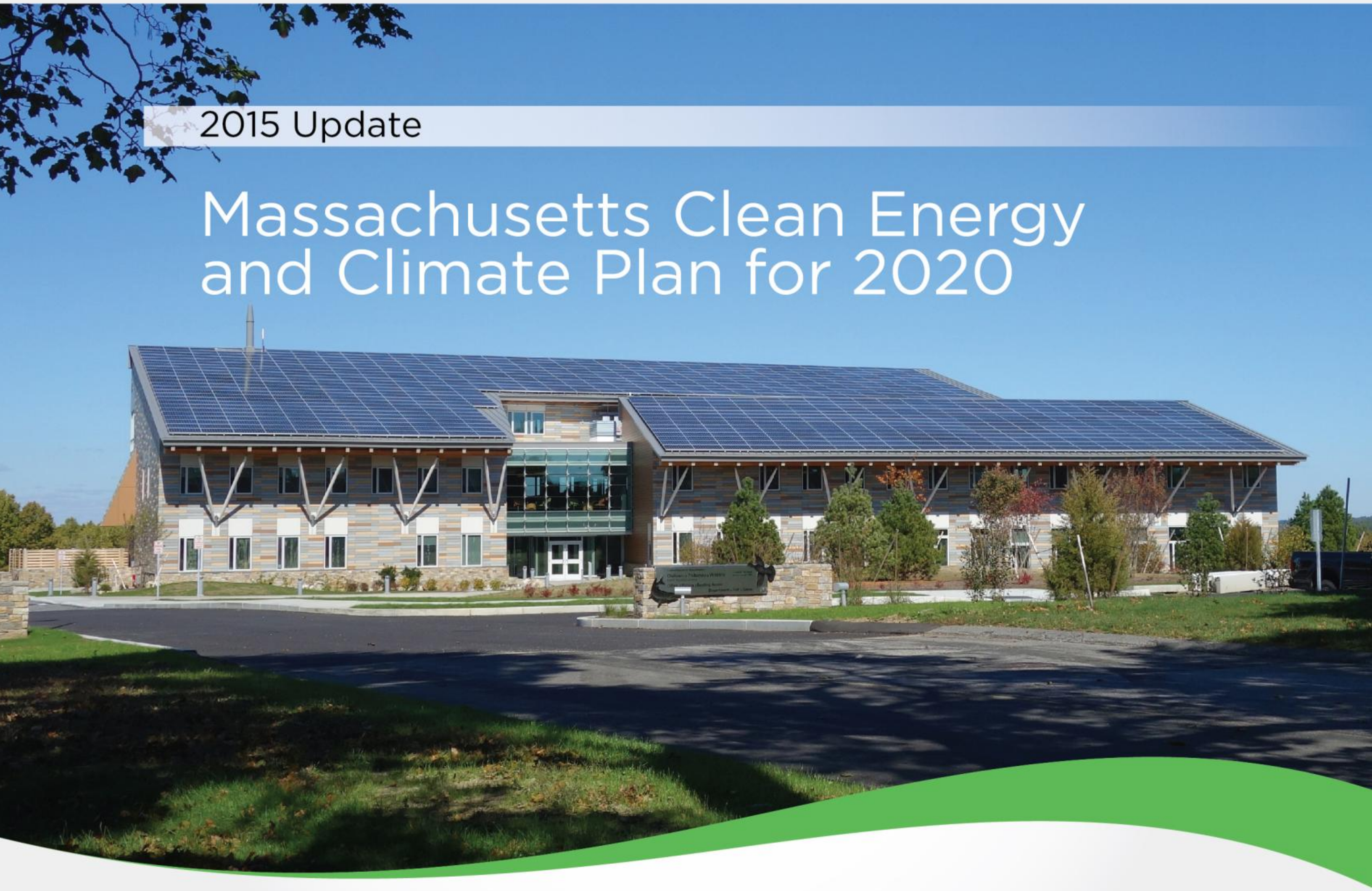
2015 Update

Massachusetts Clean Energy and Climate Plan for 2020



A report to the Great and General Court pursuant to the Global Warming Solutions Act
(Chapter 298 of the Acts of 2008, and as codified at M.G.L. c. 21N)

Secretary of Energy and Environmental Affairs Matthew A. Beaton

December 31, 2015

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Letter from the Secretary

I am pleased to release the Executive Office of Energy and Environmental Affairs' (EEA) 2015 update to the Massachusetts Clean Energy and Climate Plan for 2020 ("CECP Update"), as required by the Global Warming Solutions Act of 2008 (GWSA). Massachusetts remains a nationally recognized leader in combating climate change, and the CECP Update presents the policies upon which the Baker-Polito Administration will rely to ensure that the Commonwealth is positioned to meet the emissions reductions goals of the GWSA.

Consistent with the priorities of the Baker-Polito Administration, the CECP Update emphasizes initiatives that address energy challenges that face residents and businesses across Massachusetts. The analysis within this report indicates that a greenhouse gas (GHG) emissions reduction of at least 25% by 2020 is attainable, and reaching this goal requires consistent effort and collaboration across all sectors. Full implementation of this CECP Update will set the Commonwealth on course for a sustained, vibrant state economy with environmentally responsible economic growth for decades to come.

This CECP Update identifies policies necessary to achieve these goals, and going forward these policies will continue to evolve as we determine the strategies that best reduce greenhouse gas emissions for our immediate and long term targets. This CECP Update identifies two policies in particular that when fully implemented will result in immediate and substantial benefits: the import of cost-effective, low-carbon hydroelectric power generation and Class-1 renewable resources; and vehicle GHG emissions standards. Each policy is expected to contribute significant GHG emission reductions toward closing the gap between current emissions and the 2020 emission target. Additionally, energy efficiency investments remain critically important, as their primary impact is avoiding increases in electric demand that would otherwise have occurred, rather than reducing emissions from current levels.

Continued dialogue amongst stakeholders, advocates and lawmakers, coupled with the institution of policies that achieve incremental benefits over time, is vital to the Commonwealth's ability to reach our 2050 emission reduction goal. The *Massachusetts Clean Energy and Climate Plan for 2020* will serve as a valuable resource, and I look forward to working together to continue our aggressive efforts to meet the goals of the Global Warming Solutions Act.

Sincerely,

Matthew A. Beaton,
Secretary of Energy and Environmental Affairs

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Chapter 1: OVERVIEW

The Global Warming Solutions Act of 2008[1] (GWSA) requires the Executive Office of Energy and Environmental Affairs (EEA) to update its plan for reducing greenhouse gas (GHG) emissions once every five years. This 2015 update to the *Massachusetts Clean Energy and Climate Plan for 2020* ("CECP Update") addresses that requirement by describing policies that the Baker-Polito Administration will rely on to ensure that emission reductions required by the GWSA are achieved by 2020. Taken together, these policies provide a comprehensive strategy that addresses nearly all sources of GHG emissions in the Commonwealth.

Consistent with administration priorities, the CECP Update emphasizes policies that address energy costs across all sectors of the economy, particularly through the more efficient use of fuels in vehicles and buildings, and the delivery of additional clean electricity to consumers in Massachusetts. This updated plan focuses on the near-term requirement for emission reductions by 2020 as required by the GWSA. While focused on 2020, the CECP Update also looks forward toward 2050 when the GWSA requires that GHG emissions be reduced by at least 80% compared to the 1990 baseline emissions level. Policies that require state action now to ensure a reasonable likelihood of meeting our 2050 commitment include urban tree planting and retention, smart growth strategies, electric vehicle market development, and renewable thermal sector development. Full implementation of this CECP Update will set the Commonwealth on course for a vibrant state economy with environmentally responsible economic growth for decades to come.

This CECP Update begins with an overview chapter that includes background information and GHG emissions data, analytical results showing that the policies in this CECP Update will reduce emissions to at least 25% below the 1990 level by 2020 if fully implemented, and shorter sections on long term planning, economic impacts, and next steps. Specific emission reduction policies are introduced in the next chapter, and described in detail in an appendix. The third chapter discusses recent research and analyses conducted by EEA's consultants on Massachusetts land use GHG emissions and carbon storage for potential future policies. The final chapter includes additional discussion of policies that will deliver increasing amounts of GHG reductions over the 2020–2030 time frame and beyond.

1.1 Background

The GWSA provides a comprehensive framework that requires state agencies to develop and implement plans to reduce GHG emissions in Massachusetts. The following timeline lists past key implementation milestones:

- **2009:** The Department of Environmental Protection (MassDEP) published a statewide estimate of GHG emissions, including a determination that emissions in 1990 were 94.4

[1] Codified at M.G.L c. 21N.

million metric tons of carbon dioxide equivalent ($MMTCO_2e$). The publication included the most recent emissions data available at the time, and has been regularly revised by MassDEP to include the most recently available information.[2] Consistent with United Nations Framework Convention on Climate Change reporting protocols, emissions from the combustion of biomass and biofuels—including ethanol—are tracked separately from fossil fuels in MassDEP's GHG inventory, and are not included in these totals.

- **2010:** The EEA determined that the emission limit for 2020 would be 25% below 1990 emissions, and published the Massachusetts Clean Energy and Climate Plan for 2020 ("original CECP"). The original CECP includes an extensive menu of policies that limit GHG emissions, covering all significant categories of emission sources in Massachusetts.[3]

- **2013:** The EEA published a GWSA progress report 5 years after the promulgation of the GWSA, as required in that statute. This report identified a gap between projected 2020 emissions and the 2020 emission limit, and suggested energy efficiency and the identification of new clean electricity sources as policies that could deliver additional reductions by 2020.[4]

- **2015:** MassDEP published an updated 1990 GHG Emissions Baseline and 2020 Business as Usual (BAU) Projection for public comment, including complete emissions data from 1990 through 2012, and partial data for 2013.[5] The estimate of 1990 emissions was revised slightly to 94.5 $MMTCO_2e$. The most recent complete annual inventory data for 2012 show that Massachusetts GHG emissions dropped almost 24% below the 1990 emissions level in 2012, due to mild weather and associated lower energy use. Partial data available for 2013 indicate a reduction level greater than the 17% seen in 2011, although complete 2013 data will not be available until early 2016. MassDEP's GHG inventory data suggest that the 2020 emission limit is achievable as discussed in later sections.

