from a prescriptive code which dictates specific energy measures to one which allows building designers to focus on a building's overall energy performance. As noted in the discussion of Green Communities, over 130 communities in Massachusetts, representing more than half the population, have voluntarily adopted the MA stretch energy code (MA DOER 2013d).

A short-term impediment to GHG reductions from the adoption of advanced building codes was the housing sector-led economic recession and the resulting reduction in construction of new homes and buildings, where new codes will begin to have effect. As Figure 10 below illustrates, construction of new homes fell precipitously at the start of the recession in 2008, and remained below historical averages through 2011. Although construction has not yet recovered to its pre-recession level, new home builds in 2012 were at their highest level since 2006, so advanced building codes could soon begin to deliver expected GHG reductions in these new homes. Despite this recent increase in building code adoption, however, the expected GHG reduction target for this strategy may need to be downgraded from 1.6 percent below 1990 levels by 2020, but will be a necessary part of reaching any 2050 goals.

Figure 10: Construction of New Residential Units in Massachusetts, 2004-2012



Source: (MA DOER, 2013)

Building Energy Rating and Labeling

Rating and labeling buildings according to their energy use provides prospective building owners and tenants with a sense of the likely energy costs of using their living and work spaces. Currently, this type of information is largely absent from decision-making in real estate markets, even though Massachusetts' citizens and businesses use more energy in their buildings than any other sector. In the same way that the familiar "miles per gallon" rating of vehicle efficiency communicates to vehicle buyers how much they can expect to spend on fuel over the vehicle's lifetime, building energy ratings and labels support better decisions and create incentives for the real estate market to provide more efficient spaces by increasing transparency on energy costs.

As noted in the 2020 Plan, the potential GHG reductions associated with this strategy are indirect—having information about building energy use will ultimately change the real estate marketplace by correcting the "market failure' which exists due to the lack of information about the full costs of building ownership or occupancy, but GHG reductions will likely be captured through the 'all cost effective efficiency' policy, and the utility funded energy efficiency programs.

To strengthen the linkages between building energy rating and participation in the energy efficiency programs, the DOER has been running two pilot programs in collaboration with utility partners. For the commercial office building segment, DOER has a Building Asset Rating (BAR) pilot that is developing lower cost energy assessment tools that provide "energy use intensity" (EUI) ratings. However, BAR can also provide energy efficiency investment

recommendations at much lower cost that the current standard audit protocols. A 'Home MPG' pilot of home energy performance scores has been implemented in the Greater Springfield area of western Massachusetts. Home MPG include Energy Performance Scores (EPS) in utility-sponsored home energy assessments and efficiency upgrades, so that participating homeowners can see how their home performs both before and after making any energy improvements.

Expanding Energy Efficiency to Commercial and Industrial Heating Oil

Currently, the scope of heating oil energy efficiency programs in Massachusetts is limited to residential customers in single family homes. The objective of this strategy is to expand the availability of heating oil efficiency to all residential units and beyond to the commercial and industrial sectors as well, effectively creating a "fuel–neutral" opportunity for customers in these sectors to replace older equipment and reap efficiency gains and fuel savings, regardless of fuel type. The 2020 Plan estimates that expanding heating oil programs to commercial and industrial customers would result in GHG reductions of 0.1 $MMTCO_2e$ (or 0.1 percent below 1990 levels). Because heating oil prices are so high, there would also be considerable cost savings accompanying GHG reductions.
New legislation is required to provide the PAs with the legal authority to expand the scope of heating oil funding to commercial and industrial customers as well as residential customers.

Tree Retention & Planting to Reduce Energy for Heating and Cooling

Several national studies have shown that the canopy cover provided by trees reduces heating and cooling energy loads in buildings, as well as the urban heat island effect.[8] This strategy involves planting new trees in strategic locations and in sufficient numbers to increase the overall tree canopy in order to realize the energy benefits documented in these studies. Retaining existing trees which would otherwise be lost to disease or during new construction can be even more effective, as mature trees generate energy savings immediately. The 2020 Plan estimated that this strategy would provide GHG reductions of 0.1 MMTCO2e by 2020 (or 0.1 percent below 1990 levels).

In 2011, pilot tree planting and retention projects began in Worcester and Springfield. These aim of these projects was less an energy-saving strategy than an effort to replace trees lost to disease and disaster, including over 20,000 trees planted in Worcester neighborhoods affected by an infestation of the Asian long-horned beetle, and replanting of 1,100 trees in Springfield in areas most impacted by the 2011 tornado. Beginning in 2014, with an additional $5 million in funds available for this strategy, 15,000 additional trees will be planted targeting energy savings in low-income communities and will generate approximately 3,100 metric tons of avoided CO_2 emissions by 2020 (MA EEA 2013h). Lifetime GHG savings from reduced energy demand created these trees is expected to be 1.8 $MMTCO_2e$.

Federal Appliance and Product Standards

Efficiency standards for most products, appliances, and electronics are set by the U.S. Department of Energy (DOE). Under guidance from the Obama Administration, DOE intended to accelerate the schedule for setting new efficiency standards. The 2020 Plan estimated Massachusetts' state-wide energy savings for updated federal appliance standards at 0.5 $MMTCO_2e$, (0.6 percent reduction below 1990 levels). However, progress on this strategy has been slow, as the most relevant federal appliance standards for gas furnaces, did not move forward in May 2013 as scheduled. DOE had previously denied Massachusetts' request for a waiver to set its own higher standard for furnaces, and is not expected to be able to implement a new national or regional efficiency standard for furnaces until 2017.

[8] As noted in the 2020 Plan, studies of tree-planting programs in New York, Chicago, and Philadelphia resulted in an average reduction of 1.7-degrees Celsius in maximum temperatures in the hottest parts of the city.

4.1.3 Conclusions and Recommendations

With the impetus and authority provided by the GWSA and the Green Communities Act, EEA and supporting agencies focused a tremendous amount of energy and attention on the buildings sector and specifically, the strategy for all cost-effective energy efficiency. This focus and level of commitment produced impressive results, establishing Massachusetts as the national leader in state-based efficiency programs. As the implementation of this strategy transitions into the second Three-Year Plan period submitted by the PAs, EEA, DPU, and DOER will identify ways to enhance the effectiveness of programs given lower economic returns on natural gas efficiency projects. Working closely with the commercial real estate industry to identify approaches to improving market penetration in that sector is one such approach.

Aggressive pursuit of opportunities to expand heating oil efficiency programs to the commercial and industrial sectors will pay off not only in terms of substantial GHG reductions but very high co-benefits, in the form of substantial cost savings to consumers and businesses, a boost to local economic development, and reductions of air pollution.

4.2 Energy Generation and Distribution

4.2.1 Overview

Historically, the energy generation and distribution sector has played a very prominent role in the GHG emissions profile of Massachusetts. From 1990 to 2007, the power sector has been second only to transportation in terms of contributions to the state's total GHG emissions.[9] As a result, the 2020 Plan included a full portfolio of strategies to reduce overall energy use and emissions from energy generation. Since the passage of Massachusetts' first Renewable Portfolio Standard (RPS) in 1997 requiring electricity generators to increase their production of electricity from renewable resources, Massachusetts has been at the forefront of state-based efforts to diversify the electricity supply, use locally-sourced fuels, reduce GHG emissions, and advance clean energy technology. The Green Communities Act (GCA) of 2008 further expanded the RPS to establish even greater incentives for new renewable energy sources. The GCA also added an Alternative Portfolio Standard (APS) to spur development of highly efficient non-renewable technologies such as combined heat and power (CHP) (Commonwealth of Massachusetts 2008b).

New Clean Energy Resources, including clean energy imports from Canadian hydroelectric generation and large-scale wind energy, are also a keystone of the Commonwealth's strategy for reducing GHG emissions from energy generation and distribution. As noted in the 2020 Plan, if this strategy reaches its full potential, it could account for as much as one-fifth of the state's entire 2020 GHG limit of 25 percent below 1990 levels.

Other strategies for this sector include changes to the Regional Greenhouse Gas Initiative (RGGI), offshore wind energy production, evaluating the efficacy of a Clean Energy Standard, and more stringent federal power plant rules. "Supplemental strategies" identified for this sector since the 2020 Plan include developing the renewable thermal market and grid modernization.

4.2.2 Emission Reduction Strategies: Results and Recommendations

As Table 9 below demonstrates, the Commonwealth has made good progress on the energy generation and distribution sector, especially on the expanded RPS and power plant rules. Recent developments on the clean energy imports strategy are also promising. The rest of this section describes progress on these and other strategies, as well as the challenges to successful implementation for this sector.

[9] In 2008, the buildings sector became the second-largest source of GHG emissions, as emissions from the power section began to decline substantially in 2006.

Table 9: Summary of Progress on Energy Generation and Distribution			
Strategy	**Key Accomplishments and Highlights**	**Reductions below 1990 levels anticipated in 2020 Plan**	**Likelihood of Meeting 2020 Target /Goals**
Expanded Renewable and Alternative Portfolio Standard	• Retail suppliers met their RPS Class I target; Grew the solar PV sector from 3 MW to over 347 MW and wind energy from 3 MW to over 120 MW, both over a five-year period • APS dominated primarily by CHP plants, short of overall target	1.2%	**High**
More stringent Power Plant rules	• Retirement of two coal-fired power plants underway, third possible in 2017	1.2%	**High**
RGGI Program Review	• In collaboration w. RGGI states, lowered the regional CO_2budget to 91M tons	---	**High**
New Clean Energy Resources[10]	• Regional procurement initiative underway in collaboration w. New England governors and NESCOE	5.3%	**Medium**
Off-Shore Wind	• Developed multi-year stakeholder process for identifying and developing designated MA Wind Energy Area (largest on Atlantic Coast) • Deployed infrastructure to support offshore wind, including New Bedford Marine Commerce Terminal and Wind Technology Testing Center	---	**High**
Clean Energy Standard	• Currently investigating applicability and policy approaches for a Clean Energy Standard	---	**Low**
Grid Modernization	• MA DPU exploring approaches to grid modernization	---	**Medium**
Developing Renewable Thermal Energy Market	• Funded several pilot programs in renewable thermal • Expanded Commonwealth Accelerated Renewable Thermal Strategy (CARTS) could deliver additional 2.0 $MMTCO_2e$ in GHG reductions	0.1%, up to 2.0%	**Medium**

Expanded Renewable and Alternative Portfolio Standards

The 2008 GCA expanded the requirements of the RPS to require that 15 percent of electricity supply by 2020, and an additional one percent every year thereafter, must be produced from new renewable generation resources including solar, wind, small hydro-electric, biomass, and anaerobic digestion.[11] The GCA also instituted the APS, which requires that at least five percent of Massachusetts' electric demand be met with high-efficiency alternative energy sources, such as CHP and flywheel storage, by 2020.

The 2020 Plan estimated that GHG reductions of 1.1 $MMTCO_2e$ by 2020, equal to 1.2 percent below 1990 levels, are expected from the expansion of the requirements in the existing RPS. These GHG reductions are in addition to those resulting from renewable resources required under the original RPS.

Overall progress on the expanded RPS and APS is good. In particular, the RPS looks positioned to meet or even exceed the 2020 goals. Installation of new solar energy projects is one of the biggest success stories of the expanded RPS. Since 2008, Massachusetts' solar energy sector grew from 3 MW to over 347 MW. Solar installations are well ahead of Governor Patrick's goal of 250MW in new solar capacity by 2017. The number of Massachusetts firms with expertise in installing solar systems also grew five-fold during the last five years.

Land-based wind energy installations in Massachusetts have grown from 3 MW to 103 MW over the same five-year period. To support the continued development of land-based wind projects, EEA is leading an inter-agency initiative to provide support and guidance to municipalities, developers, and stakeholders (MassCEC, June 2012). This initiative involves:

- Supporting communities that already are reviewing proposals for new wind development or already have wind projects operating;
- Soliciting input on the Commonwealth's policy for acoustics of wind turbines; and
- Reviewing guidelines from other states and countries for sitting new land-based wind projects and developing best practices for siting Massachusetts.

The GHG reductions achieved from RPS expansion have been calculated and verified in the CCPMS. Expanded solar and wind production in 2010 and 2011 provides an annual GHG reduction of 0.1 $MMTCO_2e$.[12] Based on these preliminary numbers, the goal for this strategy by 2020 could be well within reach if investment levels in new renewables are maintained or increased.

Other programs targeting communities designed to complement the Green Communities Program have also been highly successful in increasing clean energy education and adoption. For example, the SolarizeMass Program's unique group purchasing model and grassroots approach has resulted in tremendously competitive pricing and caused a surge of solar energy installation by Commonwealth residents and businesses. Since it started as a pilot program in 2011, 31 communities have participated in the program resulting in more than 1,250 solar PV contracts being signed across the state, for a total contracted capacity of 9.4 megawatts. In addition, the joint MassCEC/ DOER Community Energy Strategies Program provides Massachusetts residents and businesses an opportunity to work with municipal leaders to identify and enable new energy efficiency, renewable energy and renewable heating and cooling projects and programs. Through this process participating communities create clean energy road maps that outline the mix of projects best suited to address local interests, needs and opportunities for clean energy development.

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[10] This strategy, New Clean Energy Resources, is a modification of the "Clean Energy Imports" title used in the 2020 Plan, which focused primarily on Northern Pass project. This new title for the strategy reflects it broad approach to expanding regional access to new, large scale, clean energy resources such as large hydro and both onshore and offshore wind energy.

[11] Under the Green Communities expansion of the RPS, new renewables are considered "Class I" resources; Class II refers to renewable resources established before the original 1997 RPS.

[12] Based on DOER calculations entered and validated in the CCPMS, November 2013.

More Stringent Power Plant Rules

Recent federal rules on power plants are also contributing to the general trend away from coal-and oil-based generation. Since 2009, EPA has proposed new rules addressing air pollution transported across state boundaries, limiting emissions of mercury and air toxics, and addressing cooling water intake at power plants. The 2020 Plan estimated that these new power plants rules could reduce GHG emissions by 1.2 percent relative to 1990 levels.

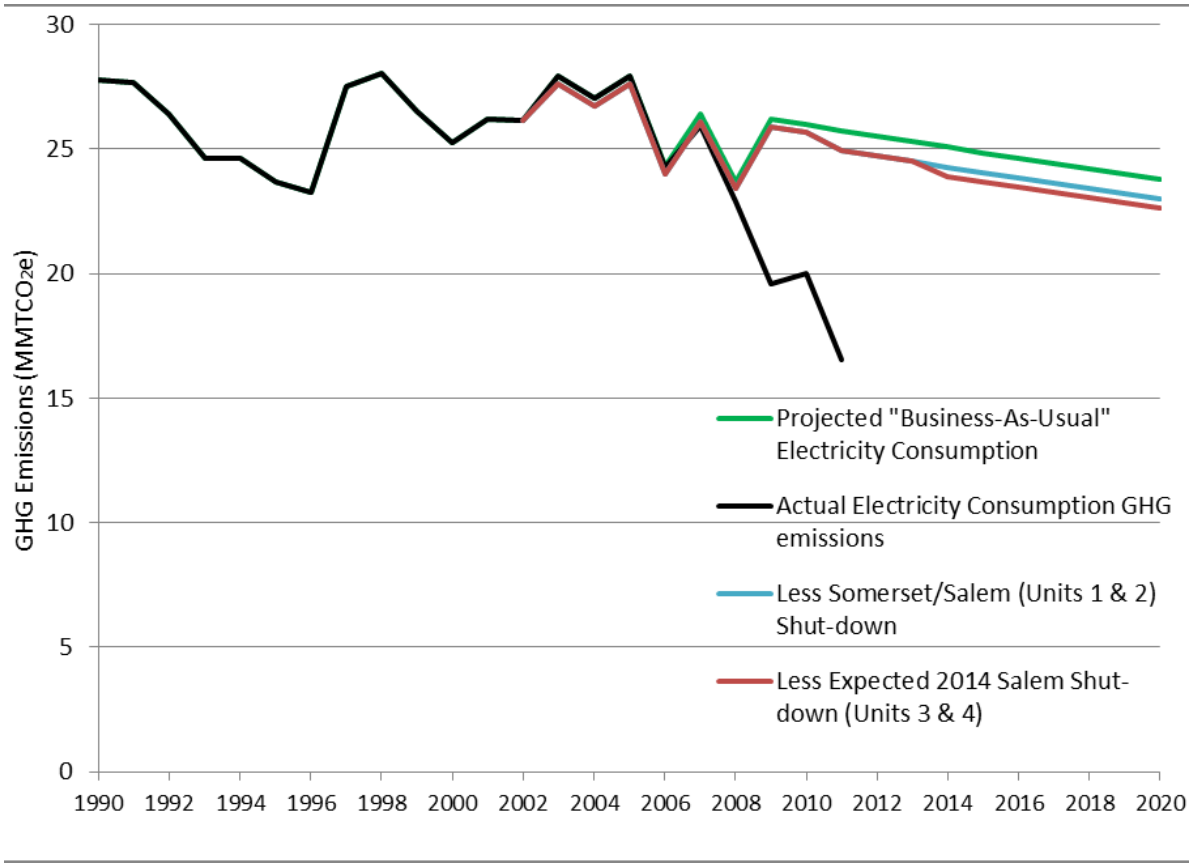
New England already hosts one of the cleanest electric power grids in the US in terms of GHG emissions per unit of generation (EIA and US EPA, 2013). Even though natural gas-fired power has been a key piece of the region's electricity supply for decades, its role is still expanding, and natural gas-fired generation continues to displace generation by coal-fired power plants. According to ISO-New England's annual emissions report, from 2010 to 2011 emissions from coal-fired generation in New England fell by 45 percent (ISO New England Inc 2013). This shift is largely attributable to the fuel price differential between natural gas and coal, which began in 2008 as shale-derived gas became available in the US and shifted the commodity price of gas downward. Despite a recent increase in natural gas prices, prices remain low in comparison to historical levels.[13]

As generators weigh the cost of upgrading emission controls for their plants to meet the federal rules against the broader economics of electricity generation, it can make more economic sense to shut older plants down than to continue operating. Since 2008, two coal-fired plants in Massachusetts have shut down some or all of their coal-based generation capacity. Somerset Station last ran in 2010, and Salem Harbor shut down two of their four coal-fired units in 2011. Salem Harbor's other two units are scheduled to close by summer 2014.