1.1.1 Massachusetts Greenhouse Gas (GHG) Inventory

The GWSA established the Climate Protection and Green Economy Act in Massachusetts General Law, which requires MassDEP to, among other actions *"… triennially publish a state greenhouse gas emissions inventory that includes comprehensive estimates of the quantity of*

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[2] Available at http://www.mass.gov/eea/agencies/massdep/climate-energy/climate/ghg/greenhouse-gas-ghg-emissions-in-massachusetts.html.

[3] See http://www.mass.gov/eea/waste-mgnt-recycling/air-quality/climate-change-adaptation/mass-clean-energy-and-climate-plan.html.

[4] Available, along with additional data on GWSA implementation, at http://www.mass.gov/eea/air-water-climate-change/climate-change/massachusetts-global-warming-solutions-act/.

[5] *Statewide Greenhouse Gas Emissions Level: 1990 Baseline and 2020 Business As Usual (BAU) Projection Update*, at http://www.mass.gov/eea/agencies/massdep/news/comment/ghg-emissions-update.html

greenhouse gas emissions in the commonwealth for the last 3 years in which the data is available," and "…*determine the statewide greenhouse gas emissions level in calendar year 1990 and reasonably project what the emissions level will be in calendar year 2020 if no measures are imposed to lower emissions other than those formally adopted and implemented as of January 1, 2009.*" [MGL chapter 21N, section 2, subsection (c) and section 3, subsection (a)].

Section 14 of the GWSA further required MassDEP to establish the 1990 GHG Emissions Baseline and 2020 BAU Projection by July 1, 2009. The *Statewide Greenhouse Gas Emissions Level: 1990 Baseline and 2020 Business as Usual Projection* (July 1, 2009) was published as required.[6] Because significant new data became available, MassDEP published the *Statewide Greenhouse Gas Emissions Level: 1990 Baseline and 2020 Business As Usual Projection Update* in November 2015.[7] The updated 1990 Baseline/2020 BAU Projection contains a complete GHG emissions inventory through the year 2012, with partial emissions for 2013, using updated data sources, methodologies, emission factors, and global warming potentials (GWPs).[8] The following overview draws on MassDEP's November 2015 inventory.

Greenhouse gas emissions in Massachusetts decreased by 22 $MMTCO_2e$ between 1990 and 2012. The GHG emissions were 94.5 $MMTCO_2e$ in 1990, peaked at 96 $MMTCO_2e$ in 1997 and 2005, and then fell to 72 $MMTCO_2e$ by 2012.[9] The overall result is a 24% reduction in GHG emissions between 1990 and 2012, with the majority of the reductions coming from reductions in fuel combustion emissions. The GHG emissions in 2013 were higher than in 2012, but complete data are not yet available for 2013, thus the 2013 data point in Figure 1 is tentative.

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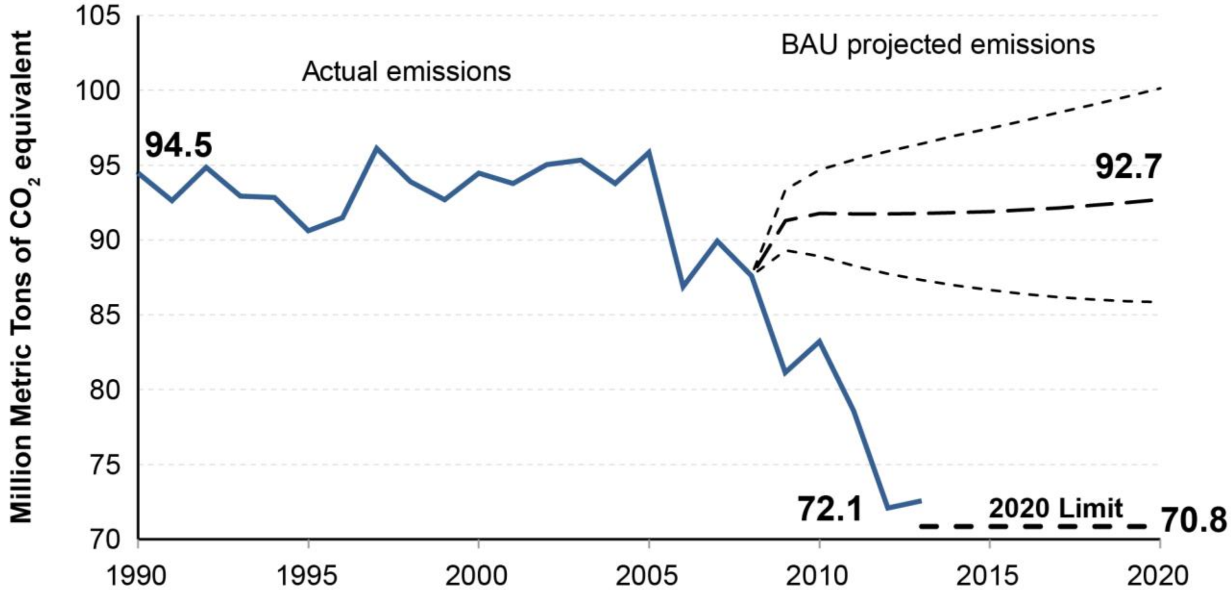
[6] http://www.mass.gov/eea/agencies/massdep/climate-energy/climate/ghg/greenhouse-gas-ghg-emissions-in-massachusetts.html#2

[7] For background on the Massachusetts GHG emissions inventory, including methodologies, see *Statewide Greenhouse Gas Emissions Level: 1990 Baseline and 2020 Business As Usual Projection Update*, November 2015, at http://www.mass.gov/eea/docs/dep/air/climate/gwsa-update-15.pdf and accompanying spreadsheets, particularly http://www.mass.gov/eea/docs/dep/air/climate/gwsa-appc.xls.

[8] Not all GHGs have the same heat-trapping capacity. To account for these differences, a standard, known as the global warming potential (GWP), relating the heat trapping potential of each GHG to an equivalent quantity of CO_2 over a 100-year time horizon, has been developed by the Intergovernmental Panel on Climate Change (IPCC). Emissions shown in this document utilize the standard published in 2007 in the IPCC's Fourth Assessment Report (AR4), and are expressed in units of million metric tons of carbon dioxide equivalents ($MMTCO_2e$). Carbon dioxide (CO_2) is defined as having a GWP of 1, while the other GHGs have the following GWPs: CH_4 (25), N_2O (298), SF_6 (22,800), and HFCs and PFCs (ranging from 124 to 17,700).

Updated Massachusetts Baseline and Business as Usual (BAU) Projection of GHG emissions 1990–2020 based on AR4 GWPs, with historical emissions for 1990–2012 and partial emissions for 2013

Figure 1



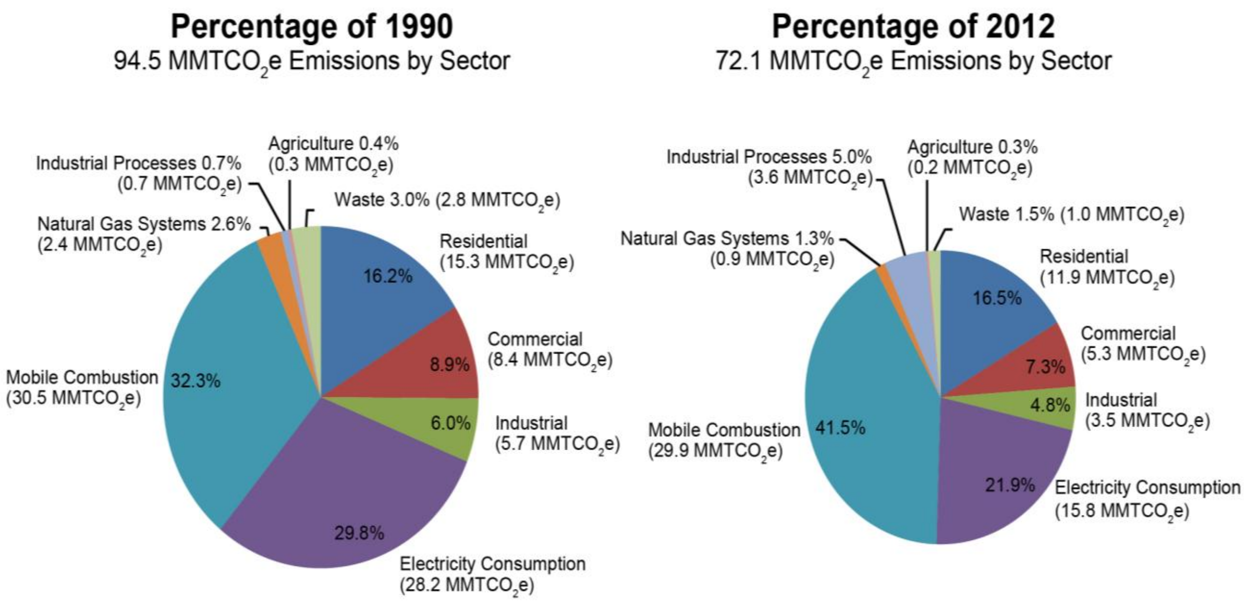
Source: MassDEP (2015).

A review of Massachusetts GHG emissions by sector (Figure 2) shows that the division between fuel combustion emissions (from 93% in 1990 to 92% in 2012) and non-energy emissions[10] (from 7% in 1990 to 8% in 2012) remains fairly stable. Within the fuel combustion sectors, the most noticeable shift in GHG emissions occurs with the decrease of the electricity consumption emissions (from 30% in 1990 to 22% in 2012) and the increase of mobile combustion emissions (from 32% in 1990 to 42% in 2012). For non-combustion sectors, the largest changes are due to the decrease of the natural gas system GHG emissions (from 3% in 1990 to 1% in 2012) and the increase of industrial processes emissions (from <1% in 1990 to 5% in 2012).

[10] Fuel combustion emissions are GHG emissions from the combustion of fossil fuel in the residential, commercial, industrial, and transportation sectors, as well as from electricity consumptions. Non-energy emissions (also referred to as non-combustion emissions) are non-CO_2 GHG emissions from natural gas systems (via pipeline leaks), industrial processes, agriculture, and waste management.

Figure 2

Massachusetts GHG emissions by sector in 1990 and 2012

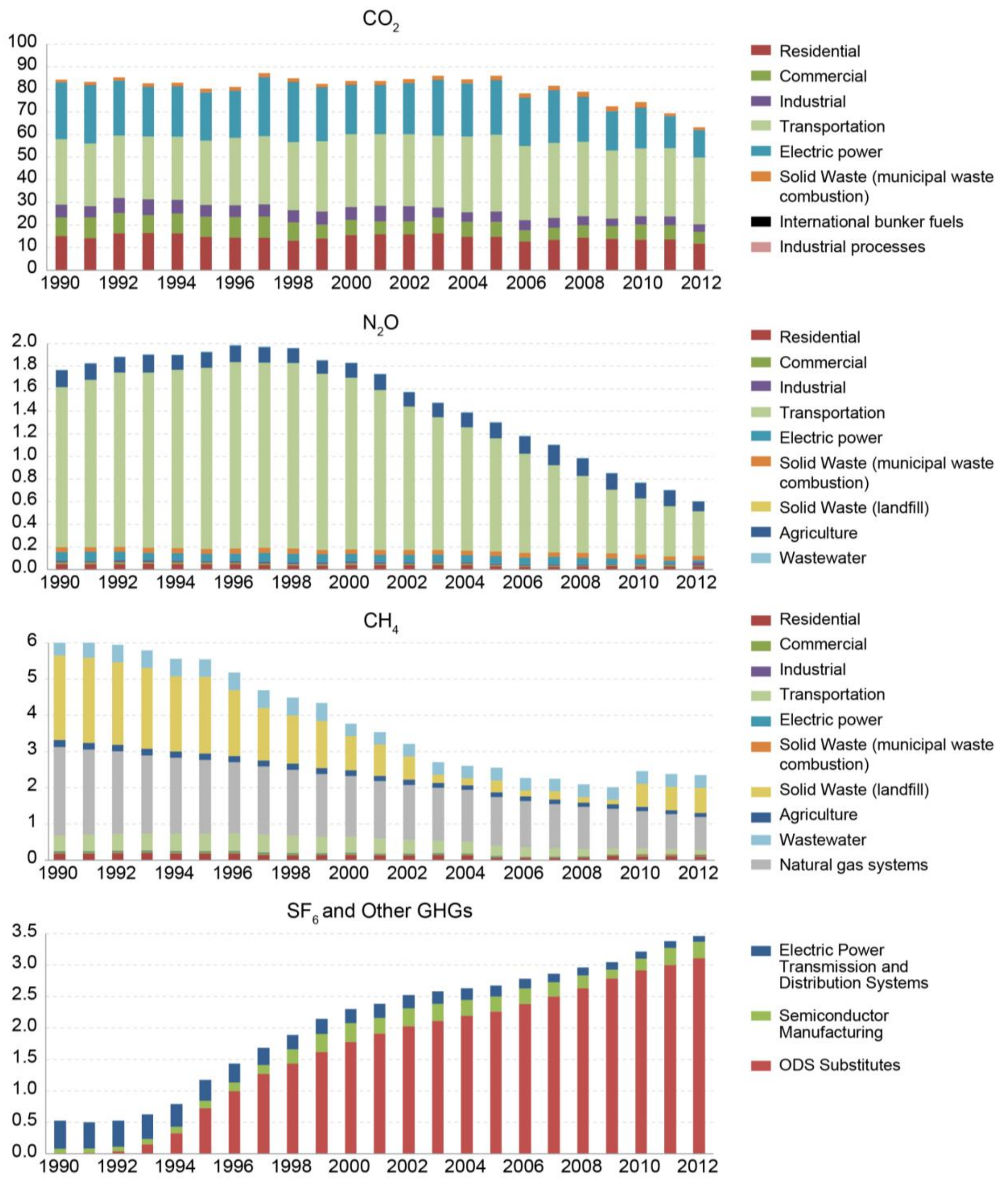


Source: MassDEP (2015).

With respect to GHG emissions from the individual gases that contribute to total GHG emissions (see Figure 3), there were reductions in carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) between 1990 and 2012, and increases in sulfur hexafluoride (SF_6) and the other GHGs (hydrofluorocarbons (HFC) and perfluorocarbons (PFC)). Carbon dioxide emissions decreased by 21 MMTCO_2e (or 25%) with most of the reduction in the electric sector. Methane emissions decreased by 4 MMTCO_2e (or 62%) due to decreases in natural gas systems and waste emissions (see below for discussion of emissions from the waste sector). Nitrous oxide emissions dropped 1 MMTCO_2e (or 66%), with the decrease almost entirely from the transportation sector. While SF_6 emissions from the electric power transmission and distribution system decreased, SF_6 and the other GHG emissions increased overall by 3 MMTCO_2e (or 557%) primarily due to leakage of HFC refrigerants (known as ozone depleting substance (ODS) substitutes).

Massachusetts emissions ($MMTCO_2e$) of individual GHGs over time

Figure 3

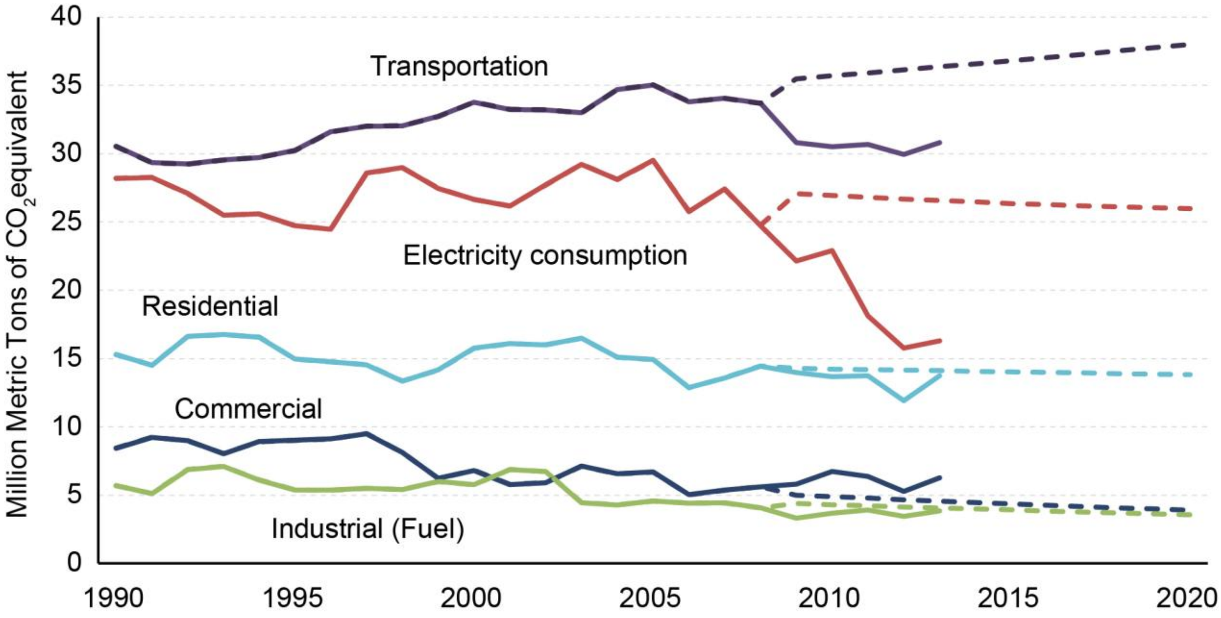


Source: MassDEP (2015).

The GHG emissions from all fuel combustion sectors (transportation, electricity, residential and industrial) peaked between 1990 and 2005, and then decreased to levels at or below emissions in 1990 by 2012 (Figure 4). The electricity sector showed the greatest decrease (14 $MMTCO_2e$), dropping approximately 50% from a high in 2005 of 30 $MMTCO_2e$ to a low of 16 $MMTCO_2e$ in 2012. Almost all the other fuel combustion sectors decreased emissions by 5 $MMTCO_2e$ between their peak year and 2012:

- Transportation from a high of 35 $MMTCO_2e$ in 2005 back to early 1990s level of 30 $MMTCO_2e$ in 2012,
- Residential from almost 17 $MMTCO_2e$ in 1993 to 12 $MMTCO_2e$ in 2012, and
- Commercial from almost 10 $MMTCO_2e$ in 1997 to 5 $MMTCO_2e$ by 2012.
- Industrial fuel combustion sector peaked at 7 $MMTCO_2e$ in 1993 and dropped to 3.5 $MMTCO_2e$ in 2012.

Updated Massachusetts Baseline and BAU Projection of fuel combustion GHG emissions 1990–2020 by sector based on AR4 GWPs — Figure **4**



Source: MassDEP (2015).

Updated Massachusetts Baseline and BAU Projection of non-fuel combustion GHG emissions 1990–2020 by sector based on AR4 GWPs

Figure
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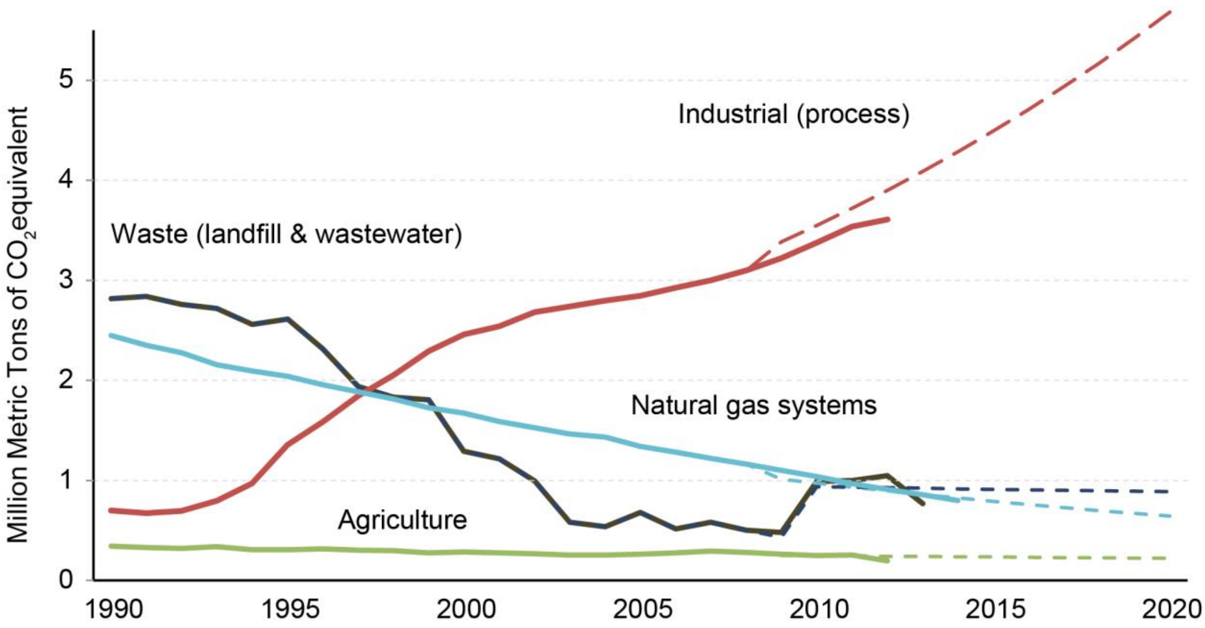

Source: MassDEP (2015).