Figure 11 below shows that actual GHG emissions from electricity used in Massachusetts have fallen 41 percent since 1990 due to power plant emission reductions, energy efficiency implementation, and changes in the economy. In 2011, emissions were well below the business-as-usual projection from the 2020 Plan. The magnitude of the GHG reductions from the recent shut-downs of Somerset and two units at Salem Harbor are shown, as well as the anticipated reductions from the shut-down of Salem's remaining two units in 2014.

[13] With low prices, more customers currently using oil or electricity for heating are converting to natural gas when possible. Because natural gas supply into the region is constrained by pipeline capacity, this is placing upward pressure on natural gas prices.

Figure 11: Actual and Anticipated GHG Reductions from MA Power Plant Closures



Source: MassDEP, 2013b.

In 2013, the owners of a third coal-fired power plant—Brayton Point—announced the likely closure of this plant 2017 (Reuters 2013). If the Brayton Point does shut down, GHG emissions could fall by an additional 3.5 MMTCO2e, which is far in excess of the original estimate for this strategy of 1.2 $MMTCO_2e$ (which was based solely on Somerset and Salem Harbor).

Enhanced Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative (RGGI), a cap-and-trade program among nine New England and mid-Atlantic states, was the first mandatory market-based regulatory program in the United States to require reductions in greenhouse gas emissions.[14] RGGI places a limit on CO_2 emissions from power plants larger than 25MW in size, and allows trading of CO_2 allowances among regulated power plant owners for purposes of compliance with the program.[15] RGGI's first compliance period, which began in January 2009 and ended in December 2011, set a regional emissions limit of 165 million short tons. Over the last two years, the RGGI states conducted a review of the program's key features, including trading conditions and allowance prices. After determining that low CO_2 allowance prices were partly due to the initial cap level, the states reduced the 2014 regional CO_2 budget, "or RGGI cap," from 165 million to 91 million short tons – a reduction of 45 percent (RGGI Inc. 2013b).

[14] Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont are current RGGI participants. New Jersey was a RGGI participant until 2009.
[15] A RGGI CO_2 allowance represents one short ton of CO_2 emissions.

From 2014 to 2020, the change to the RGGI cap could result in an additional $2.2 billion across all nine states from the sale of allowances. These funds are expected to fund even greater investments by the states in energy efficiency and similar clean energy programs. Investment of over $600 million from RGGI's first compliance period (2009 to 2011) in energy efficiency and renewable energy provided $1.3 billion in lifetime energy bill savings to households and businesses throughout the region (Analysis Group 2011). Massachusetts received $233 million of allowance revenues through October 2013, which it has used to reinvest aggressively in cost-effective energy efficiency (RGGI, Inc., 2013).

Under the program change, RGGI is likely to generate additional allowance revenues for Massachusetts beyond the level generated over the first four years of the program. By statute, the state must invest at least 80 percent of its allowance proceeds in energy efficiency, so this strategy could in turn further boost the all cost-effective energy efficiency strategy. It will also provide more funding for Green Communities program grants, renewable energy, and consumer benefit programs (Commonwealth of Massachusetts 2008b).

However, as in the 2020 Plan, RGGI is not considered a strategy which will be responsible for GHG reductions as an independent strategy. As mentioned above, Massachusetts' policies for energy efficiency and renewable energy are supported, in part, by proceeds from sale of RGGI allowances. Therefore, to avoid double-counting, GHG emissions reductions from RGGI will be attributed to these other programs in combination (MA EEA, 2010a).

New Clean Energy Resources (formerly Clean Energy Imports)[16]

The 2020 Plan estimated that clean energy imports (new clean energy resources) would reduce overall GHG emission reductions by 5.3 percent below 1990 levels, a higher impact than any single strategy except cost-effective energy efficiency. The Patrick Administration is looking to a variety of large-scale clean energy resources including large-scale wind energy and large hydro-electric. New regional transmission infrastructure will play a critical role in bolstering the Commonwealth's access to these resources. At the New England Governor's Conference in July 2012, the New England states passed a resolution supporting regional procurement of clean energy from Canada and directing the New England States' Committee on Electricity (NESCOE) to continue to forge a regional approach to procuring these resources. In late 2012, NESCOE convened procurement and legal teams, which have developed a draft Request for Proposals (RFP) and draft Power Purchase Agreements (PPA) (EEA, 2013b). Bidders to the RFP will be eligible to compete for long-term contracts.

Off-Shore Wind Energy

Wind energy experts often refer to Massachusetts and its neighboring states as the "Saudi Arabia" of offshore wind, because of the tremendous potential for this renewable energy resource along our coastline (NREL, May 2009). According to MA DOER's 2008 assessment of the Commonwealth's renewable energy potential, there are over 6,000 MW of potential offshore wind energy in Massachusetts, making it one of the state's most abundant clean energy resources (MA DOER, 2008). Governor Patrick's goal of 2,000 MW of wind energy by 2020 reflects this potential—at least 1,500 MW of this goal is expected to be generated by resources located offshore.

An important benefit of offshore wind is the proximity of its production to population centers of the East Coast (Tierney et al. 2009). In addition, optimal times for wind production often coincide with times of high demand for electricity, and can be thereby be used help manage peak needs.

The Cape Wind project, proposed for Nantucket Sound, is the first commercial offshore wind project in the United States to receive all of the required federal and state approvals. Power purchase agreements (PPAs) are currently in place for 78 percent of Cape Wind's generation capacity (MassCEC 2013c). At full build-out, wind power from Cape Wind is expected to reduce GHG emissions by 0.78 $MMTCO_2e$ per year.[17] This GHG reduction is already

[16] As noted in Table 9, this strategy, New Clean Energy Resources, is a modification of the "Clean Energy Imports" title used in the 2020 Plan, which focused primarily on Northern Pass project. This new title for the strategy reflects it broad approach to expanding regional access to new, large scale, clean energy resources such as large hydro and both on-shore and offshore wind energy.

[17] Full build-out of Cape Wind assumes 130 3.6 MW wind turbines.

considered part of the RPS strategy, and thus was not included in the 2020 Plan as a measure that would generate *incremental* GHG reductions by 2020. Completion of the financing package for Cape Wind is expected in 2014; construction could begin anytime thereafter.

Massachusetts is also home to investments in key infrastructure projects aimed at making the Commonwealth a hub for the emerging offshore wind industry on the Atlantic Coast for decades to come. In May 2009, Massachusetts received $25 million from the U.S. Department of Energy to build the *Wind Technology Testing Center,* the world's largest indoor wind blade testing facility. Operating in conjunction with the National Renewable Energy Lab, this Charlestown-based facility opened in December 2009 and is fully operational.[18] In addition, Governor Patrick and former Lt. Governor Tim Murray broke ground on the New Bedford Maine Commerce Terminal (the Terminal) in May 2013 (MassCEC 2013b). The Terminal, shown in Figure 12 below is a multi-purpose terminal designed for the construction, staging, and deployment of offshore wind projects along the Atlantic Coast. Once constructed, the terminal will be able to sustain capacity loads to rival those of the largest ports in the world.

An important accomplishment in offshore wind energy is the completion of a process to identify and designate Massachusetts Wind Energy Areas (WEAs) in federal waters. If built to their full potential of 4,000 MW, these wind areas could provide enough energy to power more than half of Massachusetts' homes and create over 6.0 $MMTCO_2e$ in GHG reductions (OpenEI, 2012).[19] Additional details on this stakeholder process are provided in the case study below. In addition to the primary wind energy area in Massachusetts, the state is working with Rhode Island on a second, 260-square mile area located in Massachusetts, Rhode Island, and federal waters.

Figure 12: Project Components of New Bedford Marine Commerce Terminal (MassCEC 2013b)

[18] Turbine blades greater than 50 meters in length.
[19] Based on an assumption of a 39 percent capacity factor (OpenEI, Transparent Cost Database). .

Case Study: The Stakeholder Process for Designated MA Wind Energy Areas

Massachusetts has a very aggressive goal for offshore wind energy. EEA expects that 1,500 MW of the Commonwealth's 2,000 MW wind energy goal will be generated by wind sites located offshore. In 2009, the Massachusetts Ocean Plan provided information that helped identify initial locations for offshore wind energy areas, also known as Request For Interest (RFIs) Areas. The initial RFI Area designated for offshore wind development is a wide, 3,000-square mile area south of Martha's Vineyard and Nantucket, the largest offshore wind area on the East Coast (shown below in the figure on left).

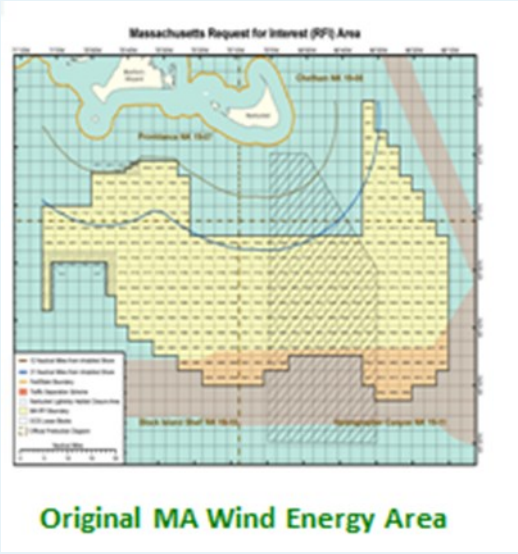
In 2009, Massachusetts convened key stakeholder groups to contribute to the process of designating new offshore wind areas. In conjunction with the federal Bureau of Ocean Energy Management (BOEM) and the US Coast Guard, EEA convened the "Task Force on Offshore Renewable Energy." This stakeholder process involved over 450 meetings attended by a variety of federal, state, local, tribal and non-governmental stakeholders, including Conservation Law Foundation, the Nature Conservancy, Mass Audubon, the New England Aquarium, the National Wildlife Federation, and the Provincetown Center for Coastal Studies.

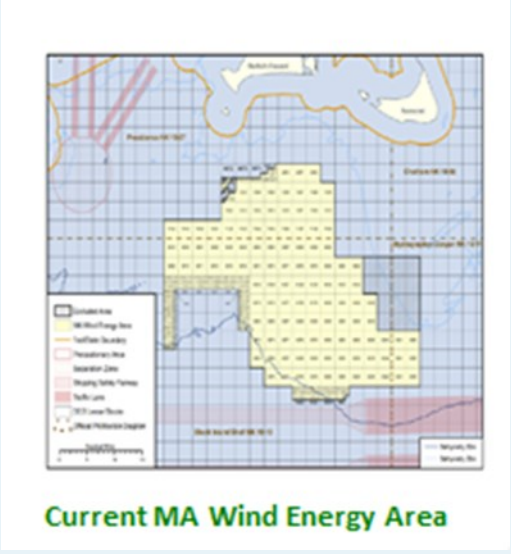
The goal of the stakeholder process was to review available science to understand the degree of compatibility between the proposed RFI Area with existing uses (including shipping and commercial fishing) and natural resources, including potential impacts on habitat for local populations of long-tail ducks, and humpback, fin and northern right whales, among others.

To address the impacts of potential development of the proposed RFI Area on fisheries, scallopers, groundfishers, lobstermen, and others also provided input. UMass-Dartmouth's School of Marine Science & Technology provided data which showed that the eastern half of the original, 3,000-square mile RFI Area designation overlapped with important scallop grounds. In 2010, more than 14,000 metric tons of scallops were landed in the State of Massachusetts, with sales totaling more than $252 million, making it the most commercially valuable species present in and around the RFI Area (US DOI BOEM 2012).

The RFI Area also overlapped with existing shipping lanes and areas where other marine species concentrated. To avoid potential impacts on valuable fisheries, marine habitat, and shipping, in 2011 EEA recommended and BOEM accepted reducing the RFI Area by 60 percent to exclude these areas. The revised RFI Area (shown below in map on right) is now 1,300 square miles in size. An auction of development leases for this RFI Area is scheduled for the first half of 2014.

Figure 13: Original and Current Massachusetts Wind Energy Areas





Clean Energy Standard

A Clean Energy Standard (CES) is an approach to encouraging a cleaner electricity generation portfolio. A CES could apply either an output-based performance standard (which would limit GHG emissions on a per megawatt hour basis), or a percent-of-sales portfolio standard (similar to RPS), to either electricity suppliers or generators. A CES gives certainty to investors who invest in any clean technology which improves the emissions profile of the overall portfolio.

If implemented, the CES could generate substantial GHG reductions, but reductions levels are highly dependent upon the CES target and other design elements of the system. As a result, the 2020 Plan did not include an estimate for this potential strategy (MA EEA, 2010a). An October 2013 analysis by Synapse Energy Economics for EEA and its agencies looked at policy options, costs, benefits, and regulatory approaches for implementation of the Clean Energy Standard and determined:

- A percent-of-sales portfolio approach applied to electricity suppliers is preferred over approaches that would apply to power plants (since RGGI has recently addressed power plants), or approaches that would specify an emissions limit per MWh of electricy supplied (since there are technical difficulties with tracking emissions of electricity sales)
- A CES would have to be thoughtfully designed to include only generators that would allow the CES to result in actual emission reductions through changes in power plant investment and/or dispatch, rather than merely taking credit for operation of existing power plants.

Supplemental Strategies

EEA has identified two supplemental strategies for reducing GHG emissions from the energy generation and distribution sector—incentives for clean energy technologies and grid modernization.

Clean Energy Incentives

The progress made under the RPS is directly supported by a robust set of clean energy incentives that are contributing to the growth of the Massachusetts clean energy sector and encouraging appropriate siting of clean energy projects across the state. The Commonwealth Wind Program has provided funding for planning through development phases of land-based wind projects across the Commonwealth. Rebates through the Commonwealth Solar II Program, together with the group purchasing model discounts resulting from the SolarizeMass Program, have catalyzed wide-scale adoption of small-scale commercial and residential solar projects. Funding through the Commonwealth Organics-to-Energy Program combined with other state regulatory and financing efforts through MassDEP and DOER, have spurred anaerobic digestion projects across the state. And the Commonwealth Hydropower Program has funded hydro-electric power that will increase energy output from ecologically-appropriate small-scale hydropower projects.

Renewable Thermal Incentives

Massachusetts households spend one-third of their total energy expenditures on heating and cooling their homes, with the average household spending $1,700 per year just on heating (Griffiths *et al.*, 2013). EEA has identified expanding the market for renewable thermal technologies as a supplemental strategy for generating GHG reductions, but these technologies have the potential to also provide substantial savings to consumers and businesses, especially those using heating oil, propane and electricity for heat. Renewable heating includes such technologies as solar hot water (SHW), biomass chips and pellets for heating, high efficiency heat pumps, biofuels, and biogas.

Developing a mature market for solar hot water and space heating is the only renewable thermal strategy originally included in the 2020 Plan. Estimated GHG reductions for solar hot water in the 2020 Plan were 0.1 $MMTCO_2e$, equal to 0.1 percent below 1990 levels. At current rates of growth, the solar hot water strategy is not on track to deliver that GHG reduction, according to a 2013 analysis by MA DOER and MassCEC. However, MassCEC is currently evaluating the program to find ways to help further stimulate the solar hot water market through its

existing efforts. If market penetration accelerates from current levels, solar hot water could deliver as much as 0.5 $MMTCO_2e$ by 2020.

The Commonwealth Solar Hot Water program, funded with $10 million from MassCEC, is supporting development of the market for this technology. Despite the fact that the lifetime costs of these systems can be very economical with combined state and federal incentives, there are some barriers to getting more solar thermal into the marketplace. Most importantly, the high upfront cost, and also a lack of customer knowledge and acceptance of these systems seem to be limiting greater penetration.

In addition to the Commonwealth Solar Hot Water program, Massachusetts is funding a broad suite of other renewable thermal programs and pilot projects, with a total of $32.5 million in funds, to promote the greater use of renewable thermal technologies. Under the Renewable Thermal Commercial Pilot Grant program, the Commonwealth is providing $4.3 million in funds to the commercial sector for high-efficiency heat pumps, commercial biomass, and district heating and cooling projects. Over the past year, MassCEC with DOER have completed other renewable thermal programs that have been successful, including: the Small-Pellet Boiler Program ($475,000 in funding); the Outdoor Hydronic Heater Program ($150,000 in funding); and the Woodstove Change-out Program ($900,000). A program funded through a U.S. Department of Energy grant provides schools and state public housing with grants to determine feasibility of projects in biomass and solar thermal heating, heat pumps, and district heating and cooling. The Low-Income Energy Affordability Network (LEAN), funded with $1 million from the MassCEC for fiscal year 2014, provides grants for renewable thermal projects at low-income housing facilities. The Renewable Thermal Business Investment Financing program provides $3 million in funds to support distribution, manufacturing, or marketing of renewable thermal technologies in the state.

Through the Commonwealth Accelerated Renewable Thermal Strategy (CARTS), the DOER is identifying the best strategies to complement incentive programs, such as leveraging efficiency programs, building codes, communication and training of HVAC professionals. Priority strategies were identified over the summer of 2013 with extensive input from stakeholders.

Modernizing the Grid

Modernizing the electric power grid is a 'supplemental' strategy identified by EEA in 2012. Recent storms and resulting power losses have highlighted the need for a grid which is more flexible and resilient to severe weather events, which are expected to increase under climate change. A 'smarter' grid will also provide more opportunities for customers to control electricity use and costs, while increasing reliability and efficiency at the same time. EEA has not yet developed a potential GHG reduction estimate for grid modernization efforts, but this could be developed as policy options, costs, and benefits for modernization efforts become better understood.