Trends in the non-energy sector are less consistent and are occasionally victim to poor historic data (Figure 5). The natural gas systems and waste sectors show decreases in GHG emissions since 1990. Natural gas systems emissions show a drop of 1.5 $MMTCO_2e$, decreasing steadily from 2.4 $MMTCO_2e$ in 1990 to 0.9 $MMTCO_2e$ in 2012. The waste sector (comprised of emissions from landfills and wastewater) emitted 2.8 $MMTCO_2e$ in 1990, dropping to approximately 0.5 $MMTCO_2e$ between 2004 and 2009 because of landfill data issues, and then held steady at 1 $MMTCO_2e$ beginning with 2010 due to methodology revisions for emissions from landfills.[11] Industrial processes are the Commonwealth's only increasing emissions sector, with refrigerants causing most of the rise from 0.7 $MMTCO_2e$ in 1990 to 3.6 $MMTCO_2e$ in 2012. It is important to note, however, that refrigerant emissions are expected to decrease in the future (see the *Stationary Equipment Refrigerant Management* policy in the appendix for details). Emissions from agriculture, Massachusetts' smallest GHG emissions sector, remained constant at 0.3 $MMTCO_2e$.

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[11] See discussion on pages 15-16 of *Statewide Greenhouse Gas Emissions Level: 1990 Baseline and 2020 Business As Usual Projection Update*, November 2015, at http://www.mass.gov/eea/docs/dep/air/climate/gwsa-update-15.pdf.

1.1.2 Synthesizing GHG Emission Trends in Massachusetts

Table 1 provides additional information about GHG emissions in recent years, as compared to 1990. Estimated 2013 emissions were determined using data included in MassDEP's published GHG inventory referenced in Section 1.1.1, with data gaps filled by carrying forward 2012 data. Emission data for 2014 and 2015 are not yet available. Table 1 also includes annual GHG reductions compared to 1990 gross emissions. To facilitate analysis, categories of emission sources are identified, as are key drivers of observed changes in emissions since 1990.

Historical GHG emissions ($MMTCO_2e$) by sector

Table 1

	1990	2010	2011	2012	2013	Drivers of observed changes
Buildings	29.4	24.1	24.0	20.6	23.9	Weather, efficiency, fuel switching
Transportation	30.5	30.5	30.7	29.9	*31.2*	Gas prices, vehicle miles/gallon
Electricity	28.2	22.9	18.1	15.8	16.3	Efficiency, fuel switching
Other [A]	6.3	5.7	5.8	5.8	*5.6*	
Total	**94.5**	**83.2**	**78.6**	**72.1**	***76.9***	
Reduction (% of 1990 level)	**0%**	**12%**	**17%**	**24%**	***19%***	

[A] "Other" includes natural gas systems, industrial processes, agriculture, and waste.
Italicized 2013 values are estimated.

A key conclusion that can be drawn from Table 1 is that, to date, the dominant source of emission reductions came from the electric sector. A significant shift from oil and coal to natural gas as a fuel for power generation accounts for a net reduction of approximately 12 $MMTCO_2e$ since 1990, as reflected in MassDEP's GHG inventory.[12] Driven in part by energy efficiency investments, electric demand has not grown significantly in recent years, removing load growth as a driver of increased emissions. Emissions from fuel combustion in buildings have also fallen moderately since 1990, largely due to improvements in the efficiency of fuel use and the substitution of natural gas for oil in space heating. Recent year to year variability is largely attributable to weather, as 2012 was a particularly mild year.

[12] Emissions from coal and oil combustion at power plants in Massachusetts fell by nearly 18 $MMTCO_2e$ between 1990 and 2013. This has been partially offset by an increase of approximately 6 $MMTCO_2e$ from natural gas fired generators in Massachusetts and from electricity imports.

While some improvements in vehicle efficiency were realized since 1990, increases in the amount of driving offset these gains, such that transportation is the only fuel combustion sector to realize increases in emissions since 1990. Additional detail on past emissions is available in MassDEP's GHG emissions inventory description in Section 1.1.1.

1.2 Getting to 25% GHG Emission Reduction in 2020

1.2.1 Overview

As discussed in Section 1.1.2, GHG emissions are currently well below the 1990 level, and the 2020 emission limit appears to be within reach. To prepare this CECP Update, EEA collaborated with participating state agencies to complete a thorough review of policies that have the potential to deliver GHG reductions by 2020. Measured in terms of the absolute amount of reductions expected to occur between 2015 and 2020, the two most significant drivers are vehicle GHG emissions standards and additional clean electricity, each of which is expected to contribute emission reductions of several $MMTCO_2e$ toward closing the gap between current emissions and the 2020 emission limit. The impact of energy efficiency investments is similar in scale, but less visible as their primary impact is in avoiding electric load growth that would otherwise have occurred, rather than reducing emissions from current levels. This CECP Update relies on key policies that are designed to ensure that these reductions are realized, and also includes contributions from a comprehensive list of policies that cover nearly all sources of emissions in Massachusetts.

The analytical approach to developing this CECP Update was rigorous. A core team of agency experts, with contractor support, worked for more than a year to complete a comprehensive review of existing and prospective policies and their potential to reduce GHG emissions. Three lines of analysis were used to project 2020 emissions, assuming that the policies in this CECP Update are fully implemented:

- First, a review of recent emission trends was combined with rough estimates of effects of key policies mentioned above (vehicle GHG standards and new clean electricity) to develop a range of potential emissions for 2020.

- Second, a detailed quantitative review of all policies was completed to estimate expected emission reductions across the economy.

- Third, a widely-used energy planning platform was used to assemble a projection of 2020 emissions across all sectors of the economy.

The results of these efforts support the conclusion that if the policies included in this CECP Update are fully implemented by 2020, emissions should be at least 25% below the 1990 level in 2020. Additional information about the full implementation of these policies is provided in the next three sections.

1.2.2 Policy-Based Assessment

Determining whether the policies listed in this CECP Update will achieve the required emission reductions necessitates a quantitative estimate of the contribution of each policy. Estimated GHG reductions in 2020 from the full implementation of all policies will likely total 25.0 $MMTCO_2e$, or 26.4% of 1990 gross GHG emissions (Table 2). However, the amount of reductions attributable to policies may be over-estimated to some degree. For example, future obstacles could impede the implementation of a policy (e.g., failure to pass enabling legislation), or assumptions used to estimate reductions could prove to be overly optimistic (e.g., emission factors).

In addition to estimating GHG reductions from policy implementation, it is also necessary to account for changes in GHG emissions since 1990 that are not addressed by policies, such as fuel switching from oil in the building and electricity sectors. Comparison of 1990 emissions to a plausible “business as usual” estimate of 2020 emissions shows that GHG reductions not attributable to the CECP Update policies could amount to an additional 2.5 $MMTCO_2e$ reduction, or 2.6% of 1990 emissions. However, the amount of GHG reductions caused by factors such as the weather, relative fuel prices, and economic growth is highly uncertain.

The impact of uncertainties in future policy implementation and non-policy factors (i.e. weather, relative fuel prices, and economic growth) is impossible to quantify precisely, but could easily amount to several $MMTCO_2e$[13] or more. Therefore, full implementation of the policies included in this CECP Update is necessary to ensure that the 2020 emission limit is achieved. A review of Table 2 suggests that a particular focus on the *Clean Energy Imports* policy is appropriate, given the amount of reductions anticipated from this policy and the fact that new legislation (or new regulation like the *Clean Energy Standard*) is required for implementation. Without this policy, there is a significant risk that the total amount of reductions realized in 2020 will be less than 25%, compared to the 1990 emissions.

[13] Because MA GHG emissions in 1990 were 94.5 $MMTCO_2e$, 1 $MMTCO_2e$ is roughly 1% of 1990 levels.

List of Policies and Reductions Anticipated in 2020 [A]

Table 2

	$MMTCO_2e$	% of 1990 level
Building Fuels and Energy Efficiency	**9.0**	**9.5%**
All Cost Effective Energy Efficiency	5.4	5.8%
Advanced Building Energy Codes	1.5	1.6%
Building Energy Rating and Labeling	—	—
Expanding Energy Efficiency Programs to Commercial and Industrial Heating Oil	<<0.1	<<0.1%
Appliance and Product Standards	1.0	1.1%
Developing a Mature Market for Renewable Thermal Technologies	1.0	1.1%
Tree Retention and Planting to Reduce Heating and Cooling Loads	<<0.1	<<0.1%
Transportation, Land Use, and Smart Growth	**5.7**	**6.1%**
Federal and California Vehicle Efficiency and GHG Standards (CAFE/Pavley)	3.7	3.9%
Federal Emissions and Fuel Efficiency Standards for Medium and Heavy Duty Vehicles	0.4	0.4%
Federal Renewable Fuel Standard (RFS) and Regional Clean Fuel Standard (CFS)	0.1	0.1%
Clean/Electric Vehicle Incentives	0.1	0.1%
GreenDOT	1.0	1.1%
Smart Growth	0.4	0.4%
Electricity Generation and Distribution	**7.8**	**8.2%**
Coal-Fired Power Plant Retirements	2.7	2.9%
Renewable Portfolio Standard (RPS)	1.1	1.1%
Clean Energy Imports	4.0	4.2%
Clean Energy Standard (CES)	—	—
Regional Greenhouse Gas Initiative (RGGI)	—	—
Electric Grid Modernization	—	—
Non-Energy Emissions	**2.5**	**2.6%**
Reducing GHG Emissions from Plastics Combustion	0.3	0.3%
Stationary Equipment Refrigerant Management	0.1	0.1%
Reducing SF_6 Emissions from Gas-Insulated Switchgear	0.4	0.4%
Reducing Emissions from the Natural Gas Distribution Network	1.7	1.8%
Cross-Sector Policies	**—**	**—**
MEPA GHG Policy and Protocol	—	—
Leading By Example	—	—
Green Communities	—	—
Consideration of GHG Emissions in State Permitting, Licensing and Administrative Approvals	—	—
Total of Reductions Attributable to Policies Assuming Full Implementation	**25.0**	**26.4%**
Other Changes Not Attributable to Policies (Since 1990)	**2.5**	**2.6%**
Total Estimated Reductions from Full Policy Implementation	**27.5**	**29.1%**

[A] For some policies, GHG reductions are shown as <<0.1 $MMTCO_2e$ because no significant reductions are expected by 2020. Cross-cutting policies have GHG reductions represented by a dash (—) because the reductions are counted in other policies. Additional information on these policies is available in Chapter 2 and the appendix.