In October 2012, the Massachusetts Department of Public Utilities (DPU) initiated a study of possible approaches to the modernization of the electric grid. To help guide this study, the DPU established a Steering Committee made up of utilities and other stakeholders to provide recommendations to the DPU. State agencies participating on the Steering Committee on grid modernization include: MassCEC, MA DPU, MA DOER, MA Department of Telecommunications/Cable, and MA EEA. In addition, various companies in the clean energy sector, environmental and consumer advocates, utilities, competitive energy suppliers, and the MA Attorney General's office also participated.

The Steering Committee met regularly and collaborated on development of a final report, which was submitted to the DPU in July 2013. This report provided principles and recommendations on key modernization issues such as planning and investment, risk/reward and cost recovery, cost allocation, interoperability, open access, cyber-security and privacy, metering, time-varying rates, and ownership principles. While the report does not present consensus positions on these issues, it describes key considerations from the vantage point of different stakeholders and provides DPU with a menu of options for regulatory approaches (Raab Associates Ltd. & Synapse Energy Economics Inc. 2013). The DPU is currently developing a straw proposal on its anticipated path for advancing grid modernization and achieving the associated benefits. The DPU will solicit feedback on the straw proposal before issuing a final order.

4.2.3 Conclusions and Recommendations

Progress on the 2020 Plan in the energy generation and distribution sector to date has been dominated, in quantitative terms, by power plant closures, and that trend may continue if additional plants close as expected. However, the fact that power plant closures are the largest GHG reductions quantified thus far belies very impressive progress on the expansion of the RPS under the Green Communities Act, especially in solar and wind energy. Other renewable energy programs outside of the RPS program—such as SolarizeMass and the Community Energy Strategies Program—have proven extremely popular with Massachusetts municipalities and homeowners, and offer a pathway to continue grassroots engagement with these program participants on other strategies as well.

Massachusetts is in a leadership role in working with other states and regional partners in securing new clean energy resources—wind and hydropower imports from Canada. Perhaps no other single strategy, other than energy efficiency, is as critical to meeting the goals of the 2020 Plan. However, the supplemental strategies identified for this sector—including renewable thermal and grid modernization—have the potential to provide GHG reductions substantial enough to provide greater diversification to the suite of strategies needed to meet the goals for this sector.

4.3 Transportation, Smart Growth and Land Use

4.3.1 Overview

Transportation is second only to the buildings sector in terms of energy use and emissions in the Commonwealth, and is the fastest growing contributor to GHG emissions. Both GHG emissions and fuel use in Massachusetts' transportation sector have increased relatively steadily since 1990, leveling off only recently during the economic downturn. Strategies to reduce GHG emissions in the transportation sector usually focus on improving one of three key drivers of transportation energy use: (1) vehicle efficiency, (2) the carbon content of fuel, (3) travel in vehicles (known as vehicle miles travelled, or VMT).

State government has a somewhat limited set of policy tools to address energy use in the transportation and land use sector. Vehicle efficiency standards are established at the federal level, and a substantial amount of the funding for large infrastructure projects also comes from federal agencies. Land use decisions, on the other hand, occur at the local level and can be difficult to influence through state-level policies.

Despite the limited toolkit available, Massachusetts developed an aggressive suite of strategies in the 2020 Plan which targeted all elements of the transportation system–vehicles, fuels, and VMT. The 2020 Plan estimated that together, this package of transportation and land use strategies would achieve an emissions reduction of 7.6 percent below 1990 levels. This section describes progress and challenges on each of these strategies since 2008.

4.3.2 Emission Reduction Strategies: Results and Recommendations

As Table 10 below demonstrates, progress on the transportation and land use strategies from the 2020 Plan has been mixed. On the one hand, strategies targeting vehicles have been a clear success story. The Obama Administration enacted aggressive federal standards for vehicle efficiency for both light-duty and medium- and heavy-duty vehicles in 2010 and 2011, respectively. These requirements will deliver very substantial reductions in fuel use and GHG emissions from passenger vehicles and commercial fleets alike. Moreover, the Commonwealth recently signed an agreement with seven other states to set a goal that 15 percent of new vehicles sold by 2025 should be zero-emission vehicles (ZEVs) and additionally, launched an electric vehicle incentive program.[20]

[20] These states include California, New York, Rhode Island, Connecticut, Oregon, and Vermont, and represent 23 percent of the US car market. Their goal is to have 3.3 million zero-emissions vehicles on the road in the US by 2025.

Table 10: Progress on Transportation and Land Use Strategies from the 2020 Plan

Strategy	Key Accomplishments and Highlights	Estimated GHG Reductions Anticipated by 2020 Plan	Likelihood of Meeting Target in 2020 Plan
Federal and California Vehicle Efficiency and GHG Standards	• Federal light-duty standards for 2012-2016 model years approved in 2010, enacting most aggressive standards in decades • MA adopted Calif. vehicle standards for model years 2017 to 2025, expected to reach 54.5 mpg by 2025 (the 2.9% for the CAFE and Payley standards includes the 0.3% from the strategy "Reducing GHG emissions from motor vehicle air conditioning" originally in the Non-Energy Emission sector of the 2020 Plan.)	2.9%	**High**
Federal Fuel Efficiency Standards for Medium and Heavy Duty Vehicles	• First-ever fuel economy standards for medium- and heavy -duty vehicles established by EPA and NHTSA in 2011, known as the "Heavy Duty National Program" • First phase of federal heavy-duty program covers model years 2014 to 2018, expected to provide nearly $50B in fuel savings nationally	0.3%	**High**
Federal Renewable Fuel Standard & Regional Clean Fuels Standard	• EPA lowering federal Renewable Fuel Standard annual volume requirements for traditional and advanced biofuels, resulting in fewer GHG benefits than anticipated • Regional Clean Fuels Standard lacks support for moving forward	1.6%	**Low**
Clean Car Consumer Incentives	• Clean Car Incentive Program not implemented, but Mass Electric Vehicle Incentive Program (MassEVIP) launched in 2013 • Massachusetts signs on to Zero Emission Vehicle program with 7 other states, sets ZEV target for 15% of market share by 2025 • MassEVIP will provide municipalities with $2.5M in grants for EV purchases and construction of charging stations • Additional incentives under development for alternative medium and heavy-duty fleets with $11.7M in federal funding	0.5%	**Medium**
Pay As You Drive (PAYD) auto insurance (pilot program)	• PAYD pilot program stalled due to potential legal challenges, unlikely to move forward until 2014 • Estimates of GHG benefits associated with a fully implemented program should be revisited	0.4-2.1%	**Low**

Strategy	Key Accomplishments and Highlights	Estimated GHG Reductions Anticipated by 2020 Plan	Likelihood of Meeting Target in 2020 Plan
GreenDOT	• Mode-shift goal established in 2012 to triple travel miles from walking, cycling, and by public transit • Committed to hiring new Assistant Secretary for GreenDOT to oversee implementation • GreenDOT Implementation Plan released (Dec. 2012) • Healthy Transportation Policy Directive released (Sept. 2013)	1.20%	**Medium**
Smart Growth Policy Package (including Sustainable Development Principles)	• Proposal submitted to fund tools and best methods for tracking land use and land cover change • Legislation reforming state planning and zoning statutes pending before the legislature •MassWorks and other infrastructure programs incorporate Smart Growth/Sustainable Development criteria in funding decisions • MassDOT and EOHED Land Use Priority Plans for S. Coast Rail, I-495, Merrimack Valley complete, Metro North underway	0.50%	**Low/Medium**
Supplemental Strategies			
Planning Ahead for Growth	• Housing production goal set in June 2013 for 10,000 multi -family units that are reasonably dense and centrally located	--	--

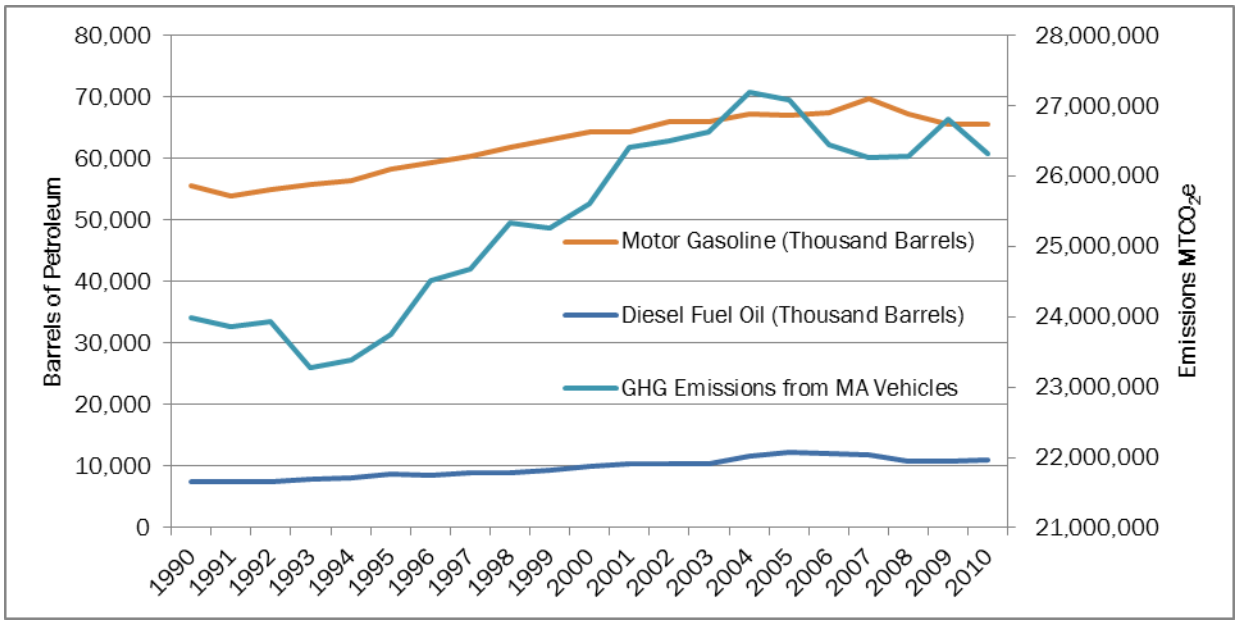
Progress on strategies targeting fuels and land use has been considerably slower than vehicle-based strategies, however. A regional fuel standard for driving the development of low carbon fuels has stalled indefinitely, while implementation of many measures within the Smart Growth policy package are underway but progressing slower than desired. Additional details on the progress of individual strategies for vehicles and fuels are below.

Vehicle and Fuel Strategies from the 2020 Plan

Federal and California Vehicle Efficiency and GHG Standards

As Figure 14 below demonstrates, transportation fuel use and GHG emissions from vehicle use rose fairly steadily in Massachusetts from 1990 to 2007, before they leveled off. Strategies to address efficiency standards for passenger and light commercial vehicles are usually set at the federal level, but under a longstanding waiver under the federal Clean Air Act, Massachusetts and other northeastern states have the opportunity to join California when it sets higher efficiency standards than the national standard. Similarly, federal agencies usually have primacy on setting standards for transportation fuels, but there are state- and regionally-based programs underway to incentivize cleaner alternative fuels. The 2020 Plan included multiple strategies to address both vehicle efficiency and the carbon content of transportation fuels.

Figure 14: GHG Emissions and Transportation Fuel use in Massachusetts, 1990-2010



Source: EIA, 2013

Federal and California Vehicle Efficiency and GHG Standards

Massachusetts has a long history of working with other northeastern states and California to push for more aggressive efficiency standards for light-duty vehicles. Although fuel economy standards are established at the federal level by EPA and the National Highway Traffic and Safety Administration (NHTSA), California has a waiver under the Clean Air Act allowing it to set more emissions standards more stringent than federal requirements. Massachusetts' law requires adoption of California's standards when they exceed federal requirements (MassDEP 2012b).

In 2010, the Obama Administration agreed to harmonize federal fuel economy standards for light-duty vehicles with California and eight northeastern states. Taking effect in the 2012 model year and continuing through 2016, the new federal light-duty fuel economy standards set the most aggressive increase in fuel economy in decades. In December 2012, Massachusetts also adopted California's "Advanced Clean Cars Package," which commits the state to California's vehicle efficiency standards for 2017 to 2025 (MassDEP 2012b). The 2020 Plan assumes that these strategies will deliver sizeable GHG reductions of 2.4 $MMTCO_2e$ by 2020 (or 2.6 percent below 1990 levels). Progress on these strategies is still being calculated but is expected to be relatively strong, given the availability of many new higher mileage vehicle options (i.e., 30+ miles per gallon) across many vehicle classes. The duration of average fleet turnover did increase during the recession, as people held onto their existing cars for longer periods. Massachusetts' vehicle sales and registration data are yet not available for 2012, but if this slow turnover effect is present, gains from new efficiency standards may be somewhat lower than anticipated in the initial model years of the new standards.

Federal Emissions and Fuel Efficiency Standards for Medium and Heavy Duty Vehicles

In the 2020 Plan, GHG reductions associated with the new, first-ever federal standards for fuel efficiency in medium- and heavy-duty vehicles equaled 0.3 $MMTCO_2e$ (or 0.3 percent below 1990 levels). Massachusetts will benefit from the recent effort by the federal EPA and the U.S. Department of Transportation program to reduce fuel use and emissions of GHGs and air pollution by establishing efficiency standards for medium- and heavy-duty vehicles, such as large pick-up trucks, vans, semi-trucks, and work trucks and busses.

Known as the Heavy Duty National Program, EPA and US DOT's National Highway Traffic Safety Administration (NHTSA) established new standards for CO_2 emissions and fuel consumption, respectively, and tailored these standards to specific classes of medium- and heavy-duty vehicle for model years 2014 to 2018 (US EPA 2011b). In addition to appearing to be on track to delivering the anticipated GHG reductions, this program will also deliver substantial fuel savings to consumers and businesses, given the current high price of diesel fuel.

Federal Renewable Fuel Standard and Regional Clean Fuels Standard[21]

The 2020 Plan presented two fuel standards—the federal Renewable Fuels Standard (RFS) and the regional Clean Fuels Standard—as one strategy because there is likely overlap in their respective impacts on the market for liquid biofuels. The 2020 Plan's estimate of a GHG reduction of 1.5MMTCO_2e (or 1.6 percent reduction below 1990 levels) was calculated based primarily on the effects of the proposed regional Clean Fuels Standard, with a separate estimate for the GHG effects of the RFS in the absence of the Clean Fuels Standard.

The primary objective of a clean fuels standard is to reduce the carbon intensity of transportation fuels by setting an intensity reduction target, measured by a fuel's GHG emissions per unit of energy delivered (e.g., per megajoule), for the region's supply of 'baseline' transportation fuels (i.e., gasoline and diesel). Credits for compliance with a clean fuels standard are then earned by refiners and fuel blenders when they provide fuels which lower the carbon intensity of the baseline fuel supply. At the time of the 2020 Plan, the Northeast/mid-Atlantic states were still evaluating the potential costs and benefits of a Clean Fuels Standard program.

The federal Renewable Fuel Standard was established by the Energy Independence and Security Act of 2007, and its goal is to reduce fossil fuel use by increasing the volume of renewable fuels in the nation's supply of transportation fuels (US EPA 2013b). The RFS sets minimum volume requirements for specific volumes of conventional biofuels (i.e., corn-based ethanol) and advanced biofuels (e.g., cellulosic ethanol) and requires refiners of transportation fuels to mix RFS-eligible fuels into gasoline and diesel up to certain blend limits.

Neither of these fuel standards are likely to deliver the GHG reductions estimated in the 2020 Plan. After studying the regional Clean Fuels Standard, the northeastern states have not developed a straw proposal for this program. And in November 2013, EPA proposed to lower the RFS volumetric targets for both corn-based ethanol and advanced biofuels for 2014 (Energy and Environment News 2013). This is the first time since the RFS was enacted that EPA has proposed a reduction to both fuel targets, and if enacted, this programmatic change would decrease GHG reductions expected from Massachusetts' fuel supply in 2014.

Clean Cars Incentive Program

The 2020 Plan identified the Clean Cars Incentive Program as a strategy that would incentivize purchases of cleaner vehicles, and could result in GHG reductions of 0.2 to 0.4 MMTCO_2e (0.2 to 0.5 percent of 1990 levels). After determining that this strategy no longer appears to be practical, the focus of this strategy shifted to direct incentives for purchases of electric vehicles.

In June 2013, the Commonwealth announced the launch of the Massachusetts Electric Vehicle Incentive Program (MassEVIP). MassEVIP is a $2.5 million competitive grant program administered by MassDEP which provides municipalities with grants to municipalities purchase electric vehicles (EV) and build fast-charging stations.[22] MassEVIP aims to promote the GWSA goals by reducing GHG emissions from vehicle use while also improving air quality and energy efficiency in cities and towns. Under a MassEVIP grant, municipalities can receive grants for up to five electric vehicles or plug-electric vehicles for their fleet or for installation of a single "Level II" fast-charging station. Initial grantees under MassEVIP will be announced in December 2013. A second phase of the MassEVIP will expand eligibility to Massachusetts colleges and universities.

[21] The regional Clean Fuels Standard was originally referred to as the "Low Carbon Fuel Standard" by the New England and mid-Atlantic states before being renamed by the states in 2010.

[22] Specifically, MassEVIP funds the construction of "Level II" charging stations, which can charge two vehicles at a time, and delivers 240V for a faster charge in comparison to the typical home charging at 120V.

Figure 15: State Electric Vehicle Charging Station

Source: GreenDOT Implementation Plan, 2012

In addition to providing grants for EVs purchases through MassEVIP, Massachusetts recently joined seven other states in adopting rules which require automakers to increase market share of ZEVs to 15 percent of new vehicles sold by 2025.[23] In October 2013, these states signed a Memorandum of Understanding (MOU) for the Zero-Emission Vehicle (ZEV) program.

Using $11.7 million in Federal Highway Administration funds for projects that improve air quality, MassDOER's Alternative Transportation team is launching a Clean Vehicle Program to replace a variety of fleet vehicles across the Commonwealth with cleaner alternatives.[24] Eligible vehicles include those which run on natural gas and propane, battery and hybrid electric vehicles, solar electric vehicles and hydraulic hybrids. The program will also support the hardware and partial installation costs for additional electric vehicle fueling stations (MA DOER, 2013e). In addition to creating additional reductions in CO_2 emissions, the Clean Vehicle Program is expected to reduce emissions of key air pollutants.[25]

Finally, although it was not a strategy initially included in the 2020 Plan, the recent multi-state agreement on ZEVs is likely to boost GHG emissions reductions from the vehicle sector even further. States in the Northeast are also coordinating on other activities to support ZEV deployments, such as harmonizing building codes for new charging stations and creating common standards for charging systems.

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[23] Zero-emission vehicles include battery electrics, hybrid battery electrics, and hydrogen fuel cell vehicles, among others.

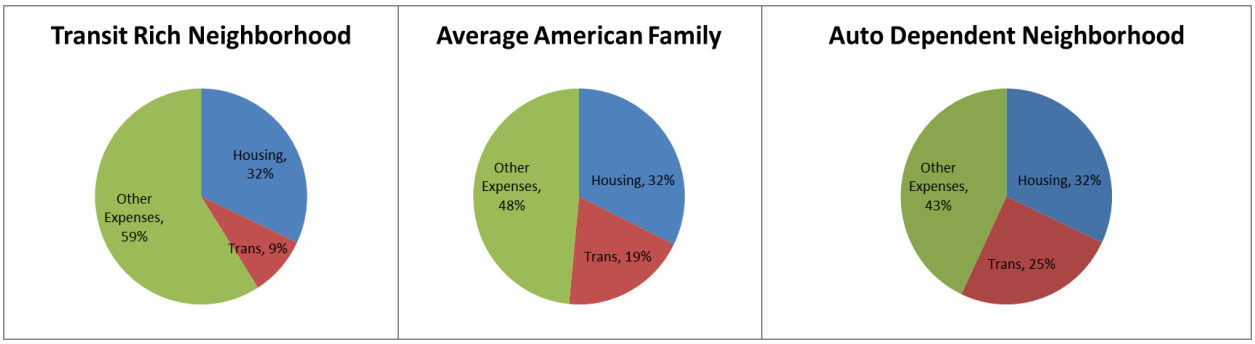
[24] Specifically, the U.S Department of Transportation's Federal Highway Administration Congestion Mitigation and Air Quality (CMAQ) improvement program sponsors surface transportation projects which result in improvements to air quality and roadway congestion mitigation.

[25] MA DOER's initial calculations for the Clean Vehicle Program include reductions in emissions of carbon monoxide (CO), volatile organic compounds (VOCs), particulate matter (both fine and coarse), and nitrogen oxides (NOx).

Land Use Strategies in the 2020 Plan

In addition to vehicle and fuel technologies, land use decisions also have a significant influence on energy use and emissions from transportation. The dominant approach to land use and housing development in the U.S. since World War II presumes the majority of travel occurs by driving. This auto-dependent approach to land use planning has resulted in steady increases in energy use from the transportation sector. It has also created development patterns which limit options for reducing congestion, travel times, and expenditures on transportation fuels. Figure 16 below illustrates the differences in annual travel expenditures of households living in denser neighborhoods with public transit options versus households located in auto-dependent neighborhoods, which spend more than three times as much on travel.

Figure 16: Transit Rich vs. Auto Dependent Neighborhoods



Source: Center for TOD Housing & Transportation Affordability Index, 2004
Bureau of Labor Statistics

In 2007, the Urban Land Institute estimated that a continuation of this typical pattern of auto-dependent housing development across the US would result in VMT increases that would more than counteract the benefits of improving fuel economy standards for light-duty vehicles.[26] The 2020 Plan identified a group of strategies designed to reduce VMT, increase travel modes and options, and improve the efficiency of the entire transportation system. These strategies include GreenDOT, the Smart Growth Policy Package, and Sustainable Development Principles. A supplemental strategy identified to further enable reductions in auto-dependent development is Planning Ahead for Growth. EEA, the Executive Office of Housing and Economic Development (HED), and MassDOT issued a Common Vision policy in June 2013. This policy identified Planning for Growth as the approach by which the Commonwealth will pursue development patterns which are consistent with Massachusetts' Sustainable Development Criteria, and that have a substantially lower GHG footprint than those associated with auto-dependent development.

GreenDOT

GreenDOT is the Massachusetts Department of Transportation's (MassDOT) sustainability initiative for the transportation sector. In June 2010, Massachusetts Secretary of Transportation Jeffrey Mullan issued a Policy Directive that established sustainable development and environmental protection as hallmarks of the full range of MassDOT's activities going forward, from strategic planning to construction to system operations

[26] Note that ULI's calculations were based on federal fuel economy standards before the more aggressive changes made in 2010 under the Obama Administration.

(MassDOT 2010).The primary goals of GreenDOT include: (1) reducing greenhouse gas emissions; (2) promoting healthy transportation modes of walking, bicycling, and public transit; and (3) supporting Smart Growth development.

The 2020 Plan estimates that GreenDOT could achieve GHG reductions of 1.2 percent below 1990 levels by 2020. Since the release of the GreenDOT Implementation Plan in December 2012, MassDOT has taken several important steps forward in operationalizing the goals and tasks included in the Plan. As a first measure, the Divisions and Shared Service departments submitted annual work plans. To review these submittals, MassDOT's Office of Transportation Planning (OTP) is working with the University of Wisconsin's State Smart Transportation Initiative (SSTI). Through a grant from the Barr Foundation, SSTI is undertaking an analysis of these plans with the objective of identifying top strategies for reducing GHG emissions throughout MassDOT.

MassDOT has also introduced new elements under GreenDOT that were not initially considered when the 2020 Plan was developed. In October 2012, Secretary Richard Davey announced a statewide goal to triple person-mile trips by walking, biking, and transit by the year 2030 (MassDOT 2012). MassDOT established this goal in response to changing demographics that include a shift in demand for young customers who want new travel options as well as an aging population that will require such options. The intent behind the mode-shift goal was also to provide infrastructure to allow for healthier travel.

To further operationalize mode-shift at MassDOT, Secretary Davey issued the Healthy Transportation Policy Directive, which formalizes MassDOT's commitment to provide access to safe and comfortable healthy transportation options for all of its customers through targeted improvements to the project design and development process. With a focus on improving project development and design practices throughout the Divisions, the Directive requires that all projects funded or designed by MassDOT encourage an increase in pedestrian, bicycle, and transit trips, and that each Division undertake a review process to evaluate their projects for conformance with Directive specifications.

Progress on GreenDOT implementation thus far appears to be mixed, in part because GreenDOT measures or tasks have not yet reported quantitative estimates of progress to date, even where progress has been made. Secretary Davey will soon appoint an Assistant Secretary of GreenDOT to coordinate these activities and develop tracking systems for GreenDOT projects. This new position, along with the results of SSTI's work, will position MassDOT to directly measure its progress on GHG reductions through GreenDOT.

Figure 17: Bicycle lane on Massachusetts Avenue in Cambridge

Source: MassDOT Bicycle Transportation Plan, 2008.

Bike lanes (as shown in Figure 17) and other measures to support healthy travel options are included in the "GreenDOT Implementation Plan," which was completed in December 2012 (MassDOT 2012). The Implementation Plan provides key indicators of progress and expected completion dates for major tasks. The Office of Performance Management and Innovation (OPMI) is tasked with tracking these tasks and indicators.

Smart Growth Policy Package

As described earlier in this section, land use and development patterns are important due to the role they play in determining VMT, transportation fuel use, and emissions. The Smart Growth Policy package aims to reduce car travel by promoting denser development, preferably near transit options, which allows travel by multiple modes. In the 2020 Plan, the Smart Growth package was projected to deliver GHG reductions of 0.4 $MMTCO_2e$ (0.4 percent below 1990 levels).

The 2020 Plan assumes 80 percent of new residential development will occur in areas that are higher-density and provide opportunities for multiple travel modes. This is a very aggressive target, and if it can be achieved, would result in substantial changes to land use and greatly reduced transportation energy use. However, the state currently lacks adequate land use/land cover data to track progress on denser development and patterns of land use change. EEA, with the assistance of the MassGIS Office, is currently working on a proposal to provide data on land use and land cover every other year (MassGIS 2009). This proposal envisions a cooperative effort involving EEA, HED, MassDOT and other agencies to make this expensive endeavor possible.

Another means of encouraging denser mixed-use development is to reform state-wide planning and zoning statutes in order to provide municipalities a better framework and set of tools with which to exercise their land use planning and regulatory responsibilities. Through revised statutes, communities will be better able to use zoning to encourage transit oriented, cluster, and other types of development that result in lower GHG emission footprints. The Administration continues to work with bill sponsors, committee chairs, other key legislators, and stakeholders, hoping that legislation improving state land use statutes will be passed in the current legislative session.

Aligning state spending with the Sustainable Development Principles is another strategy in the 2020 Plan's Smart Growth Policy Package, and considerable progress has been made to incorporate these Principles into the decision-making process for state-funded infrastructure. The best example of success is the MassWorks Infrastructure Program. This program utilizes project selection criteria that carefully align infrastructure spending with the Principles. An exemplary project was recently announced—the City of Salem was awarded $1.275 million to support the improvement of Grove Street. The project will produce a "complete streets" circulation environment with pedestrian and bicycle accommodations and directly support the proposed redevelopment of five key sites within the North River Canal Corridor. These sites will create a total of 315 housing units and revitalize this blighted, former industrial area into a mixed-use neighborhood.

Pay-As-You Drive Auto Insurance Pilot

The Pay-As-You-Drive (PAYD) Auto Insurance Pilot is being funded by a Federal Highway Administration grant. PAYD auto insurance converts a fixed annual premium for auto insurance into a variable cost based on the traveled, creating an incentive to reduce discretionary driving and shift to other modes of travel. In the 2020 Plan, GHG reductions estimated for a fully implemented PAYD program range from 0.4 $MMTCO_2e$ (0.4 percent below 1990 levels) for a voluntary system to 2.0 $MMTCO_2e$ (2.1 percent below 1990 levels) for a mandatory system featuring a variable pricing mechanism based on a per-mile charge.

The Commonwealth's plan to first initiate a pilot program, which could then be transitioned into a broader program, is delayed due to potential legal challenges. Without a successful pilot program, it will be challenging to fine-tune and deploy a broader PAYD program that is effective at reducing VMT while also addressing the needs of insurers and consumers. In addition, the estimates of potential GHG reductions associated with a fully deployed PAYD program from the 2020 Plan should be revisited to explore whether they are still reasonable.

4.3.3 Conclusion and Recommendations

Aggressive federal vehicle efficiency regulations for both light-duty and medium/heavy-duty vehicles are the primary success story in this sector to date. Complementing the federal regulations are new incentive programs for advanced vehicles under the MassEVIP and Clean Vehicle Program—both programs will increase the market penetration of these vehicles and necessary fueling infrastructure, although at much more modest levels than under federal programs.

Progress on fuel-based GHG reduction strategies, such as the regional Clean Fuels Standard and the federal Renewable Fuel Standard, is much more limited. Given the relative weight of these strategies in the 2020 Plan, supplemental strategies will need to be identified to replace their contributions to GHG reductions planned for this sector.

Initial progress on GreenDOT, the Smart Growth policy package, and sustainable development principles seems to position these strategies well for delivering on their goals, but developing credible metrics for evaluating and validating these strategies is a formidable challenge going forward. EEA, MassDOT, and supporting agencies are currently pursuing necessary information and establishing systems to track the effectiveness of VMT reductions and changes in land use and land cover change.

4.4 Non-Energy Emissions

4.4.1 Overview

Greenhouse gas emissions from activities not related to energy use, like refrigeration, insulation, and waste disposal, represent a small but important part of statewide GHG emissions. Many of the gases released from these activities have a global warming potential (GWP) thousands of times higher than CO_2 (MA EEA 2010a). The 2020 Plan set a goal of reducing CO_2e emissions in this sector[27] by 1.8 percent from the 1990 benchmark level through three strategies—reducing leaks from high GWP gases used in refrigeration; reducing leaks for high GWP gases used in electricity distribution and transmission; and reducing emissions from the disposal of plastic wastes (MA EEA 2010a). Table 11 below outlines progress made on these strategies. In addition to implementing these strategies, the Commonwealth has also identified several possible new supplemental strategies that may be implemented in the future.

Table 11: Summary of Progress on Non-Energy Emissions

Strategy	Key Accomplishments and Highlights	Reductions below 1990 levels anticipated in 2020 Plan	Likelihood of Meeting 2020 Target /Goals
Reducing SF_6 emissions from gas -insulated switchgear	• Conducted a survey of major users of SF_6 • Proposed new regulations on the emissions of SF_6 from gas-insulated switchgear, currently in public comment	0.2%	**High**
Stationary Equipment Refrigerant Management	• Engaged in stakeholder meetings • Draft regulation in progress	1.3%	**Medium**
Reducing GHG emissions from plastics	• Detailed necessary actions to reduce plastics combustion in the Massachusetts 2010-2020 Solid Waste Master Plan	0.3%	**Medium**

4.4.2 Emission Reduction Strategies: Results and Recommendations

Reducing SF_6 Emissions from Gas-Insulated Switchgear

The reduction of sulfur hexafluoride, or SF_6, emissions from gas-insulated switchgear is a new policy outlined in the 2020 Plan. SF_6 has a GWP 23,900 times higher than CO_2, and has an atmospheric life of 3,200 years. One

[27] Motor vehicle air conditioning emission reductions, which used to be included in this sector, are addressed in the new low emission vehicle regulations and therefore are included in the transportation sector.

pound of SF_6 has the same global warming impact as 11 metric tons of CO_2 emissions. Approximately 80 percent of SF_6 emissions are estimated to result from the electricity transmission and distribution systems, where it is used to insulate switchgear (MA EEA 2010a).

In preparation for possible new regulations, MassDEP distributed a survey to electric utilities, municipal light plants, competitive suppliers of electricity, and power plants to learn more about SF_6-containing equipment in Massachusetts. Over 80 survey responses were received, including responses from the two largest utilities operating in Massachusetts. MassDEP also reviewed emissions data in the Massachusetts GHG Registry. In June 2013, MassDEP published a draft regulation, 310 CMR 7.72, *Reducing Sulfur Hexafluoride from Gas-Insulated Switchgear*. This regulation would limit companies to purchasing new switchgear with a one percent emission rate and would require appropriate handling of SF_6 when switchgear is removed from service. It would also require owners of switchgear required to report SF_6 emissions under EPA's GHG reporting regulation to comply with a declining emission rate standard (MassDEP 2013b) for existing gas-insulated switchgear. Currently, only the two largest gas-insulated switchgear owners in Massachusetts would be subject to this requirement. The declining emission rate standard would eventually decrease to one percent (MassDEP 2013a). The regulation is in the process of being finalized by MassDEP.

Reducing Leaks from Stationary Refrigerant Equipment

Reducing leaks of refrigerant from non-residential refrigeration equipment is another strategy in this sector. Common refrigerants include several types of hydrofluorocarbons (HFCs), which have a GWP thousands of times greater than CO_2 (MA EEA 2010a). MassDEP has met with stakeholders to gather more information regarding the use of these refrigerants in Massachusetts, and is drafting legislation related to leak detection and repair for facilities with larger refrigeration units. Other possible future actions include working with stakeholders to transition to lower GWP refrigerants and incorporating refrigeration guidelines into the MEPA protocol. This strategy accounted for a 1.3 percent emissions reduction in the 2020 Plan – the greatest reduction in the non-energy sector. Progress on the new leak detection and repair regulations will be critical to meeting the goal for the sector.

Reducing GHG Emissions from Plastics

Increasing recycling rates in Massachusetts will decrease GHG emissions associated with the disposal and incineration of plastics and other high-carbon materials. While direct emissions from solid waste management are only a small percent of Massachusetts' baseline 1990 emissions, the GHG emissions generated over the lifetime of disposed materials are much larger (MassDEP 2013c). The *Massachusetts 2010-2020 Solid Waste Master Plan* (SWMP), published in April 2013, sets a goal of decreasing solid waste disposal by 30 percent by 2020 and by 80 percent by 2050. Recycling also results in additional environmental and economic benefits, like reducing the use of virgin materials and the releases of toxics into the environment, creating green jobs, and reducing the cost of disposal (MassDEP 2013c).

One of three major objectives in the SWMP is to maximize commercial/industrial recycling and residential recycling in Massachusetts. The SWMP sets a goal of diverting 900,000 tons of commercial materials and 500,000 tons of residential materials from disposal by 2020, and identifies over 20 strategies that should be implemented to achieve this goal. These action items include working with businesses, schools, and municipalities to establish cost -effective recycling and waste reduction programs, improving waste ban compliance, and creating targeted educational campaigns.

Advancing proven programs such as Pay-As-You-Throw (PAYT), mandatory recycling, and single stream recycling has the potential to significantly increase residential recycling. PAYT programs have been very successful at increasing recycling and composting and reducing disposal (see case study below). The SWMP set a goal of serving 50 percent of the state's residents via PAYT programs by 2020 (MassDEP 2013c). As shown in Figure 18, PAYT participation has been increasing steadily; however, the rate of implementation needs to increase for this goal to be achieved.

While programs that increase recycling and composting ultimately reduce disposal costs and have the potential to generate revenue, municipalities can have difficulty finding the initial capital required for these programs. MassDEP's Sustainable Materials Recovery Program (SRMP) Municipal Grants were instituted to address this

gap, and fund a variety of activities, including plastics diversion, single-stream recycling support, enforcement coordinators, and PAYT implementation. The amount of funding available and the diversity of funded activities have increased significantly over the past few years, as shown in Figure 19. Funding for SRMP grants comes from municipal waste combustor renewable energy credits.