An energy sector accounting tool was used, with contractor support, to represent projected GHG emissions from all emission sources in Massachusetts in 2020, consistent with the policy-based assessment described above. A particular purpose of this step was to analyze cross-sector relationships, such as the impact of increased use of electric vehicles on electricity sector emissions. The results of this exercise support the conclusion that the policies will reduce emissions by more than 25%, relative to the 1990 level.

1.2.3 Sector-Based Assessment

To support the projection that the policies in this CECP Update will reduce emissions as required, recent GHG emissions inventory data were also reviewed, along with factors that are most likely to drive change between 2015 and 2020. Table 3 illustrates this approach, and shows a range of plausible outcomes. Discussion of each sector appears below Table 3, along with a projection of a likely outcome that emissions will be reduced by 25% in 2020, relative to 1990, if policies in this CECP Update are fully implemented. Importantly, this section includes discussion of a high emissions scenario in which the 2020 emission limit is not achieved. While meeting the 2020 emission limit appears likely, this scenario shows the importance of fully implementing all of the policies included in this CECP Update to ensure the 25% reduction against the 1990 level by 2020.

Historical and 2020 projected GHG emissions (MMTCO$_2$e) by sector

Table 3

	1990	2010	2011	2012	2013	2020 Estimate	Key drivers
Buildings	29.4	24.1	24.0	20.6	23.9	*20–24*	Varies with weather
Transportation	30.5	30.5	30.7	29.9	*31.2*	*29–32*	Vehicle GHG standards
Electricity	28.2	22.9	18.1	15.8	16.3	*11–14*	New clean imports
Other [A]	6.3	5.7	5.8	5.8	*5.6*	*6*	
Total	**94.5**	**83.2**	**78.6**	**72.1**	***76.9***	***66–76***	
Reduction (% of 1990 level)	**0%**	**12%**	**17%**	**24%**	***19%***	***20–30%***	

[A] "Other" includes natural gas systems, industrial processes, agriculture, and waste. Italicized 2013 values are estimated.

For each sector, the following information was considered:

- **Buildings** – The predominant source of direct[14] emissions from buildings is the combustion of fuels for space heating, so emissions are significantly affected by weather, as illustrated in the variability observed in recent years. Fuel prices can also have significant impacts. Therefore, emissions from this sector are difficult to forecast with any precision. However, because of the long-term trend toward substitution of natural gas for oil, and a suite of policies that reduce fuel demand in buildings and encourage the deployment of renewable thermal technologies, moderate emission reductions from this sector are likely by 2020 with greater gains expected post-2020. Therefore, accounting for these trends and recent observed variability, 20–24 $MMTCO_2e$ appears to be a robust range for 2020, with 22 $MMTCO_2e$ representing a reasonable central estimate.

- **Transportation** – Passenger vehicles are the dominant source of emissions from the transportation sector, with significant contributions also coming from diesel trucks and aviation. Emissions from fuel combustion are determined by the efficiency and usage of vehicles (as measured in "vehicle miles traveled," or "VMT"), and characteristics of fuels. Between 2015 and 2020, significant improvements in vehicle efficiency will occur as the stringency of vehicle GHG standards increases. Analysis completed by contractors to support this CECP Update projects reductions in the range of 3–4 $MMTCO_2e$ from fuel use in vehicles in Massachusetts between 2013 and 2020, driven by increases in vehicle efficiency. Other policies will have positive impacts by supporting the use of alternative transportation modes (such as transit and walking) and fuel switching (to electricity and possibly advanced low carbon biofuels). However, recognizing the historic increase in VMT from 1990 to 2013 of 22%, it remains possible that an increase in VMT will offset some or all of these benefits. Therefore, accounting for these trends and recent emission data, 29–32 $MMTCO_2e$ appears to be a robust range for 2020, with 30 $MMTCO_2e$ representing a reasonable central estimate.

- **Electricity** – Changes in electric sector emissions between 2015 and 2020 will be determined by a number of discrete factors, each of which is reasonably well understood. Consistent with recent trends, EEA anticipates that energy efficiency investments will fully offset increasing demand for electricity in homes and businesses. The loss of the Commonwealth's only nuclear power plant, and largest non-emitting electricity generation source, will present a significant challenge, reversing some of the gains achieved by replacing coal-fired electric generation with lower emitting, more efficient gas-fired generation. However, new supplies of clean electricity, such as RPS-eligible renewables and hydropower, will help if fully implemented before 2020. Analyses by EEA suggest that, taken together, net reductions of as much as 5 $MMTCO_2e$ by 2020 are possible. The *Clean Energy Imports* policy contributes approximately 17% of the

[14] Indirect emissions from electric generation are the largest source of building emissions, but are addressed in the electric sector.

overall 25% reduction goal (or 4.2% of the emissions in 1990) if fully implemented before 2020. Other risks to fully realizing these emission reductions include: non-compliance with the RPS program, inadequate transmission infrastructure development, extreme weather increasing electricity demand, or increased oil use for power generation in 2020 as a result of constraints on the gas system or other factors. Therefore, assuming successful implementation of the *Clean Energy Imports* policy, 11–14 $MMTCO_2e$ appears to be a robust range for 2020, with 12 $MMTCO_2e$ representing a reasonable central estimate.

- **Non-Energy** – Changes in non-energy emissions between 2015 and 2020 are not expected to be significant compared to changes in other sectors, so 6 $MMTCO_2e$ appears to be a reasonable estimate for 2020 emissions. Additional information about non-energy emissions is included in Section 1.1.1 of this CECP Update.

The sector-based approach suggests that, assuming the key policies discussed above are fully implemented, a reasonable central estimate of GHG emissions in 2020 is 70 (22 + 30 + 12 + 6) $MMTCO_2e$, which represents a 26% reduction relative to 1990 emissions.

1.3 Beyond 2020

The GWSA includes a long term goal of reducing emissions by at least 80%, relative to the 1990 baseline level, by 2050. It also requires EEA to set specific emission limits for 2030, 2040, and 2050. To maintain consistent progress toward the GWSA goal for 2050, it is particularly important to set a 2030 emission limit and finalize a plan for meeting that limit by the end of 2020. Populating the energy sector accounting tool that was mentioned in Section 1.2 with draft projections for 2030 and 2050 supports this effort. Over the coming years, EEA will refine these projections, including multiple scenarios, to determine how best to address GWSA requirements for 2030. A critical part of this work is identifying policies that are important for achieving the 2050 emission limit, because they have the potential to compound over time. Examples of such policies include:

- ***Clean Energy Imports*** **–** Additional clean energy imports are necessary to complement the existing RPS program, particularly as electrification of the vehicle and space heating sectors is expected to result in increased electricity demand.

- ***Advanced Building Energy Codes*** **–** The long lifespan of buildings means that the emissions profile in this sector is slow to change. Energy efficiency in new construction is the most cost effective way for the buildings sector to reduce emissions between 2015 and 2050.

- ***Federal and California Vehicle Efficiency and GHG Standards*** **–** Standards are in place to increase vehicle efficiency each year through 2025, and GHG reductions will continue as older vehicles are replaced by more efficient new vehicles.

- ***Clean/Electric Vehicle Incentives*** **–** Meeting the 2050 emission limit requires powering the transportation sector largely with electricity. This transition requires new infrastructure, incentives, and sustained policy over the 15–30 years it takes for the vehicle fleet to turnover.

- ***Smart Growth*** – New growth takes a long time to substantially alter land use patterns and the amount of driving that results from those patterns. However, the synergistic effect of applying multiple smart growth techniques can substantially reduce vehicle miles traveled for existing and new households alike.

- ***Appliance and Product Standards*** **–** Appliance standards that reduce energy consumption from electric and gas-fueled appliances will take time to deliver reductions, and therefore must be in place by 2030 in order to be fully implemented by 2050.

- ***Developing a Mature Market for Renewable Thermal Technologies*** – Continued and accelerated renewable thermal installations are required to electrify the buildings sector's heating and cooling loads, and utilize Massachusetts' clean electric supply.

- ***Tree Retention and Planting to Reduce Heating and Cooling Loads*** **–** Trees take decades to mature, so planting must be enhanced and sustained to achieve the desired reductions in 2050.

A common conclusion across past 2050 planning studies, including the study that was completed to support the original CECP, is that the only viable path to deep reductions in GHG emissions is through a combination of reduced energy consumption (through increased energy efficiency in vehicles and buildings), expanded availability of clean electricity, and electrification of the transportation and heating sectors. Electrification poses a particular challenge because of the need for new infrastructure, including transmission lines, storage capacity, and consumer-facing components such as public vehicle charging stations and smart meters. The scope of the challenge can be summarized in three words: reduce, electrify, and decarbonize. The need to complete this transition by 2050 will guide planning for 2030, and, as required by GWSA, ensure that a 2030 limit is established that maximizes the potential to reduce emissions by at least 80% by 2050, relative to 1990 emissions.

1.4 Economic Impacts

Massachusetts has a vibrant green economy with the Commonwealth's clean energy industry growing 64% since 2010,[15] illustrating the positive economic impact of key policies in this CECP Update. Since 2010, the date of publication of the original CECP, emissions have fallen and the economy has thrived (Figure 6). As longer term benefits are realized across sectors, this trend is expected to accelerate.