Figure 18: Pay-As-You-Throw Participation in MA

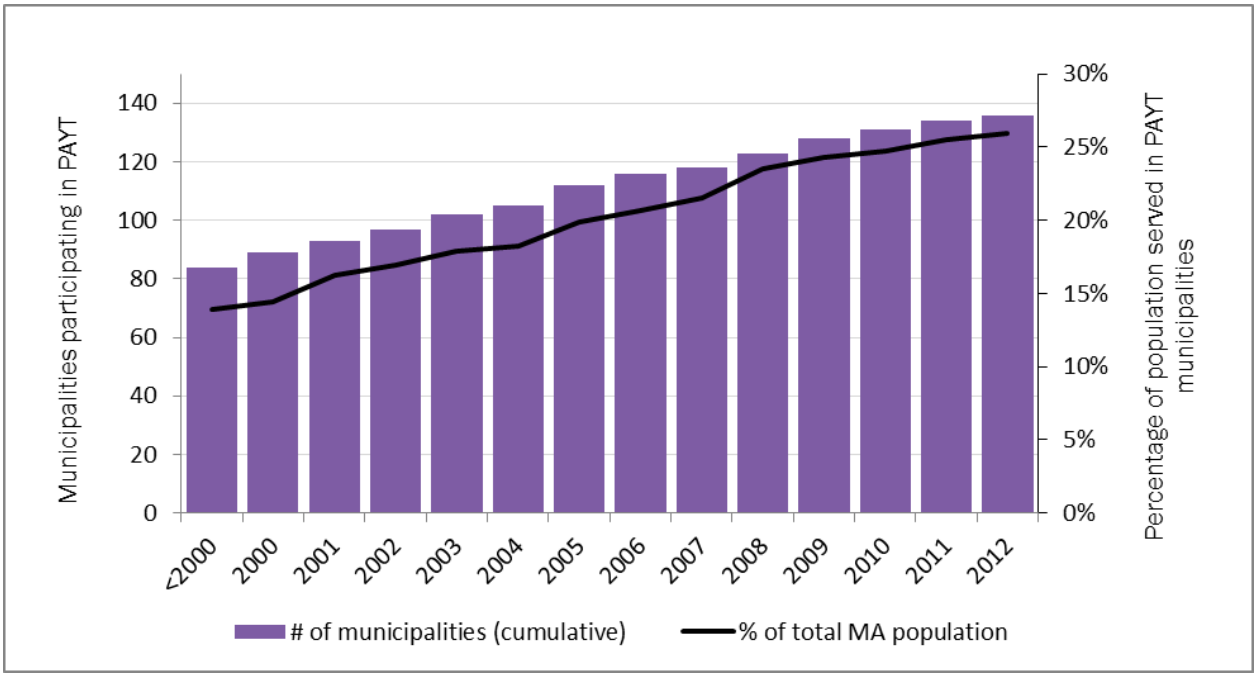
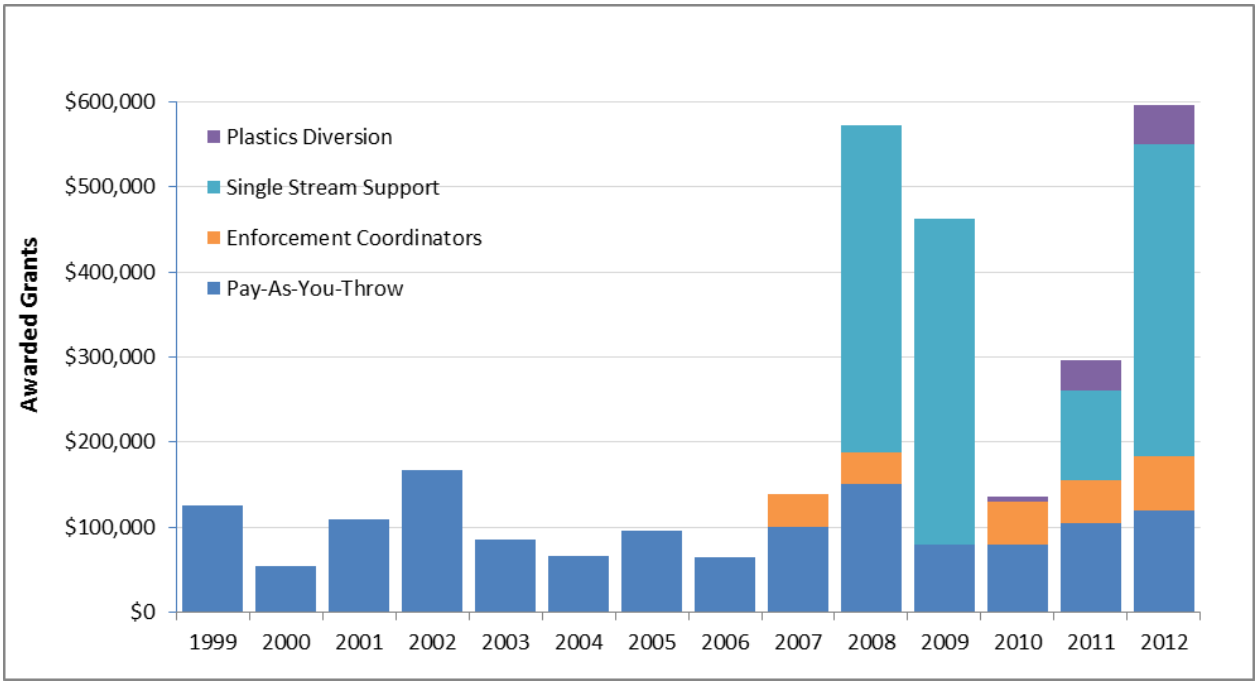


Figure 19: Sustainable Materials Recovery Program (SMRP) Municipal Grants for Diverting Plastics from MA Landfills



Case Study: City Sandwich Pay-As-You-Throw (PAYT) Program

In a Pay-As-You-Throw (PAYT) solid waste program, residents purchase pre-printed stickers or bags for trash disposal, thereby paying directly for the amount of solid waste they generate. There is no direct fee for recycling. The town of Sandwich started a PAYT program in July 2011 and was awarded a PAYT start-up grant of $27,000 from MassDEP. Residents pay $1.20 for each 30-gallon bag, $0.60 for each 15-gallon bag, and $0.25 for 8-gallon bags. Residents also purchase a sticker to access the transfer station, which costs $55/year. In the first six months of the program, commingled recycling increased 65% and solid waste decreased 41%. The net bag revenue was $127,000 and the city saved $83,600 in waste disposal. (MassDEP 2011)

Supplemental Strategies

Two supplemental strategies have been identified within the non-energy subsector. The first aims to reduce leaks from the natural gas distribution network. Methane is the main component of natural gas and has a much higher GWP than carbon dioxide. This strategy is closely related to other GHG emission reduction strategies, including expanding the use of natural gas in Massachusetts. The Department of Public Utilities is currently quantifying the amount of natural gas lost or accounted for during distribution, and is reviewing and identifying methods and procedures to reduce methane emissions.

A second supplemental strategy would reduce fluorinated gas emissions from the semiconductor industry, similar to the efforts to reduce SF_6 from gas-insulated switchgear. MassDEP is investigating possible first steps, including conducting a survey to learn from users of fluorinated gases. California regulations could serve as a model for a program, just as regulations in that state were a model for the Massachusetts SF_6 regulations in progress.

4.4.3 Conclusions and Recommendations

Massachusetts has made significant progress on the three non-energy strategies outlined in the 2020 Plan. However, it is important that this momentum continue. Regulations of SF_6 and stationary equipment refrigerant still need to be finalized, and additional collaboration with industry is needed in the transition from high-GWP to low-GWP refrigerants. Implementing the strategies outlined in the SWMP is necessary to both achieving the SWMP goals and to meeting the GWSA limit in 2020.

Finally, quantification of the CO_2e reductions from these strategies is necessary to track current progress and plan for any evident shortfalls. The non-energy sector, along with transportation, does not currently have any quantified CO_2e reductions in the Clean Energy and Climate Performance Management System. Quantifying these emission reductions is especially important in light of the significant progress that has been made to-date.

4.5 Cross-Cutting Policies

4.5.1 Overview

Cross-cutting policies drive GHG emission reductions across all sectors through a wide variety of initiatives and projects. The 2020 Plan identifies three existing policies – the Massachusetts Environmental Policy Act (MEPA) Greenhouse Gas Emissions Policy and Protocol, the Leading by Example Program (LBE), and the Green Communities program - that have had a significant impact on GHG emissions. The 2020 Plan listed recommendations and goals for these three programs, however, to avoid double-counting of their GHG reductions, these reductions were included in estimates for other strategies, such as all cost-effective energy efficiency and renewable energy. Table 12 below lists the key accomplishments in these three programs.

Table 12: Summary of Progress on Cross-Cutting Policies

Strategy	Key Accomplishments and Highlights	Reductions below 1990 levels anticipated in 2020 Plan	Likelihood of Meeting 2020 Target /Goals
MEPA GHG Policy and Protocol	• Incorporated new greenhouse gas emissions thresholds into revised MEPA regulations in 2013. • Established a Greenhouse Gas Emissions Policy and Protocol (2007) applicable to all projects requiring an Environmental Impact Report for MEPA review.	---	**High**
Leading by Example	• Tracked energy consumption, GHG emissions, and the use of renewable energy sources at 49 state agencies.	---	**Medium**
Green Communities Division	• 123 communities enrolled in the Green Communities Act program • Almost $28 million dollars invested in energy-saving projects.	---	**Medium**

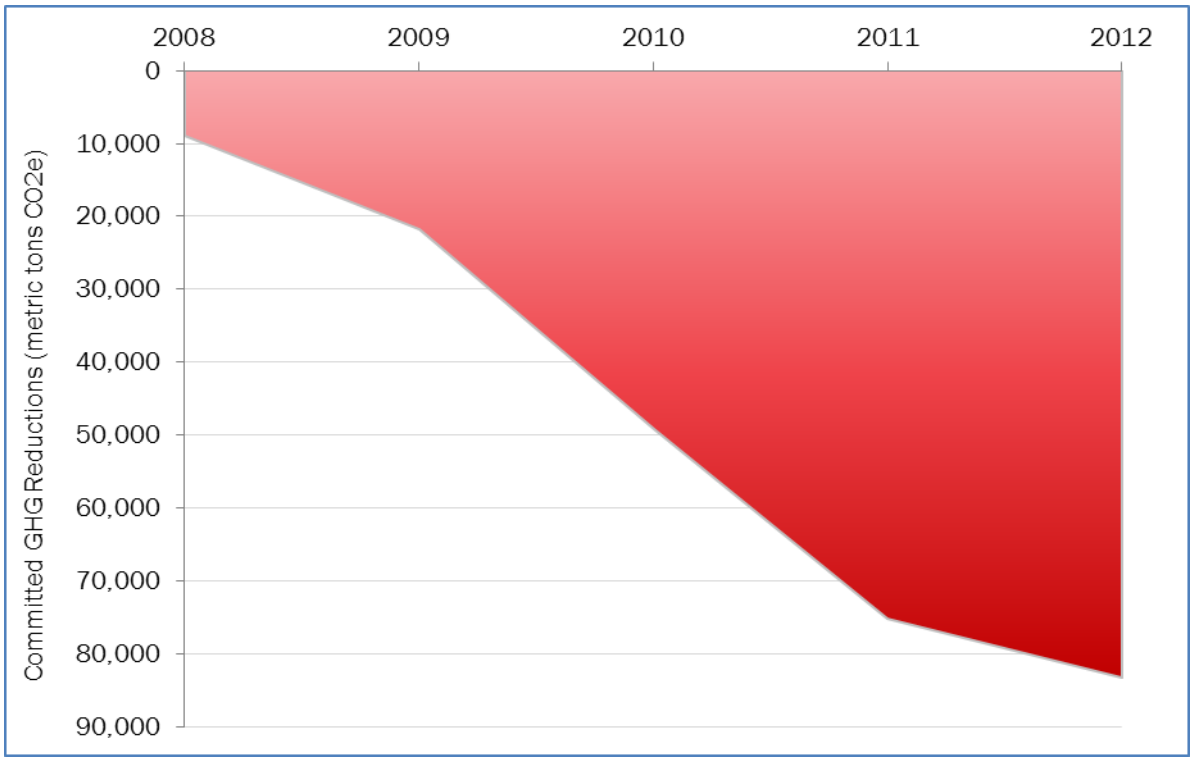
4.5.2 Emission Reduction Strategies: Results and Recommendations

MEPA GHG Policy and Protocol

MEPA requires that certain projects within the Commonwealth, i.e., those that are proposed by state agencies or require state agency action (i.e., permits, funding, or land transfer), should be evaluated to assess their environmental impacts and analyze alternatives to avoid, minimize, and mitigate damage to the environment to the maximum extent feasible (MA EEA 2010a). The MEPA GHG Policy and Protocol was established in 2007 and revised in 2008, 2010, and 2013. This protocol applies to all projects that are required to submit an Environmental Impact Report (EIR) under MEPA regulations; the EIR should include an analysis of project-related GHG emissions and identify measures to avoid, minimize, or mitigate these emissions. Project proponents provide estimates of GHG emissions associated with a project baseline and then with a preferred alternative that incorporates energy efficiency and GHG reduction mitigation measures (MA EEA 2010b).

From 2008 to 2012, 58 projects completed MEPA review in accordance with the MEPA GHG Policy. These projects have resulted in commitments to reduce GHG emissions by over 83,000 metric tons of CO_2e per year to date, as shown in Figure 20.

Figure 20: Committed GHG Reductions by MEPA Projects (including projects with waiver from MEPA review process)



EEA is continuing to consider how to assess project-related GHG emissions and climate change adaptation through the MEPA process. Alteration of large amounts of land can have a significant impact on GHG emissions. EEA and MEPA are developing a protocol to assess GHG emissions associated with land alteration, which will be applied to projects that exceed the MEPA EIR threshold for land alteration of 50 acres.

In addition, in 2013 EEA and MEPA convened a working group to begin development of a climate change adaptation policy that will be applied to certain projects during MEPA review. This policy is intended to guide the assessment of climate change impacts and evaluation of opportunities to increase resiliency of infrastructure and natural resources. The policy will address impacts associated with sea-level rise, precipitation, and temperature. While several projects subject to MEPA review have been required to address, or have voluntarily addressed, potential impacts associated with projected sea-level rise, less emphasis has been placed on temperature and precipitation. These policies will be developed, and in consultation with State Agencies and stakeholders, will be integrated into the MEPA review process.

Case Study: MEPA GHG Policy and Education First Office Building, Cambridge

Education First, a company with 34,000 employees worldwide, began construction on a new Cambridge office building in September 2012 (Ross 2012). This project was subject to MEPA and the GHG Policy and Protocol. Part of the MEPA review included modeling baseline CO_2e emissions, using the standard Massachusetts building code, and estimating reductions in CO_2e that could be achieved through additional mitigation efforts. The baseline emission level for the 295 million square foot, 10-story mixed use building was estimated to be 1,386 tons of CO_2e per year from stationary emission sources (including direct sources like boilers and heaters, and indirect sources like electricity consumption) and mobile emission sources (which includes emissions associated with vehicle use by employees, vendors, and customers). Through a variety of measures to increase energy efficiency and reduce GHG emissions, the total emission level was reduced by 20 percent to 1,105 tons per year. Mitigation measures include building envelope upgrades, the use of daylight and occupancy sensors for reduced interior lighting demand, the elimination of ozone-depleting refrigerants in the HVAC systems, and the use of water conservation and wastewater reduction

Leading by Example

Governor Deval Patrick's Executive Order No. 484 established the Leading by Example (LBE) Program in April 2007(Massachusetts State Governer's Office 2007). This program, overseen by the EEA and the Executive Office for Administration and Finance (A&F), coordinates efforts at state agencies to reduce their environmental impact. These efforts are critical, considering that state government is the largest single user of energy in the state, consuming over 1 billion kWh of electricity and emitting over 1 million metric tons of CO_2e per year (MA Executive Office for Administration and Finance 2013). The 2007 Executive Order set several ambitious targets for state government operations, including:

- Reducing energy consumption 20 percent by 2012 and 35 percent by 2020;
- Reducing GHG emissions 25 percent by 2012 and 40 percent by 2020; and
- Obtaining 15 percent of total electricity from renewable sources by 2012 and 30 percent by 2020. (MA Executive Office for Administration and Finance 2013)

The state has made impressive strides towards implementing these goals, although it has missed some of the specific targets set for 2012. Continued progress towards these targets will have a significant impact on total GHG emissions in Massachusetts.

Energy Reduction

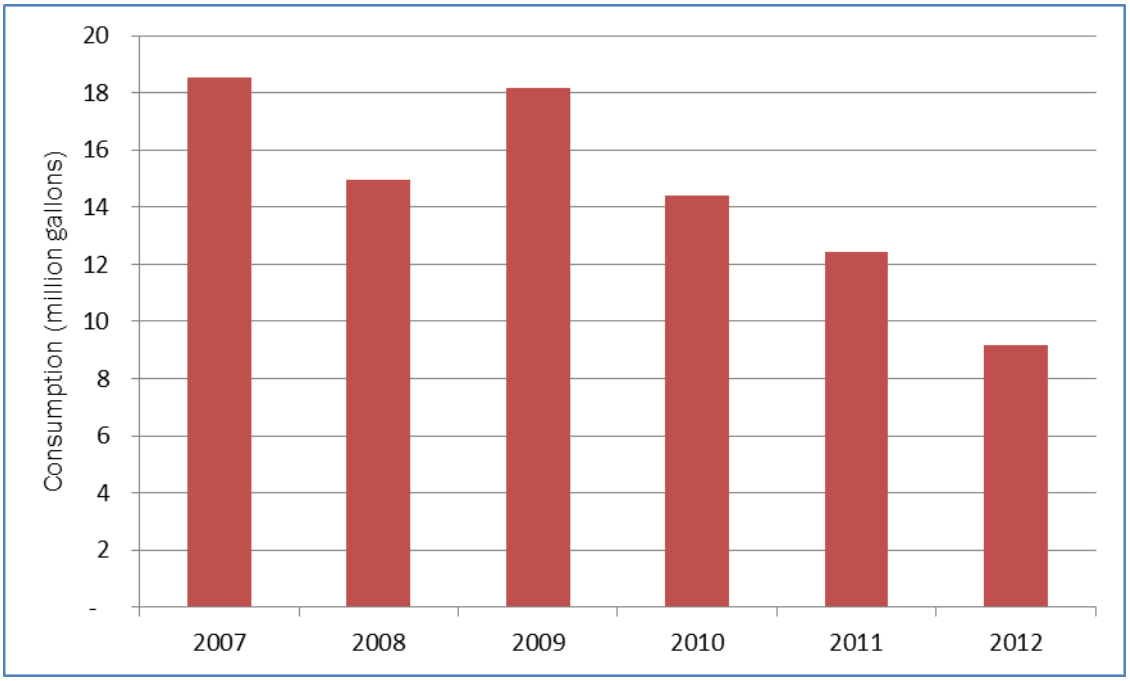
Hundreds of projects to reduce energy use have been implemented across the state, varying from large comprehensive efficiency efforts to smaller projects and equipment and fixture replacements. Energy use intensity (EUI, a measure of energy consumption per sq. ft. of buildings) has decreased in the 49 agencies tracked in LBE program, from 153 to 146 kBtu per sq. ft., a 5 percent decrease from the 2004 EUI baseline. While this falls short of the 20 percent reduction target for 2012, this decrease has occurred even though many state colleges and universities have expanded their hours, which would normally increase EUI. Also, many large energy efficiency projects require significant time to implement, and savings from these projects will become evident within the next three years (MA DOER 2013a).

Greenhouse Gas Emissions

Governor Patrick's Executive Order also set an ambitious goal for reducing GHG emissions at state facilities, leading the way for the reductions required in the GWSA. The past five years have seen a large reduction in GHG emissions at state facilities, despite a significant increase in the number of buildings, square footage, and increased enrollment and hours at many state colleges and universities. At the end of 2012, GHG emissions dropped by 19 percent from the 2002 baseline. Community colleges have shown the greatest reductions, decreasing by 26 percent from their baseline, even though student enrollment has increased over the same timeframe.

A key element in LBE's strategy for reducing GHG emissions is a transition from heating oil to natural gas. Natural gas is significantly cleaner than heating oil, which is the highest emitting fuel still used at state facilities. Between 2007 and 2012, the use of natural gas increased 44 percent and the use of heating oil at state facilities decreased by over 9 million gallons, or 51 percent (MA DOER 2013a). Many state facility and campus locations are in the process of converting from heavy fuel oil to natural gas, and several are on track to eliminate all uses of fuel oil. Figure 21 below shows the decrease in heating oil consumption at state facilities.

Figure 21: Heating Oil Consumption in State Facilities: FY2007—FY2012



Source: MA DOER, 2013a.

Renewable and On-Site Energy Generation

The third goal associated with the LBE program, obtaining 15 percent of annual electricity consumption from renewable sources by 2012 and 30 percent by 2020, is important to meeting GWSA's GHG reduction goals. Massachusetts has made tremendous strides in increasing electricity generation by renewable sources, and state agencies have played a significant role in this success. Electricity generation in state buildings from on-site solar PV and wind has grown from less than 1 million kWh in 2007 to more than 13 million kWh in 2012. Combined heat and power, or CHP, has also become an important source of efficient on-site generation of electricity, and Massachusetts has targeted replacement of heating plants with CHP facilities powered by natural gas. CHP systems produce both electricity and heat from the same fuel source, which increases the efficiency of energy systems, cuts emissions of GHG and other air pollutants, saves on energy costs, and reduces reliance on the electricity grid. Solar PV, hydro, wind, on-site generation from CHP, and anaerobic digestion at state facilities totaled 210 million kWh in 2012, or 15.2 percent of total electricity consumption at state facilities. Between 2006 and 2012, state facilities have reduced consumption of grid electricity by 8.6 percent, despite growth in square footage and facility operating hours. Continued expansion of renewable energy sources and clean on-site energy generation is critical to meeting the LBE target of generating 30 percent of total energy use from renewable sources by 2020 and to meeting the GWSA 2020 GHG emissions limit.

Case Study: Hogan Regional Center and Wrentham Development Center

The Department of Developmental Services, with assistance from the Division of Capital Asset Management and Maintenance, completed a $25 million comprehensive energy project at two full-time residential facilities for the developmentally disabled—Hogan Regional Center and Wrentham Developmental Center. This project, completed in 2013, has reduced GHG emissions by 58 percent and reduced energy bills by $3.2 million.

Project features include power plant upgrades, the installation of combined heat and power and solar PV, comprehensive lighting upgrades, programmable thermostats, and improved insulation and weather stripping. In the first year of full operation, the project demonstrated impressive energy and cost savings, including a 97 percent reduction in oil consumption, a 26 percent reduction in grid-based electricity consumption, a 57 percent reduction in total energy bills, and a 58 percent reduction in GHG emissions.

The LBE program continues to reduce energy consumption, environmental impacts, and costs for state facility buildings. In January, the LBE program announced creation of the Accelerated Energy Program. This program will complete energy efficiency retrofits at 700 buildings in 700 days, targeting an energy use reduction of at least 25 percent (MA DOER 2013a). This program will save the Commonwealth an estimated $43 million annually and decrease annual GHG emissions by 135,000 metric tons (MA Executive Office for Administration and Finance 2013).

The LBE program faces several challenges moving forward. First is tracking energy use and emissions across such a large and diverse portfolio of buildings and agencies. Energy consumption, renewable energy generation, emissions, and cost data are critical to program success, and must be gathered from a wide variety of sources. Several new tools have been created to help with data collection. The DOER Green Communities division created Mass Energy Insight (MEI), a web-based tool that loads usage and cost data directly from electric and gas utilities and allows DOER and state agencies to access and compare energy use, costs, and associated GHG emissions. DOER also invested $9.7 million in federal stimulus funding to deploy the Enterprise Energy Management System (EEMS), which uses energy meters to provide real-time metering and utility bill tracking across 25 million square feet of building space. Almost 1,300 energy meters in 482 buildings have been installed to-date. In April 2013, an EEMS Advisory Committee was created to guide continued implementation of the program (MA DOER 2013a). Effective implementation will provide more accurate energy use data, and will also enable building and facility managers to quickly adjust operations to maximize building efficiency (MA DOER 2013a).

Other challenges facing the LBE program include financing major energy efficiency projects and streamlining the timeline for these projects. Clean energy investments to-date total over $300 million, including approximately $70 million in ARRA funding. The Clean Energy Investment Program (CEIP), created in 2009, utilizes general obligation bonds to support projects that pay off their financing debt through energy savings. It allows DCAMM to secure low-cost financing for large energy efficiency projects and finance more aggressive projects that result in greater savings and emission reductions. Actions taken to streamline major projects include bundling 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, like lighting upgrades, where savings are well-documented. These actions will help ensure continued success of the LBE program.

Green Communities

The Green Communities Program, created by the Green Communities Act of 2008, is one of the most successful programs of the GWSA and leads the nation in demonstrating how a state can encourage and guide climate action at the municipal level. Since 2010, 123 municipalities have become designated Green Communities by meeting the following five criteria:

- Provide as-of-right siting designated locations for renewable/alternative energy generation, R&D, or manufacturing facilities;
- Adopt an expedited application and permit process for as-of-right facilities;
- Establish a municipal energy use baseline and develop a plan to reduce energy use by 20 percent within five years;
- Purchase only fuel-efficient vehicles for municipal use; and
- Set requirements to minimize life-cycle energy costs for new construction (such as through adoption of the Stretch Code) (MA EEA 2013b).

The Green Communities Division also serves all Massachusetts cities and towns as a hub for energy related issues and activities, helping communities increase energy efficiency and the use of renewable energy.

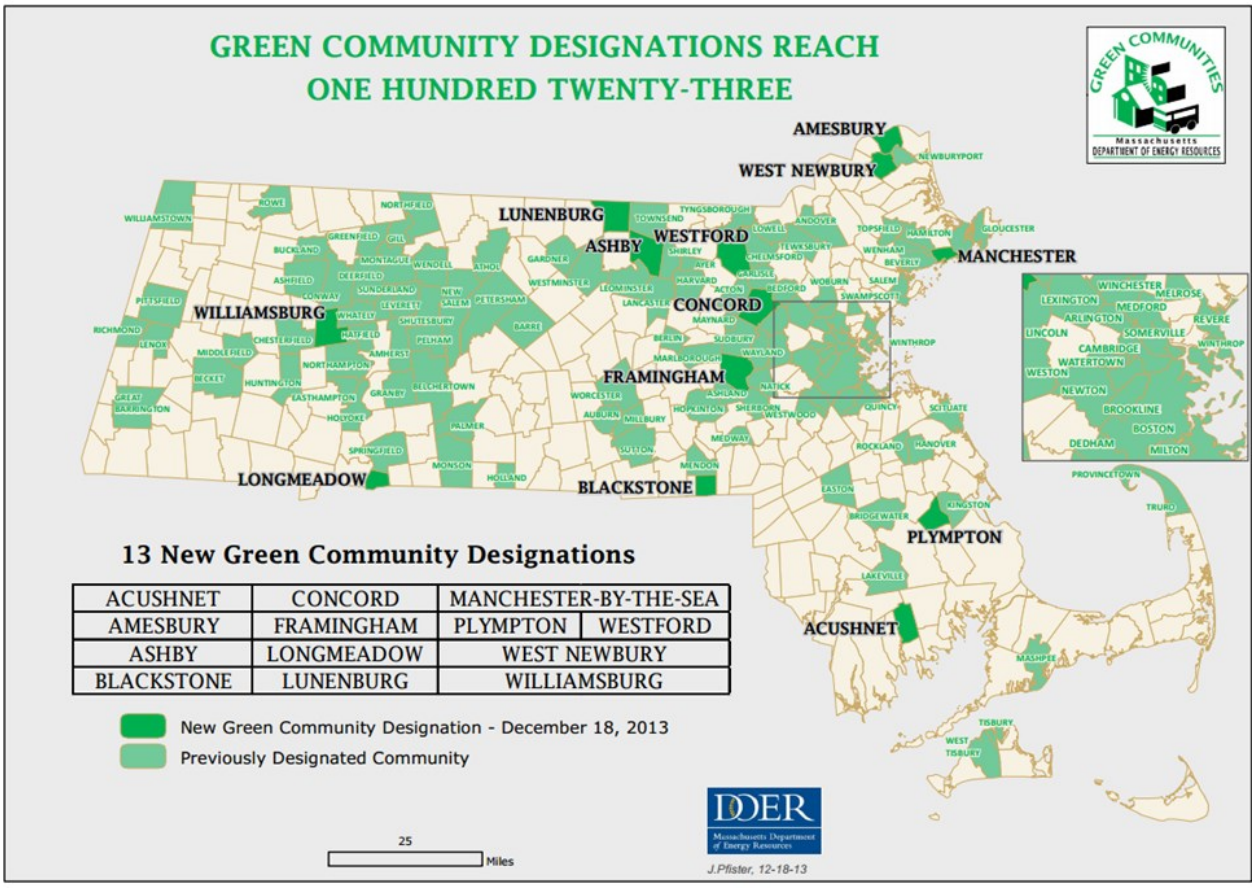
Activities and projects supported by the Green Communities Program have created significant GHG reductions and energy savings. All Green Communities must commit to lowering municipal energy use by 20 percent from their baseline value over five years. To date, this commitment is equal to over 173,000 tons CO_2e, or the equivalent of taking nearly 31,000 cars off the road. Green Communities are also eligible for state grants. So far, grants totaling nearly $28 million have funded energy conservation measures, energy performance contracts, solar photovoltaic installations on municipal and school facilities, hybrid vehicle acquisitions, and other projects. Fifty-three grant-funded projects have been completed to date. These projects represent annual municipal energy savings of $2.2 million.

The Green Communities Program has been successful largely due to the interest and engagement of municipalities. A 2011 survey of Green Communities found that the largest share of respondents had a pre-existing desire to reduce the municipality's energy use, which saves taxpayer money and reduces GHG emissions. Although the program requires ambitious action on the part of communities, most municipalities perceive these steps to be achievable and worthwhile. In addition, four DOER Regional Coordinators work directly with communities and

are able provide ongoing information, advice, and assistance. This assistance had made it possible for most interested municipalities to navigate the process. The success of the Green Communities program is being used as a model for other states, including New York and Maryland, who are starting similar municipal clean energy programs.

To date, 123 of Massachusetts' 351 cities and towns have been designated as Green Communities, which represents 48 percent of the state's population. Green communities are of many sizes and socio-economic types, and are located around the state, as shown in Figure 22.

Figure 22: Green Communities as of December 2013



The Green Communities program faces several opportunities moving forward, as municipalities approach the five-year milestone and the program continues to expand. The Green Communities Division plans to begin a formal rulemaking process to create regulations that will clarify and expand on existing policies and address questions about future steps for the program. One important consideration is the future of municipalities once they have been a designated Green Community for five years. As part of their designation criteria, these municipalities developed a plan to reduce energy use by 20 percent from their energy-use baseline. If municipalities reach this target, how should they set new targets? And what happens if they do not meet the target? Another consideration is whether penalties or actions should be taken against Green Communities who violate their designation criteria or fail to submit annual reports (MA DOER 2013b). Future regulations may clarify these and other issues, and will allow the Green Communities program to continue to effectively support municipalities' efforts to reduce energy use and GHG emissions.

4.5.3 Conclusions and Recommendations

MEPA, Leading by Example, and the Green Communities Program demonstrate how cross-cutting policies, which take a comprehensive approach to reducing GHG emissions, can be extremely effective at reducing GHG emissions. After several years of success, all three programs are looking towards future actions and next steps that will continue to reduce GHG emissions from new projects, state-owned facilities, municipalities, and towns. Future actions include developing a MEPA Climate Change Adaptation Policy, incorporating adaptation guidance into MEPA, executing LBE's new Accelerated Energy Program, and planning for the future of the Green Communities Program through possible new regulations. These steps will be critical to meeting the 2020 Plan emissions limit and will build on the programs' successes.

Progress on Climate Change Adaptation

5.1 Overview

While EEA has been working on climate change adaptation throughout the Patrick Administration, the devastation caused by recent storms, including Hurricane Sandy and the Nor'easter "Nemo," highlighted the need for Massachusetts to enhance preparedness for and adapt to the projected impacts of climate change. In 2013, Governor Patrick reiterated that climate change adaptation is a top priority for EEA through the end of his administration. Since 2008, EEA has taken major steps to assess the Commonwealth's vulnerabilities to climate change and to identify key strategies for improving its resiliency.

In response to the requirements of the GWSA, in 2009 EEA established the Climate Change Adaptation Advisory Committee, composed of a broad range of stakeholders across state agencies, non-governmental organizations, academia and local governments. The Committee's charge was to analyze strategies for adapting to the predicted impacts of climate change in the Commonwealth.

The Adaptation Advisory Committee met regularly over a one-year period and in 2011, the Committee released the "Massachusetts Climate Change Adaptation Report (the Adaptation Report)" (MA EEA and MA Climate Change Adaptation Advisory Committee 2011). This report, prepared in coordination with EEA, is the first broad overview of the potential effects of climate change on Massachusetts, and provides an analysis of vulnerabilities in each of five sectors:

- Natural Resources and Habitat
- Key Infrastructure (including energy, water, wastewater, solid waste, and transportation)
- Human Health and Welfare
- Local Economy (including manufacturing, services, agriculture, forestry, and fisheries) and Government (including land user and emergency preparedness)
- Coastal Zone and Ocean

The Adaptation Report describes over 200 potential strategies to increase resilience and preparedness across these sectors.

Following release of this report, in 2012, EEA formed an Adaptation Subcommittee to further enhance coordination and communication among stakeholders involved in implementing climate change adaptation recommendations. This Subcommittee, which meets quarterly, is composed of stakeholders from state and federal agencies, municipalities, regional planning agencies, non-governmental organizations, and academia. Over the past year, the Subcommittee has established priorities related to emergency preparedness and protection of human life and infrastructure, shared key information on projects and modeling efforts related to vulnerability assessments, developed and offered a climate tools workshop for state agency staff, and heard from several guest speakers about their work on adaptation.

5.2 Current Progress

The Adaptation Subcommittee and its working groups have been coordinating with various state agencies and regional organizations as they prioritize and implement the recommendations from the Adaptation Report. Below are brief summaries of the key adaptation priorities identified for each sector, as well as case studies of specific projects and their results.

Natural Resources and Habitat

The Adaptation Report outlines strategies for addressing current and potential impacts to critical natural resources. The Natural Resources and Habitat sector addresses four broad ecosystem types in Massachusetts - forests, aquatic, coastal, and wetlands, all of which are already experiencing measurable impacts from climate change. General principles that apply across ecosystems include protecting ecosystems of sufficient size and quality across a range of environmental settings; protecting multiple example ecosystems to capture redundancy; maintaining large-scale ecosystem processes and preventing isolation; limiting ecosystem stressors; and maintaining ecosystem health and diversity. Strategies are generally of four types: land protection; policy, flexible regulation, planning, and funding; management and restoration; and monitoring, research, and adaptive management.

The Report emphasizes the need to collaborate on a unified vision for conservation of natural resources. Land protection can mitigate potential climate change impacts by reducing habitat fragmentation and expanding habitat connectivity, thereby strengthening ecosystem resiliency. The Department of Fish and Game's land protection program permanently protected over 5,600 acres of the Commonwealth's highest priority fish and wildlife habitats last fiscal year, and plans to conserve another 2,300 acres of land in2012-2014.

State agencies are providing analyses and blueprints to galvanize the conservation community, as described in the example below.

Case Study: Department of Fish and Game

In 2010, the Department of Fish and Game's (DFG) Division of Fisheries and Wildlife conducted a climate change vulnerability assessment to better understand how projected climate change conditions would affect important fish and wildlife resources in the Commonwealth (MA EEA 2013c).