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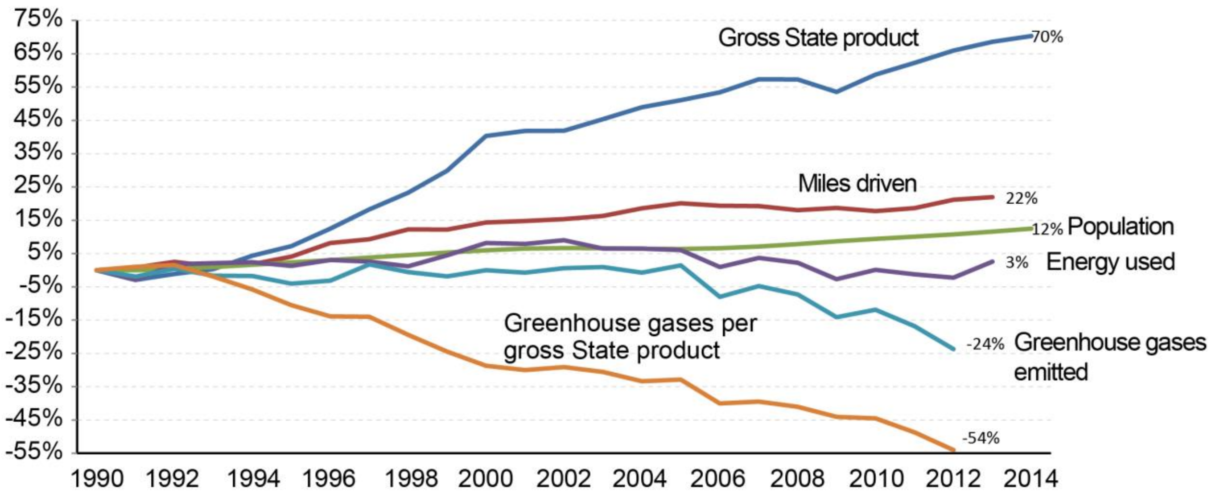
[15] See http://images.masscec.com/2015MassCleanEnergyIndustryReport.pdf.

Figure 6

Historic MA emissions and economic indicators: cleaner air and a growing economy



Source: MassDEP (2015).

The Acts of 2008 created the Massachusetts Clean Energy Center (MassCEC) through the Green Jobs Act to support the development of a clean energy market through education, research, and workforce development. The MassCEC's *2015 Massachusetts Clean Energy Industry Report*[16] highlights the economic impact of both energy efficiency and renewable energy markets in the Commonwealth. The report estimates that there are currently 98,895 workers and 6,439 firms working as part of the approximately $11 billion Massachusetts clean energy sector. According to MassCEC, clean energy job growth continues at a rate that outpaces general job growth in the Commonwealth. Growth has been steady despite changing state incentives. Every region in the Commonwealth has seen positive growth. Some sectors of the clean energy economy have become robust, such as energy efficiency and building envelopes, efficiently producing greater numbers of installations with fewer employees, while others, such as alternative transportation, are emerging markets that will see even further job growth. Ongoing investment in electric sector efficiency and building envelope improvements is expected to contribute $3.2 billion to the gross state product. Massachusetts is also a leader in clean energy innovation, a job sector that can drive the market, offer higher wages for its employees, and attract investment.

Many of the policies in this CECP Update have initial implementation costs, coupled with economic benefits that accrue over time. While quantification of these effects is beyond the scope of this CECP Update, policy costs are considered and managed, and benefits can be

[16] See http://images.masscec.com/2015MassCleanEnergyIndustryReport.pdf.

significant. Many policies reduce the economy's use of fossil fuel, which must be imported from out-of-state. There are significant fuel savings with both building and vehicle energy efficiency and renewable energy, creating a long term economic benefit. Smart growth reduces vehicle ownership and fuel consumption while promoting high density mixed-used development and increasing building efficiency. Vehicle and residential efficiency standards reduce money spent on out-of-state fuel, increasing the funds consumers can spend on in-state goods. For non-energy emissions, the avoided costs of replacing material (e.g. refrigerants or natural gas) leaking into the environment can be significant. As these policies are implemented, many will lead to new jobs and job sectors, such as alternative transportation and renewable thermal.

1.5 Next Steps

The EEA and other agencies will complete the following tasks in the coming years:

- **Ongoing** – Continue to implement policies in this CECP Update, as necessary and appropriate.
- **Ongoing** – Continue to monitor, evaluate progress, and estimate GHG savings from policy implementation in the Clean Energy and Climate Performance Management System (CCPMS), which is a Web-based performance data management system designed by Abt Associates in 2013 for EEA and participating agencies. The CCPMS contains hundreds of quantitative metrics and qualitative milestones used to track the progress of each policy in the CECP Update. When agency staff report progress data at the end of each calendar quarter, the system converts the data (e.g., British thermal units (Btu) of natural gas saved) into GHG reduction estimates, and updates output reports that summarize progress made under each policy.
- **Ongoing** – Update MassDEP's GHG inventory with the latest data as they become available, so that progress can be measured in advance of 2020.
- **Ongoing** – Analyze emission reduction pathways for reducing emissions at least 80% by 2050, relative to 1990 emissions, with a focus on 2030, the next year with a GWSA emission limit requirement.
- **2016** – Continue to work toward the passage of legislation that will ensure delivery of additional clean electricity to Massachusetts by 2020.
- **2018** – Publish the second GWSA progress report as required by GWSA once every five years from the passage of the Act.
- **2020** or before – Establish a 2030 emission limit, and adopt an accompanying plan to reduce emissions.

Chapter 2: UPDATES TO THE CLEAN ENERGY AND CLIMATE PLAN FOR 2020

This chapter describes all policies in this CECP Update, organized by sector. Additional information about each policy is included in an appendix. The policy appendix includes, as applicable for each policy, assumptions used to estimate emission reductions, qualitative information about potential economic impacts, discussion of interactions with other policies and associated implementation obstacles, and related information. The appendix also documents significant changes from the original CECP. Throughout this chapter, italics are used to identify references to specific policies.

2.1 Building Fuels and Energy Efficiency

2.1.1 Sector Overview

Buildings consume more than 50 percent of the energy used in Massachusetts including the vast majority of the electricity and significant amounts of natural gas and oil primarily for space heating. Emissions from buildings represent over 50 percent of GHGs in 2013, with direct fossil fuel use (i.e., excluding buildings use of electricity) accounting for almost a third of the Massachusetts GHG inventory.

The amount of existing and new building space in use is primarily driven by demographic and economic trends that are largely outside the scope of this CECP Update.[17] Building location is also a key driver of state-wide energy use and emissions, and is covered in the transportation chapter. This sector focuses on the characteristics of energy use within the building stock, which can be significantly influenced by policies targeting (1) the improvement of new and existing buildings energy performance and (2) clean energy sources in buildings. Combining these two key factors can achieve net zero energy buildings.

- **Improving building energy performance** – Global, national, and regional studies have consistently pointed to investments in energy efficiency to improve the energy performance of buildings as the largest and most cost-effective of all clean energy opportunities. This is particularly true in Northeast states such as Massachusetts, where the combination of a cold winter, a humid summer, and heavy reliance on carbon-intensive heating oil results in both high energy use[18] and high average fuel costs.

  All Cost-Effective Energy Efficiency programs and the *Rating of Building Energy Performance* policy accelerate energy demand reductions in existing and new buildings, through financial incentives, access to financing, and enhanced awareness of improved

[17] In general, the amount of building space is driven by broader trends such as economic growth, federal policy relating to real estate and capital markets, and personal preferences.

[18] The Northeast census region uses 16% more energy per capita than the U.S. average, due largely to having 46% more heating degree days than the U.S. average (EIA Annual Energy Review 2009).

comfort and economic benefits. For new buildings and major building renovations, energy performance can move to higher standards through *Advanced Building Energy Codes*. Finally, *Appliance and Products Standards* can be updated to address the growing portion of building energy use from appliance and equipment ‘plug-loads’. Based on the 2009 Residential Energy Consumption Survey[19] for Massachusetts, appliances, electronics, and lighting accounted for 24 percent of all household end-use consumption in the Commonwealth.

- **Clean energy sources for buildings** – In addition to improving performance through reducing energy waste in buildings, there is a clear opportunity to transition to cleaner energy sources. Since 1990, there has been a significant economic trend of buildings switching from heating oil to using natural gas. This trend is expected to continue, although it is currently being tempered by a combination of historically low oil prices and natural gas supply constraints in much of the Commonwealth. More recently, the range of economically viable alternative heating options has grown to include cold-climate air-source heat pumps, geo-thermal and solar thermal systems, and clean biomass heating with locally sourced wood pellets or wood chips. These low carbon alternatives to fossil-fuel space and water heating are being supported by the *Developing a Mature Market for Renewable Thermal Technologies* policy.

- **Towards net zero energy buildings** – The confluence of improved building energy performance and shifting to clean energy sources is in net zero energy or energy positive buildings. These can balance energy needs with energy production at the building, eco-district, or neighborhood scale. Massachusetts began to develop a buildings sector-wide strategy to address many of these policy opportunities through the Zero Net Energy Buildings Task Force. This stakeholder group, made up of energy and building industry professionals working with DOER, released a report called *Getting to Zero*[20] in March 2009. Since then the awareness of zero energy buildings has grown and DOER has recently launched a Pathways to Zero grant and technical assistance program to accelerate policy and implementation in this area.

While improving the design and efficiency of buildings is the focus of this sector, the siting and geographic location of buildings can also affect energy use and GHG emissions. Section 2.2 on transportation covers in more depth the importance of livable and walkable communities and the necessity of smart growth policies as we continue to build infrastructure in our growing economy.