The State Wildlife Action Plan (SWAP) of 2006 recognized climate change as a threat to the fish and wildlife resources of the Commonwealth. Working with the Manomet Center for Conservation Sciences, the Division of Fisheries and Wildlife assessed the vulnerability to climate change for habitats identified as being in greatest conservation need within the SWAP. The results of the assessment include a relative ranking of the overall vulnerability of the habitat types under projected climate conditions, a narrative detailing the vulnerability factors which led to the ranking, and a discussion of the overall confidence level associated with the vulnerability ranking.

DFG is applying the results of the vulnerability assessment to adjust existing conservation strategies, such as land acquisition and habitat management. The Department can also use the results to develop new strategies to meet the challenges of conserving these most vulnerable natural resources in a changing climate.

Through this process, Massachusetts has become a successful early adopter of a systematic approach to climate vulnerability assessment and priority setting. A leader in this area, DFG is involved in national and regional efforts to develop and implement vulnerability assessments elsewhere in the country.

Key Infrastructure

The Adaptation Report highlights the need for Massachusetts to focus on the critical services and infrastructure needs of its communities and discusses at length the specific infrastructure that is most vulnerable to climate change. All sectors—energy, transportation, water, dams, solid and hazardous waste, built infrastructure and buildings, and telecommunications—are likely to be affected by climate change. Most key infrastructure is built based on historic weather patterns, leaving it vulnerable to current and predicted changes to sea level, precipitation, and flooding.

Today's builders and planners can counter climate change effects by designing new facilities for expected climate change, such as increases in intensity and frequency of extreme events; identifying vulnerabilities in existing structures (such as potential for flooding or loss of power); and retrofitting those facilities over time. Redesigning and upgrading existing infrastructure and careful siting and design of future infrastructure will help to minimize anticipated impact of climate change effects.

Other strategies to mitigate climate change in future infrastructure include upgrading efforts in conservation, efficiencies, reuse of resources and timely maintenance; building system redundancies; updating land use, siting, design and building standards to include climate change projections; using natural systems for enhanced protection; and increasing resilience of infrastructure and the built environment .

Case Study: Massachusetts Department of Transportation Federal Highway Administration

The Massachusetts Department of Transportation (MassDOT) and the Federal Highway Administration (FHWA) are co-sponsoring the project, "Climate Change and Extreme Weather Vulnerability and Adaptation Options of the Central Artery" through FHWA's 2013-2014 Climate Resilience Pilot Program. Many assets near the MassDOT's Central Artery in Boston are vulnerable to flooding under 100-year flood conditions. This first-of-its -kind project involves developing a computer model combining storm surge dynamics and wave impacts, and creating a highly accurate inventory of flood vulnerable assets of the Central Artery. The project also includes the examination of physical linkages between the Central Artery and Massachusetts Bay Transportation Authority (MBTA) infrastructure (Blue, Red, and Silver Lines).

The work focuses on climate impacts and adaptive capacity for the present and the year 2030. Climate scenarios are also being developed for 2070 and 2100 for use in high level-conceptual adaptive options. Assessment of predicted impacts over time will aid in budget programming for adaptation options.

The project features unprecedented collaboration between MassDOT, the Cities of Boston and Cambridge, the Department of Conservation and Recreation, the Massachusetts Port Authority, and Coastal Zone Management. Stakeholder meetings aid in providing progress updates and acquiring key information for the project.

Human Health and Welfare

Climate change is expected to have a significant impact to human health and welfare. Increased health complications from heat stress and poor air quality are predicted. Post-Hurricane Sandy conditions in the Northeast powerfully demonstrate how extreme weather events can disrupt human health and daily existence. Power outages affect sanitary conditions in housing, as well as health care services and access to safe food and drinking water.

Health effects may include increased respiratory diseases from higher ozone and particulate matter concentrations in the air, and increased potential for water-borne diseases associated with flooding and bacterial contamination of recreational waters. Surface water quality may become more degraded with increased stormwater run-off, potentially increasing human exposure to pathogens, pesticides, and other pollutants. Changes in disease patterns may increase outbreaks of vector-borne diseases. Certain populations, like the elderly, those with limited resources to take protective and adaptive measures, and those already coping with chronic illnesses are especially vulnerable and will require specific measures to address their needs.

The 2011 Adaptation Report highlights the challenges faced by the Commonwealth's public health infrastructure, which already is addressing increasing burdens and lack of resources. The report presents several potential strategies for addressing climate change impacts on public health, including a system-wide climate change needs assessment to assist adaptation planning. Changes in the current local public health program model, such as enhancing regionalization efforts to address non-emergency situations, would allow for more efficient mutual aid and increased coverage across the state. The need for enhanced capacity in core public health activities could be met by a regional system that supports the critical skills necessary to prevent disease and injury in communities.

Case Study: Department of Public Health

Massachusetts has local boards of health for each of its 351 cities and towns, serving as the front line in addressing public health. The Department of Public Health (DPH) has worked with the U.S. Centers for Disease Control and Prevention to develop an understanding of the capacity of local health departments to respond to the public health effects of climate change.

The study's report summarizes the results of a comprehensive survey of local boards of health in Massachusetts. Survey results indicate that most local health departments are not prioritizing addressing health effects from climate change, and most local health boards feel unprepared and lack resources and expertise to address these issues.

DPH presents recommendations aimed at strengthening the Commonwealth's capacity to prepare for and respond to health effects from climate change, including:

- Resources to help identify areas of special concern, including maps that identify particularly vulnerable populations, such as the elderly living alone;
- Model adaptation strategies that can be used by local health departments and other officials;
- Planning tools such as templates for conducting Health Impact Assessments to help local officials most efficiently direct resources toward adaptation strategies;
- Education and training, such as regional symposia for local health and other officials involved in adaptation planning; and
- Other public education and outreach efforts

The DPH survey results will be shared across state agencies involved in responding to climate change projections or impacts in Massachusetts.

Local Economy and Government

As outlined in the Adaptation Report, the impacts of climate change will add pressure on government by increasing demand for emergency and other services. Local economies reliant on weather-dependent industries like agriculture, forestry, and fisheries will be affected by the increase in weather extremes, potential water shortages, and changes in pest population dynamics. Flooding, declines in winter precipitation and higher temperatures can also impact manufacturing and service industries. Local economies will have to navigate changing land use needs, as farms, residential development and industry compete for available land.

Strategies described in the Adaptation Report include increased emergency preparedness, water conservation and storage, changes to building codes, and improved planning and land use practices. To adapt to changing weather patterns and temperatures, the agriculture, forestry, and fishing sectors will require increased research into species vulnerability, pest and disease patterns, as well as technical assistance at the local level.

There has been progress implementing strategies to enable local economies and the industries they rely on to become more resilient to climate change. Below is one such example.
through the StormSmart Coasts program described below.

Case Study: Massachusetts Department of Agriculture Resources

A water conservation strategy implemented by Massachusetts' cranberry industry provides an excellent example of a successful climate change adaptation measure. The cranberry sector is an intensive user of water, primarily for frost management and during harvesting. Auto-start irrigation systems use remote technology to automatically start and stop irrigation based on ambient temperature or pre-scheduled events, and allow farmers to remotely monitor pump speed, pressure, and other conditions. Auto-start systems have been estimated to save 280,000 gallons per season for a typical cranberry farm for frost management alone. The Massachusetts Department of Agricultural Resources has provided funding for auto-start systems through its Agricultural Environmental Enhancement Program, resulting in the widespread adoption of such systems over the past five years.

The system contributes to overall preparedness for unpredictability in precipitation patterns and water availability as a result of climate change. As the Adaptation Report highlights, technology to ensure greater conservation of water is a key need moving forward.

Coastal Zone and Ocean

Massachusetts' coastal zone and ocean are extremely important to the Commonwealth's economy and way of life, with the coastal economy contributing an estimated 37 percent of annual gross state product (MA EEA and MA Climate Change Adaptation Advisory Committee 2011). Unfortunately, the coastal zone and ocean are also uniquely vulnerable to the impacts of climate change. Temperature changes can have major impacts on sensitive ecosystems, threatening biodiversity and ecosystem-based economies, such as fisheries, tourism, and recreation. Sea level rise exacerbates effects from erosion and storm damage on coastal ecosystems like salt marshes, barrier beaches, and floodplains. The Adaptation Report specifically looks at coastal development, coastal engineering, and ecosystem services from coastal habitats. Strategies highlighted in the Adaptation Report include siting development outside of projected vulnerable and future resource areas, and decreasing risk and repetitive losses to existing development. Many of the strategies involve increasing research and assessment capabilities to understand local ecological processes like erosion and sedimentation, as well as monitoring and modeling of ambient air and water conditions and fish and wildlife populations. Coastal resiliency can be improved by bolstering land conservation efforts, which accounts for changing landscape and natural communities and protects valuable ecological resources.

Many of the strategies for the coastal zone and ocean described in the Adaptation Report involve reaching out to communities and providing tools, technical assistance, and other resources to assist in local planning and decision making, much of which is ongoing through the StormSmart Coasts program described below.

Case Study: Office of Coastal Zone Management

To help coastal communities address challenges arising from storms, floods, sea level rise, and other climate change impacts, the EEA's Office of Coastal Zone Management (CZM) launched its StormSmart Coasts program in 2008 to promote storm-resilience by providing technical tools, information, and direct assistance to communities for effective planning and implementation. These tools include maps, data, fact sheets, case studies, planning strategies, and other technical assistance materials. In 2009, CMZ began pilot projects in seven communities to test local implementation of the tools through workshops, meetings, and collaborative project implementation. Highlights of some hazard identification and mapping tools that CZM has recently made available include:

Shoreline Change — Mapping and analysis of short– and long-term shoreline change rates (i.e., erosion)

Sea Level Rise — Current and future tidal inundation levels as modeled by the National Oceanic and Atmospheric Administration's Coastal Services Center. Maps and visualization tools for projected sea level rise scenarios for the entire Massachusetts coast for potential sea level rise at 1-to 6-foot intervals. The maps and data can be accessed on the Massachusetts Ocean Resource Information System (MORIS), which allows users to interactively view the data with other information such as aerial photographs, assessor maps, public Facilities and infrastructure locations, and natural resource areas.

Shoreline Stabilization Structures — Coast-wide inventory and assessment of privately-owned shoreline stabilization structures (i.e., seawalls, revetments, groins, and jetties) complementing an existing inventory of state and municipal shoreline stabilization structures. A full summary was developed in 2009 that includes a 20-year work program for repairs and rehabilitation to the structures by order of a priority selection matrix. This report has been used for identifying the most crucial areas of need and has assisted in storm recovery. Locations and information are available on MORIS and reports and static maps are on CZM's StormSmart Coasts websites.

CZM's successful StormSmart Coasts program led to the development of a national StormSmart Coasts network, in partnership with national and regional coastal decision makers. A national website provides local decision makers with information on erosion, flooding, storms, and sea level rise and helps them connect and collaborate.

Interagency and Regional Collaboration

The Patrick Administration continues to spearhead Massachusetts interagency and regional collaboration in addressing climate change through the adaptation subcommittee and agency initiatives, such as those highlighted below:

The **Department of Environmental Protection** is coordinating with other New England states and Region 1 of the U.S. Environmental Protection Agency (EPA) to improve preparedness for storms, storm surge, and other expected impacts. In March 2013, New England state agencies held an informal information-sharing event to share lessons learned from Hurricane Sandy. EPA Region 1, in collaboration with the New England states, hosted an Adaptation Conference in November 2013.

The **Office of Coastal Zone Management's** South Coastal Regional Coordinator and Buzzards Bay National Estuary Program are using geographic information systems to overlay scenarios of sea level rise onto existing Federal Emergency Management Agency Flood Insurance Rate Maps and assessors' maps to assess risk from sea level rise. The methodology is being refined to apply coast-wide (Buzzards Bay National Estuary Program 2013).

CZM is also co-managing a grant with the Gulf of Maine Council and the Northeast Regional Ocean Council, from NOAA's Climate Program Office to advance municipal adaptation around the region. Under this grant, six municipal pilot projects were funded, including projects in Scituate, Marshfield, and Duxbury. Roger Williams University Law Fellows researched transfer of development rights and rolling easements as tools for climate adaptation in the coastal New England states. Best practices, case studies, communications materials, and results of pilot projects will be featured on the national StormSmart Coasts website (Gulf of Maine Council on the Marine Environment 2013).

The **Department of Conservation and Recreation (DCR)** Bureau of Forestry has been planting trees in forests affected by storms and pests. An Asian Longhorn beetle infestation in the Worcester area has led to the removal of about 32,000 trees, but DCR, along with the U.S. Forest Service, has planted more than 13,500 trees in this area. Some of this funding was also allocated through DCR for the purchase of 3,000 trees by the Worcester Tree Initiative. In 2012, with the end of federal funding, both the U.S. Department of Agriculture and the Commonwealth have identified $4 million to continue tree planting in the affected area. In the spring of 2013, 1,200 additional trees were planted by DCR staff.

The **Massachusetts Port Authority** has initiated a $500,000 study of Disaster and Infrastructure Resiliency Planning that will include an evaluation of sea level rise and coastal surge scenarios through 2033 on infrastructure at Logan International Airport Maritime Properties. The project will result in the development of a Mitigation Action Plan to address hazards and vulnerabilities and is expected to be completed in spring 2014.

Working in partnership with land trusts and municipalities, the **Executive Office of Energy and Environmental Affairs and its agencies** have protected over 110,000 acres of land during the Patrick Administration. This land will help provide habitat and protect ecosystems and their functions.

Photo courtesy of the Trust for Public Land (Bean-Allard Farm)

The Adaptation subcommittee played a key role in supporting interagency coordination and regional collaboration. Cross-cutting issues and interactions between mitigation and adaptation were among the many topics discussed and will continue to be an important focus going forward. Land use and smart growth, for example, and green infrastructure are important cross-cutting topics. Smart growth can help reduce the rate of forest loss to development while promoting more clustered development in areas near transit. Land use decisions that are consistent with sustainable development principles can serve to minimize energy use and vulnerability to climate change impacts such as flooding, and help protect green infrastructure that is essential to protecting people and ecosystem resilience. Another example of a cross-cutting issue is the significance of carbon sequestration in forests and wetlands and its consideration in development-related policy and decision-making.

5.3 Conclusions and Next Steps

The development of the Massachusetts Climate Change Adaptation Report focused state agency attention on the growing issue of climate change impacts, and facilitated the initiation of research and implementation projects across the state. Information on climate science, research, project outcomes and other climate-related efforts are being shared through a broad climate change adaptation subcommittee chaired by EEA staff; preparedness at the local level to respond to public health impacts was assessed and recommendations on how to strengthen response were made; impacts from sea level rise and storm surge to key transportation infrastructure such as the Central Artery and parts of the MBTA, and to Logan International Airport are being analyzed through modeling and assessment projects; assistance to communities in the vulnerable coastal part of the state has been enhanced and targeted; a stakeholder process to develop a MEPA climate change adaptation policy to address the potential impacts of climate change during the MEPA review process has been launched by EEA Secretary Rick Sullivan; vulnerability assessments on impacts to fish and wildlife resources were conducted; the newly updated state hazard mitigation plan includes climate change. In addition, several regional and local entities have been engaged in developing climate plans and climate vulnerability assessments – for example, the Metropolitan Area Planning Council (MAPC), the Pioneer Valley Planning Commission (PVPC), the City of Boston, and the City of Cambridge.

Earlier this year, Governor Patrick announced that climate change adaptation will be one of EEA's top three priorities through the end of his Administration. In doing so, he highlighted that the Commonwealth must properly assess risks and vulnerabilities and plan for them, ensure that emergency services have the ability to keep residents safe, protect natural habitats, and maintain healthy communities. He stressed that due to the complex nature of climate change adaptation, it is essential to work across agencies, across all levels of government, and with stakeholders to address this issue. To help implement the Governor's priority Secretary Sullivan added a full time staff member – a Policy Advisor for climate change adaptation, and each Secretariat designated a point of contact on adaptation to identify and advance adaptation activities that reflect Administration- and Commonwealth-wide priorities. Already, this enhanced coordination is helping to bridge efforts at various Secretariats, allowing climate change to be considered in new ways to benefit the Commonwealth and highlighting important cross-cutting issues between mitigation and adaptation. While prioritization of activities is ongoing, EEA anticipates accelerating adaptation related work over the next year.

References

ACEEE (2013). State Energy Efficiency Policy Database: Massachusetts. Published online at http://aceee.org/sector/state-policy/massachusetts.

Ailworth, E. (2013). "Mass. Utlities Go for Wind Power, Contracts Would Bring Savings." Boston Globe, September 23 2013.

Analysis Group (2011). The Economic Impacts of the Regional Greenhouse Gas Initiative. Published online at http://www.analysisgroup.com/uploadedFiles/Publishing/Articles/Economic_Impact_RGGI_Report.pdf.

Buzzards Bay National Estuary Program (2013). Potential Floodplain Expansion with Sea Level Rise in Buzzards Bay. Published online at http://climate.buzzardsbay.org/flood-zone-expansion.html.

Center for Transit-Oriented Development (2009). Mixed-Income Housing: Increasing Affordability with Transit. Federal Transit Administration. November 18 2013: Published online at http://ctod.org/pdfs/tod201.pdf.

Commonwealth of Massachusetts (2008a). Chapter 298 of the Acts of 2008: An Act Establishing the Global Warming Solutions Act.

Commonwealth of Massachusetts (2008b). Chapter 169 of the Acts of 2008: An Act Relative to Green Communities. Published online at https://malegislature.gov/Laws/SessionLaws/Acts/2008/Chapter169.

Commonwealth of Massachusetts (2008c). Advanced Biofuels Task Force Report.

Commonwealth of Massachusetts (2013). Massachusetts General Law Chapter 111, Section 142 K "Motor Vehicle Emission Standards; Late Models". Published online at https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXVI/Chapter111/Section142K.

Energy and Environment News (2013). After RFS release, both sides of the debate double down. November 18, 2013.

Energy Modeling Forum (2013). Changing the Game? Emissions and Market Implications of New Natural Gas Supplies. Published online at http://emf.stanford.edu/files/pubs/22532/Summary26.pdf.