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[19] U.S. Energy Information Administration. 2012b. 2009 RECS survey data. http://www.eia.gov/consumption/residential/data/2009/index.cfm?view=consumption#end-use

[20] The *Getting to Zero* report can be downloaded at: http://www.mass.gov/Eoeea/docs/eea/press/publications/zneb_taskforce_report.pdf

2.1.2 Buildings Sector Policies

All Cost-Effective Energy Efficiency

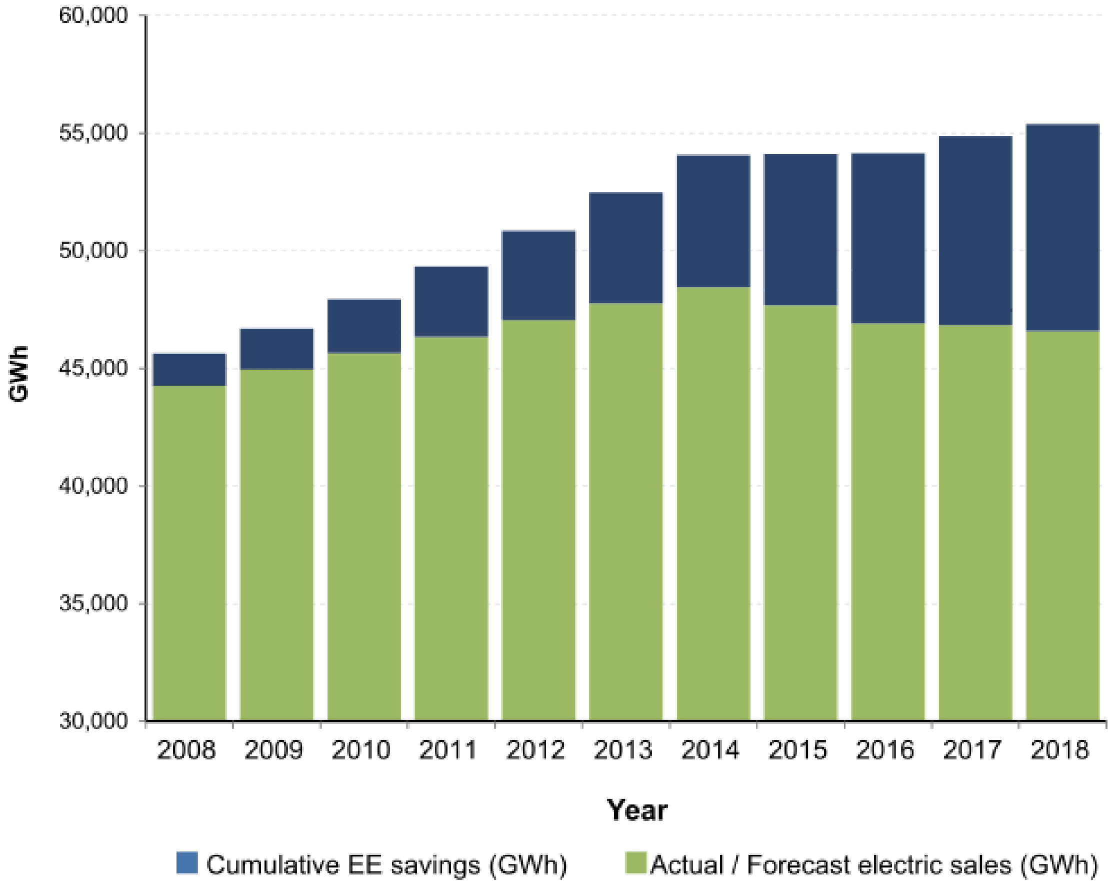
The Green Communities Act (GCA) of 2008 created a framework to promote additional investments in building energy improvements. Taken together, the first nine years of pursuing all cost effective energy efficiency are expected to return more than $20 billion in ratepayer benefits, as well as providing the largest source of greenhouse gas reductions in the buildings sector. Figure 7 below illustrates the impact that this policy has had on statewide electric demand, which has recently started declining as the cumulative impact of energy efficiency has begun to outweigh the historical 1% annual growth in customer electric demand.

The MA Energy Efficiency Advisory Council (EEAC) recently approved[21] three year energy efficiency plans (2016–2018) that establish nation-leading savings levels that ensure continued growth of energy efficiency in the Commonwealth primarily though the Mass Save® programs. The Mass Save® statewide efficiency programs are the primary delivery mechanism, and serve residential (including low income), commercial, and industrial buildings. Participation in the Mass Save program is supported by enabling policies such as the *MEPA GHG Policy and Protocol*, and pilots to advance *Building Energy Rating and Labeling*. They are further supported by state and municipal funding in addition to technical assistance from the *Leading by Example* program and the *Green Communities* Division at DOER. The Mass Save programs now cover *Deep Energy Efficiency Improvements for Buildings* (previously its own initiative) in portions of the Commonwealth that are serviced by National Grid, and allow for energy efficiency services to oil and propane heated homes.

[21] The proposed plans are currently under review by the Department of Public Utilities with a final ruling expected in late January 2016.

Impact of energy efficiency (EE) in curbing final electric demand

Figure 7



Source: DOER (2015).

Expanding Energy Efficiency Programs to Commercial and Industrial Heating Oil

Estimates indicate that 45% of commercial and industrial buildings in Massachusetts are heated with fuel oil[22]. Currently, these buildings do not have access to the Mass Save energy efficiency programs in the same way that electric or gas heated commercial buildings, or all small residential buildings do. This building segment presents a potential opportunity for expanding both energy efficiency and fuel conversions to renewable thermal. The DOER is updating regulations using its existing statutory authority under Residential Conservation Services (RCS)

[22] http://www.mass.gov/eea/docs/doer/renewables/thermal/carts-report.pdf, page 64.

to ensure that oil and propane heated commercial multi-family buildings are able to receive Mass Save services commensurate with other homes. For other commercial and industrial facilities, however, this policy would require new regulations or new legislation to implement. Greenhouse gas reductions resulting from expanding the coverage of the Mass Save programs would be very modest by 2020. Nonetheless, it can be further evaluated to estimate the potential for post-2020 savings and other economic benefits.

Advanced Building Energy Codes

New construction in Massachusetts accounts for approximately 0.50–0.75 percent a year of the total building stock for residential units, and approximately 1 percent for commercial space. This translates into turnover of 6 percent to 10 percent of the building stock from 2010 through 2020, and 25–40 percent by 2050. These buildings have an expected lifetime ranging from 30 years to more than 300 years. As a direct consequence, the design of buildings newly built today and in coming years will have a large and lasting impact on fossil fuel use and corresponding GHG and local air pollution emissions.

Massachusetts general law requires the Commonwealth to adopt the latest International Energy Conservation Code (IECC) from the International Code Council (ICC), the body that develops and maintains model building codes for the United States. In addition to this energy code baseline, which updates every three years, the Massachusetts Board of Building Regulations and Standards (BBRS) adopted a local-option stretch energy code for municipalities in 2009. Over 160 municipalities in Massachusetts have already adopted this higher-efficiency code, and it has had national benefits as the 2009 stretch code for commercial buildings became the basis for the 2012 IECC commercial chapter, part of the largest improvement in the energy efficiency of the national model code in its 35 year history. The next round of building code updates to adopt the IECC2015 model energy code is expected in 2016. The Massachusetts stretch code has helped to advance a broader national shift to performance-based energy codes, through performance targets and testing requirements for new homes and through energy modeling requirements for large commercial buildings.

Building Energy Rating and Labeling

This CECP Update includes *Building Energy Rating and Labeling* as an enabling policy to help grow the markets for energy-saving investments in existing buildings. Currently, there is a lack of detailed data available on the energy use of existing buildings, which prevents buyers and renters—and their lenders—from placing a value on the energy performance of spaces. Under the original CECP, Massachusetts has piloted both residential building energy labeling and commercial office ratings that allow apples-to-apples comparisons of building energy performance in much the same way that miles per gallon (MPG) ratings allow fuel efficiency comparisons of cars and light trucks. The Home MPG pilot program in and around Springfield, Massachusetts ran from 2012–2014 and developed a model scorecard similar to those now being implemented statewide in Vermont and Connecticut. On a regional basis, New England states will seek to enable the voluntary integration of this new information on energy use into the real estate marketplace through Multiple Listing Service listings and trainings for contractors, realtors, and home appraisers. The commercial building asset rating (BAR) pilot developed streamlined building audits for commercial office buildings, and deployed both operational energy ratings (based on utility energy bills and similar to the EPA Energy Star Portfolio Manager program) and asset ratings (similar to home energy ratings or vehicle miles-per-gallon) in the Greater Boston region in 2013–2014. These more detailed energy ratings reveal to property managers whether heating, plug loads, or other energy services in the building are driving the whole building energy usage, and help identify cost-effective retrofits and operational savings. The DOER is finalizing a report on the BAR pilot that will be available in early 2016.

Appliance and Products Standards

The federal government is authorized to set energy efficiency standards for most major appliances, electronics, and other products. The U.S. Department of Energy (DOE) accelerated the rulemaking schedule for setting new standards between 2009 and 2013 which yielded several new standards, though the majority of savings will occur in 2025 and beyond. In 2015, progress continues in setting new federal appliance standards, notably for roof-top air conditioning units starting in 2018. Nationwide, these are expected to yield major savings in both electricity and fuel costs for homeowners and businesses, and commensurate reductions in greenhouse gas emissions, with Massachusetts getting its proportional share.[23]

Massachusetts also has the option of setting its own appliance efficiency standards on the modest set of products not covered by federal action. State-level efficiency standards, which would require new legislation, could generate a small set of additional savings on energy bills and emissions, primarily in the decade following 2020.

Developing a Mature Market for Renewable Thermal Technologies

Policies that target high emitting fuels used for space heating and promote the transition to renewable thermal technologies can have a significant impact on GHG reductions. In Massachusetts, 60% of residential end-use energy consumption is used for space heating with an additional 16% of energy being used for water heating.[24] In Massachusetts, approximately 45% of commercial buildings are heated with fuel oil.[25] This creates an opportunity to grow a robust renewable thermal market that will provide cost savings to the buildings sector while increasing the use of sustainable fuels and reducing GHG emissions.

In 2014, DOER released the *Commonwealth Accelerated Renewable Thermal Strategy (CARTS) Final Report* which investigated policies to help achieve a cleaner renewable thermal future.[26] The report prioritized policies, many of which have been implemented or are currently under review. Massachusetts is promoting the marketing and deployment of renewable thermal installations through Massachusetts Clean Energy Center rebates and workforce development.

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[23] http://www.appliance-standards.org/sites/default/files/Progress_toward_3_billion_CO2_reduction_Sept_2015.pdf

[24] https://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ma.pdf

[25] http://www.mass.gov/eea/docs/doer/renewables/thermal/carts-report.pdf, page 64.

[26] See http://www.mass.gov/eea/docs/doer/renewables/thermal/carts-report.pdf

The Administration supports the long term growth of a sustainable biomass market. Deployment of cost saving renewable thermal technologies is targeted at low income communities that can benefit from the provided savings and health benefits. Because many of these technologies have high upfront costs, the Commonwealth is planning to include specific efficient technologies in the Alternative Portfolio Standard (APS), allowing their thermal production to be eligible for Alternative Energy Credits (AECs). This market-based incentive will reduce upfront costs and prioritize efficient technologies, similar to the role of Renewable Energy Credits (RECs) in the *Renewable Portfolio Standard (RPS).*

The effect of these policies is expected to grow significantly after 2020, making renewable thermal an important piece of achieving the Commonwealth's 2050 goals. Market growth will depend both on policies and programs, but also the cost effectiveness of the technologies. The cold-climate air source heat pump (ccASHP) market has seen substantial growth because of technological efficiency improvements. For the purpose of this CECP Update, most predicted ccASHP savings are included in the *All Cost Effective Energy Efficiency* policy. Additional ccASHP growth outside the Mass Save energy efficiency programs is included in the expected emission reductions for this *Developing a Mature Market for Renewable Thermal Technologies* policy. Other renewable thermal technologies will likely see similar technological improvements and market growth in the future. The recent drop in oil prices may slow renewable thermal growth in the short term, and future market growth will depend on the cost effectiveness of fuel switching.