Gulf of Maine Council on the Marine Environment (2013). Northeast Climate Change Adaptation. Published online at http://necca.stormsmart.org/home/about/.

IPCC (2013). Climate Change 2013: The Physical Science Basis, Summary for Policymakers. Published online at http://www.climatechange2013.org/images/uploads/WGI_AR5_SPM_brochure.pdf.

ISO New England Inc (2013). 2011 ISO New England Electric Generator Air Emissions Report. February 2013: Published online at http://www.iso-ne.com/genrtion_resrcs/reports/emission/2011_emissions_report.pdf.

ISO New England Inc (2013). Final 2013 Energy Efficiency Forecast 2016-2022, prepared by the Energy Efficiency Working Group and ISO Staff. February 22, 2013.

MA DOER (2013a). Executive Order 484: Toward Our Targets.

MA DOER (2013b). Green Community Designation and Grant Program: Request for Information.

MA DOER (2013c). Massachusetts RPS & APS Annual Compliance Report for 2011. April 9, 2013: Published online at http://www.mass.gov/eea/docs/doer/rps-aps/rps-aps-2011-annual-compliance-report.pdf.

MA DOER (2013d). Green Communities: Stretch Code Adoption, by Community. October 30, 2013: Published online at http://www.mass.gov/eopss/docs/dps/buildingcode/inf3/stretch-code-towns-map-and-list-fall-2013.pdf.

MA DOER (2013e). MassDOER Alternative Vehicle Program's Scope of Work for the Clean Vehicle Program

MA EEA (2010a). Massachusetts Clean Energy and Climate Plan for 2020. December 29, 2010: Published online at http://www.mass.gov/eea/air-water-climate-change/climate-change/mass-clean-energy-and-climate-plan.html.

MA EEA (2010b). Revised MEPA Greenhouse Gas Emissions Policy and Protocol. Published online at http://www.env.state.ma.us/mepa/downloads/GHG%20Policy%20FINAL.pdf.

MA EEA (2010c). Summary of the Final Revisions to the MEPA Greenhouse Gas Emissions Policy and Protocol. Published online at http://www.mass.gov/eea/docs/mepa/ghg-policy-final-summary.pdf.

MA EEA (2010d). Determination of Greenhouse Gas Emission Limit for 2020. December 28, 2010.

MA EEA (2011). Massachusetts and Offshore Wind Stakeholder Engagement. Presentation by Bill White, EEA to the American Wind Energy Association, October 13, 2011.

MA EEA (2013a). Global Warming Solutions Act of 2008 Hearing. Testimony of: Undersecretary of Environment, Phil Griffiths, Undersecretary for Energy, Barbara Kates-Garnick, Assistant Secretary for Energy, Steven Clarke. Massachusetts Senate Committee on Global Warming and Climate Change. April 22 2013: Published online at http://www.mass.gov/eea/docs/eea/gwsa/gwsa-oversight-hearing-4-22-13.pdf.

MA EEA (2013b). Green Communities Designation and Grant Program. Published online at http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities/gc-grant-program/.

MA EEA (2013c). Climate Change and Massachusetts Fish and Wildlife. Published online at http://www.mass.gov/eea/agencies/dfg/dfw/wildlife-habitat-conservation/climate-change-and-massachusetts-fish-and-wildlife.html.

MA EEA (2013d). Massachusetts Clean Energy and Climate Performance Management System. MA-CCPMS - 2.1.600 (7789a4484305). Retrieved November 13, 2013, Published online at http://partners.carboncounts.com/CarbonCounts-MA-CCPMS/.

MA EEA (2013e). Implementation Advisory Committee. Retrieved November 13, 2013, Published online at http://www.mass.gov/eea/air-water-climate-change/climate-change/massachusetts-global-warming-solutions-act/implementation-advisory-committee.html.

MA EEA (2013f). ENF Filing and Circulation Requirements. Retrieved November 13, 2013, Published online at http://www.mass.gov/eea/agencies/mepa/filing-with-mepa/enf-filing-and-circulation-requirements.html.

MA EEA (2013g). Global Warming Solutions Act Dashboard. Published online at http://www.mass.gov/eea/air-water-climate-change/climate-change/massachusetts-global-warming-solutions-act/global-warming-solutions-act-dashboard.html.

MA EEA (2013h). Tree Planting for Energy Efficiency Program, notes on progress to date Personal Communication with Celia Riechel, EEA to Abt Associates. October 11 2013.

MA EEA (2013i). Public Hearing Notice on 310 CMR 7.72. M. D. o. E. Protection: Published online at http://www.mass.gov/eea/docs/dep/service/regulations/proposed/sf6phn.pdf.

MA EEA (2013j). Patrick Administration Provides $32 Million for Clean Energy Heating and Cooling Projects. Executive Office of Energy and Environmental Affairs. October 31 2013.

MA EEA (2013k). Leading by Example: Background - State Clean Energy and Efficient Buildings. Executive Office of Energy and Environmental Affairs: Published online at http://www.mass.gov/eea/grants-and-tech-assistance/guidance-technical-assistance/leading-by-example/leading-by-example.html.

MA EEA (2013l). GHG Projects Master List with GWSA in Progress. Comminucation between Holly S Johnson and Rebecca D Fink. November 1, 2013.

MA EEA (2013m). Governors Announce Bold Initiative to Put 3.3 Million Zero-Emission Vehicles on Road by 2025. Published online at http://www.mass.gov/eea/agencies/massdep/news/releases/governors-initiative-to-put-3-3-m-zevs-on-road-by-2025.html.

MA EEA (2013n). Patrick Administration Collaborates with Other New England States on Regional Initiative for Large Hydro. June 17 2013.

MA EEA (2013o). Large Hydro and GHG Emissions: Review of Science. June 2013.

MA EEA (2013p). Draft - Appendix I. State Experiences with Reducing Carbon Pollution. October 25 2013.

MA EEA and MA Climate Change Adaptation Advisory Committee (2011). Massachusetts Climate Change Adaptation Report. Published online at http://www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf.

MA EEA and MA DOER (2012). Heating and Cooling in the Massachusetts Alternative Portfolio Standard. Report to the Massachusetts Legislature, prepared with assistance from Meister Consultants Group and MassCEC: Published online at http://images.masscec.com/uploads/attachments/Create%20Basic%20page/MA_Renewable_Heating_and_Cooling_Opportunities_and_Impacts_Study_4-4-12.pdf.

MA EEA and MA DOER (2013). Massachusetts Renewable and Alternative Energy Portfolio Standards (RPS & AP): Annual Compliance Report for 2011. April 9, 2013.

MA EEAC (2009). 2010-2012 Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Plan. Published online at http://www.ma-eeac.org/2010-2012%20Plan%20Archive.html.

MA EEAC (2010). Efficiency as our First Fuel: Strategic Investments in Massachusetts' Energy Future.

MA EEAC (2012a). Strategic Investments Yield Energy, Economic, and Environmental Benefits: The 2011 Report of the Massachusetts Energy Efficiency Advisory Council. Published online at http://www.mass.gov/eea/energy-utilities-clean-tech/energy-efficiency/eeac-2011-report-ee-advisory-council.pdf.

MA EEAC (2012b). 2013-2015 Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Plan. Published online at http://www.ma-eeac.org/Docs/4.1_Three%20Year%20Plans/2013-2015%20Plan/Exhibit%20Compact-1%20Statewide%20Electric%20and%20Gas%20Three-Year%20%20Plan%2011-2-12.pdf.

MA EEAC (2013). Massachusetts Energy Efficiency Advisory Council General Information. Published online at http://www.ma-eeac.org/General%20Information.html.

MA Executive Office for Administration and Finance (2013). Patrick-Murray Administration Announces Accelerated Energy Program. Executive Office for Administration and Finance. January 16 2013: Published online at http://www.mass.gov/anf/press-releases/fy2013/administration-announces-accelerated-energy-program.html.

Massachusetts State Governer's Office (2007). Executive Order No. 484: Leading by Example - Clean Energy and Efficient Buildings. Issued by Governor Patrick: Published online at http://www.mass.gov/governor/docs/executive-orders/leading-by-example-eo.pdf.

Massachusetts State Governer's Office (2013a). Governor Patrick Gives Remarks Celebrating 5 Years of Green Massachusetts. Issued by Governor Patrick: Published online at http://www.mass.gov/governor/pressoffice/speeches/0731-cleanenergy.html.

Massachusetts State Governer's Office (2013b). Patrick-Murray Administration Reaches 2017 Solar Energy Target, Sets New Goal. Issued by Governor Patrick. May 1 2013: Published online at http://www.mass.gov/governor/pressoffice/pressreleases/2013/0501-solar-power-goal-reached.html.

MassCEC (2010). New Bedford Port Terminal to Host Offshore Wind Assembly and Construction. October 19 2010.

MassCEC (2011). Governor Patrick Celebates Opening of Nation's First large-Scale Wind Blade Testing Facility. May 19, 2011.

MassCEC (2013a). 2013 Massachusetts Clean Energy Industry Report.

MassCEC (2013b). Governor Patrick and Lieutenant Governor Murray Break Ground on New Bedford Marine Commerce Terminal. Published online at http://www.masscec.com/news/governor-patrick-and-lieutenant-governor-murray-break-ground-new-bedford-marine-commerce.

MassCEC (2013c). Personal communication with Bill White, MassCEC and Abt Associates. November 14 2013.

MassDEP (2009). Statewide Greenhouse Gas Emissions Level: 1990 Baseline and 2020 Business As Usual Projection Published online at http://www.mass.gov/eea/docs/dep/air/climate/1990-2020-final.pdf.

MassDEP (2011). Town of Sandwich Pay-As-You-Throw (PAYT) Program. Published online at http://www.mass.gov/eea/docs/dep/recycle/reduce/m-thru-x/paytsand.pdf.

MassDEP (2012a). Final 2006-2008 Massachusetts Greenhouse Gas Emissions Inventory Published online at http://www.mass.gov/eea/docs/dep/air/climate/ghg08inf.pdf.

MassDEP (2012b). 310 CMR 7.40: U Low Emission Vehicle Program Published online at http://www.mass.gov/dep/air/laws/levregs.pdf.

MassDEP (2013a). Background Information and Technical Support Document for 310 CMR 7.72. Published online at http://www.mass.gov/eea/docs/dep/service/regulations/proposed/sf6tsd.pdf.

MassDEP (2013b). 310 CMR 7.72: Reducing Sulfur Hexaflouride Emissions from Gas-Insulated Switchgear. Published online at http://www.mass.gov/eea/docs/dep/service/regulations/proposed/sf6dreg.pdf.

MassDEP (2013c). Massachusetts 2010-2020 Solid Waste Master Plan Massachusetts Department of Environmental Protection: Published online at http://www.mass.gov/eea/agencies/massdep/recycle/reports/solid-waste-master-plan.html.

MassDEP (2013d). Massachusetts Annual Greenhouse Gas Emissions Inventory: 1990 through 2010, with Partial 2011 & 2012 Data. Published online at http://www.mass.gov/eea/docs/dep/air/climate/ghginv9012.xls.

MassDEP (2013e). MassDEP GHG Reporting Program Summary Report and Facility List Emissions Year 2012 Published online at http://www.mass.gov/eea/docs/dep/air/climate/12facghg.pdf.

MassDEP (2013f). Greenhouse Gas Reporting Frequently Asked Questions (FAQ) Version 3.1. Published online at http://www.mass.gov/eea/docs/dep/air/climate/ghgrfaq.pdf.

MassDEP (2013g). Massachusetts Electric Vehicle Inventive Program (MassEVIP) Questions & Answers. Published online at http://www.mass.gov/eea/docs/dep/air/community/massevipqa.pdf.

MassDEP (2013h). Actual and Anticipated GHG Reductions from MA Power Plant Closures.

MassDOT (2010). GreenDOT Policy Directive, P-10-002. June 2 2010.

MassDOT (2012). GreenDOT Implementation Plan. Published online at http://www.massdot.state.ma.us/Portals/0/docs/GreenDOT/finalImplementation/FinalGreenDOTImplementationPlan12.12.12.pdf.

MassGIS (2009). MassGIS Datalayers. Published online at http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/layerlist.html.

MassINC and Clean Energy States Alliance (2012). Rising to the Challenge: Assessing the Massachusetts Response to Climate Change. Published online at http://www.massinc.org/research/rising-to-the-challenge.aspx.

MassSave (2012). Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Plan: 2013-201. Report to the MA Department of Public Utilities: Published online at http://www.ma-eeac.org/Docs/4.1_Three%20Year%20Plans/2013-2015%20Plan/Exhibit%20Compact-1%20Statewide%20Electric%20and%20Gas%20Three-Year%20%20Plan%2011-2-12.pdf.

MassSave (2013). Program Administrators' Presentation to DPU on Reporting of Energy Efficiency Data. Presentation prepared for MA DPU: Published online at http://www.ma-eeac.org/Docs/6_DPU%20Proceedings%20Page/DPU%20Order%2011.120%20Reporting%20Work%20Group/PA%20DPU%2011-120%20Reporting%20Presentation%205-7-13.pdf.

Meister Consultants Group (2012). Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study. Prepared for MA DOER and MA CEC: Published online at http://images.masscec.com/uploads/attachments/Create%20Basic%20page/MA_Renewable_Heating_and_Cooling_Opportunities_and_Impacts_Study_4-4-12.pdf.

Mulkern, Anne C. (2013). "8-state pact pushes for electric vehicles, but faces roadblocks." E&E News, October 28 2013.

National Renewable Energy Laboratory (2009). US Wind Resource Map. Published online at http://windpoweringamerica.gov/pdfs/wind_maps/us_windmap.pdf.

Navigant Consulting (2008). Massachusetts Renewable Energy Potential: Final Report. Prepared for MA DOER and Massachusetts Technology Collaborative

Raab Associates Ltd. & Synapse Energy Economics Inc. (2013). DPU 12-76 --- Massachusetts Electric Grid Modernization Stakeholder Working Group Process. Final report prepared for the Massachusetts Department of Public Utilities. July 2 2013.

Reuters (2013). UPDATE 1-EquiPower to shut Brayton Point, Mass. coal power plant in 2017. Published online at http://www.reuters.com/article/2013/10/08/utilities-equipower-brayton-idUSL1N0HY1D920131008.

RGGI Inc. (2013a). Regional Greenhouse Gas Initiative: CO2 Emissions & Allowance Tracking Retrieved November 2013, 2013, Published online at http://www.rggi.org/market/tracking.

RGGI Inc. (2013b). RGGI States Propose Lowering Regional CO2 Emissions Cap 45%, Implementing a More Flexible Cost-Control Mechanism. February 7, 2012: Published online at http://www.rggi.org/docs/PressReleases/PR130207_ModelRule.pdf.

Ross, Casey (2012). "New NorthPoint project making a big splash." Boston Globe: Published online at http://www.bostonglobe.com/business/2012/09/24/education-company-new-building-near-zakim-bridge-feature-dramatic-glass-waterfall/HrMfP1ULA1PAFe7xcb2HiP/story.html?event=event12.

Stecker, Tiffany (2013). "Biofuel producers brace for major EPA changes as big lobby groups clash." E&E News, November 7, 2013: Published online at http://www.eenews.net/stories/1059990127.

Sullivan, Richard K. (2012). Certificate of the Secretary of Energy and Environmental Affairs on the Single Environmental Impact Report: EF Office Building. Published online at http://www.env.state.ma.us/mepa/mepacerts/2012/sc/pbd/14803pbd.pdf.

Synapse Energy Economics (2011). Avoided Energy Supply Cost Study. Prepared for ISO New England.

Tierney, Susan F., *et al.* (2009). "Strategic Options for Investment in Transmission in Support of Offshore Wind Development in Massachusetts. Summary Report." Analysis Group: Published online at http://www.analysisgroup.com/uploadedFiles/Publishing/Articles/Strategic_Options_Offshore_Wind_12-01-09.pdf.

Transparent Cost Database (2012). Open Energy Information (en). http://en.openei.org/wiki/Transparent_Cost_Database

Urban Land Institute (2009). Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions. Cambridge Systematics, Inc.

US Department of Commerce Bureau of Labor Statistics (2004). Housing & Transportation Affordability Index.

US Department of the Interior Bureau of Ocean Energy Management (2012). Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore Massachusetts. Published online at http://www.boem.gov/uploadedFiles/BOEM/BOEM_Newsroom/Library/Publications/2012/BOEM-2012-087.pdf.

US DOT Federal Highway Administration (2006). Highway Statistics: Table VM-2 - Functional System Travel 2008 Annual Vehicle Miles. Published online at http://www.fhwa.dot.gov/policyinformation/statistics/2011/vm2.cfm.

US EIA (2013). Annual Energy Outlook 2013: Oil/Liquids Annual Energy Outlook. Published online at http://www.eia.gov/forecasts/aeo/source_oil_all.cfm#oil_price.

US EPA (2011a). EPA and NHTSA Adopt First-Ever Program to Reduce Greenhouse Gas Emissions and Improve Fuel Efficiency of Medium- and Heavy-Duty Vehicles. Published online at http://www.epa.gov/otaq/climate/documents/420f11031.pdf.

US EPA (2013a, September 1, 2013). Summary 2011 GHG Data. Retrieved November 13, 2013, Published online at http://www.epa.gov/ghgreporting/documents/xls/ghgp_data_2011_09012013_FINAL.xlsx.

US EPA (2013b). Renewable Fuel Standard (RFS). Retrieved 11/1/2013, 2013, Published online at http://www.epa.gov/OTAQ/fuels/renewablefuels/index.htm.

US EPA, Office of Transportation and Air Quality (2011b). Regulatory Announcement: EPA and NHTSA Adopt First-Ever Program to Reduce Greenhouse Gas Emissions and Improve Fuel Efficiency of Medium-and Heavy-Duty Vehicles. EPA-420-F-11-031. August 2011: Published online at http://www.epa.gov/otaq/climate/documents/420f11031.pdf.