Tree Retention and Planting to Reduce Heating and Cooling Loads

Tree planting and retention can reduce building heating and cooling loads over the long-term and provide climate mitigation benefits, as well as other benefits such as storm water management. Recognizing the significance of urban tree canopy—each 1% of new tree canopy saves 1–2% in heating and cooling costs—as well as the success of pilot planting efforts in Chelsea, Holyoke, and Fall River, the Baker-Polito Administration has radically expanded the state tree planting program. Over the next three years, the Greening the Gateway Cities Program will fund eleven crews in each planting season, up from three, and more than 27,000 trees will be planted in selected urban neighborhoods in 14 Gateway Cities. The goal of this aggressive planting effort is a 5–10% increase in tree canopy in target neighborhoods as trees reach maturity in 30 years. Because of the slow rate at which trees grow, tree planting and retention provide almost all their GHG emissions reduction beyond 2020. Energy savings and GHG reductions begin about eight years after planting, and increase each year thereafter for decades.

2.2 Transportation, Land Use, and Smart Growth

2.2.1 Sector Overview

Transportation is the largest emissions sector in 2015, and is likely to be so in 2020. Thus, effective policies and programs to reduce the number and distance of vehicle trips, enhance vehicle efficiency, and decrease the amount of carbon in fuels are critical if GHG goals for 2020 and beyond are to be realized.

Passenger vehicles are the dominant source of emissions from the transportation sector, with significant contributions also coming from diesel trucks and aviation. Emissions from fuel combustion are determined by vehicle efficiency and use (as measured in “vehicle miles traveled,” or “VMT”) as well as the characteristics of the fuel burned. Between now and 2020, significant improvements in vehicle efficiency will occur as the stringency of vehicle GHG standards increases. Analysis completed by contractors to support this CECP Update projects a reduction of 3.7 MMTCO_2e from fuel use in light and medium duty vehicles in Massachusetts between 2009 and 2020, driven by increases in vehicle efficiency. Other policies will have positive impacts by supporting the use of alternative transportation modes (such as transit and walking) and fuel switching (to electricity and possibly advanced low carbon biofuels). However, while this CECP Update anticipates a 1.7% reduction in VMT over business as usual in 2020, VMT historically increased 22% between 1990 and 2013, raising concern that future VMT growth may offset vehicle efficiency and fuel carbon content gains.

2.2.2 Transportation Sector Policies

Federal and California Vehicle Efficiency and GHG Standard

Improving the fuel economy of vehicles is one of the most effective tools to reduce energy consumption and GHG emissions. This CECP Update anticipates a reduction of 3.7 MMTCO_2e in 2020 from this policy, the largest in the transportation sector.

Federal Corporate Average Fuel Economy (CAFE) standards were first enacted in 1975. Federal law raised the standards in 2007, and they are now on an accelerated schedule through 2025 thanks to a joint Environmental Protection Agency (EPA) / National Highway Traffic Safety Administration (NHTSA) National Program that harmonized its rules with those of the California Air Resources Board. California has also amended its regulations and adopted the key elements of the National Program.

The EPA and NHTSA have set harmonized standards for light-duty vehicle miles per gallon (MPG) and GHG emissions in two phases, for model year (MY) 2012 through 2016 and MY 2017 through 2025 vehicles. The standard is raised from 27.5 MPG in 2011 to 35.5 MPG in 2016, and then to 54.5 MPG in 2025.

Massachusetts law requires the Commonwealth to adopt and implement California’s motor vehicle emission standards as long as they are at least as protective as the federal standards, and California has harmonized its standards with the federal standards through 2025. Because of these standards, per-mile GHG emissions from 2025 model year vehicles are forecast to be 34% lower, on average, compared to 2016 model year vehicles.

Clean/Electric Vehicle Incentives

The Commonwealth has set an ambitious zero emission vehicle (ZEV) target, and offers a variety of policies and programs encouraging the purchase and use of efficient vehicles. This CECP Update anticipates that the use of clean or electric vehicles will result in 0.1 MMTCO_2e reduction in 2020, based on a gradual increase in clean/electric vehicles from the current level of about 6,000 to 300,000 in 2025.

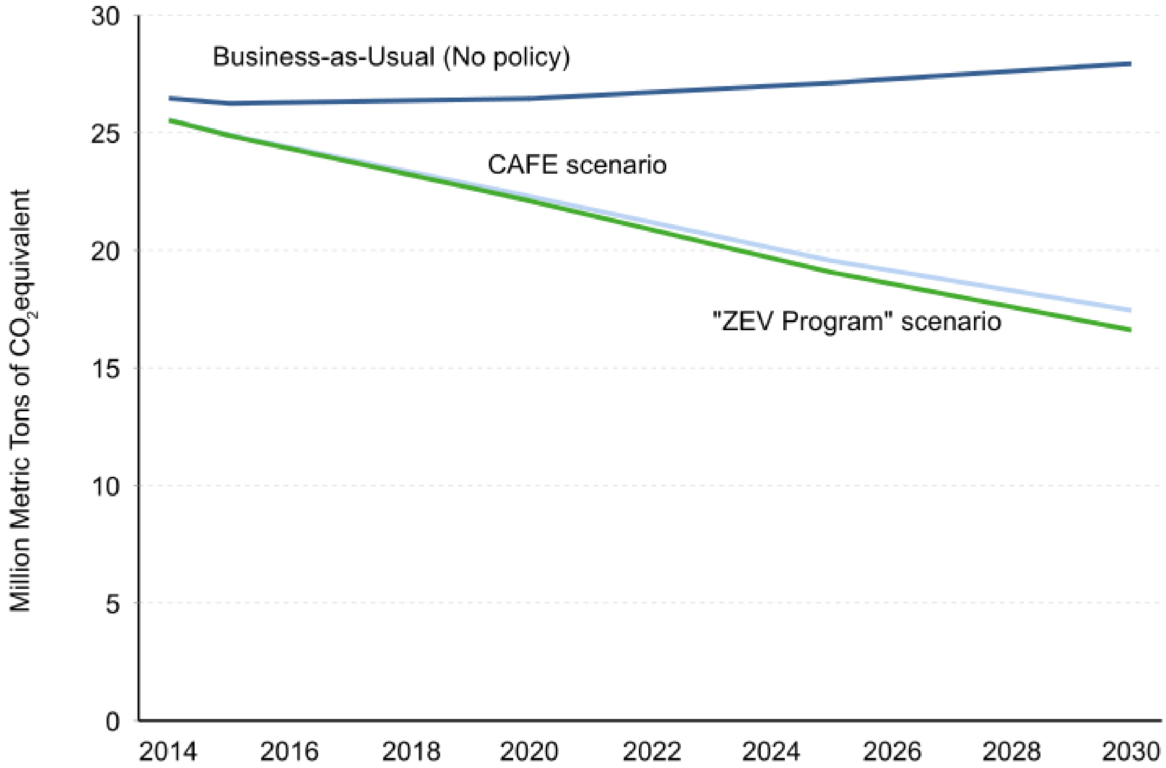
Partnerships within and outside the Commonwealth are a hallmark of Massachusetts's ZEV approach. The Commonwealth signed a memorandum with seven states to coordinate ZEV adoption efforts, and with these states is implementing a "Multi-State ZEV Action Plan" that includes 11 key actions. Critically, the eight states have committed to having at least 3.3 million ZEVs in operation by 2025; the MA share of the target is about 300,000 vehicles. An example of a specific action is a focus on the development of publicly-available charging infrastructure throughout the Commonwealth and, in coordination with neighboring states, installation of fast charging systems along major travel corridors.

Massachusetts has initiated several programs funded from state and federal sources to provide charging infrastructure, incentives and education. Examples include a program offering rebates to consumers to purchase more fuel-efficient models, a clean vehicle grant program for medium and heavy-duty alternative fuel vehicles, and funding to communities and institutions of higher education to purchase plug-in electric vehicles and install charging stations.

Going forward, new complementary policies are necessary to achieve our GHG reduction and MOU goals such as facilitating at-home vehicle charging, providing non-financial consumer incentives, and increasing consumer awareness of ZEVs via outreach and education. In addition, rebate and incentive programs will need to be updated to keep pace as alternative fueled vehicles and associated infrastructure markets change. The Administration will work with the statutorily established Zero Emission Vehicle Commission, charged with making recommendations to the Administration and reporting findings, including draft legislation, to enhance existing policies and adopt new policies and programs to get clean and electric vehicles on the road as quickly as possible.

Reductions in Massachusetts highway vehicle emissions resulting from vehicle GHG, efficiency, and ZEV standards

Figure 8



Source: Abt Associates and NESCAUM (2015).

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

The EPA and the NHTSA are implementing the first phase, and have announced the second, of complementary efforts to reduce GHG emissions and improve fuel efficiency for medium and heavy duty vehicles. Since these vehicles account for 11 percent of total emissions, opportunity exists for significant emissions reductions. In fact, this CECP Update anticipates a 0.4 $MMTCO_2e$ reduction in 2020 from both phases.

The Phase I effort applies to everything from a large pickup truck to semi-trucks and buses for model years 2014–2018. The Phase II standards, which apply to semi-trucks and phase in between model years 2021 and 2027, are anticipated to achieve GHG emissions and fuel consumption up to 24 percent lower than Phase 1.

Federal Renewable Fuel Standard (RFS) and Regional Clean Fuel Standard (CFS)

Reducing the amount of carbon in the fuel vehicles burn is one of three primary ways to reduce transportation sector emissions. This CECP Update forecasts a 0.1 $MMTCO_2e$ reduction in 2020 from substitution of advanced low carbon cellulosic ethanol for petroleum in gasoline by 2020. The reductions are anticipated to occur through ongoing implementation of the federal RFS program, which requires blending of increasing volumes of low carbon biofuels into the fuel supply over time. Consistent with recent experience, production of large volumes of cellulosic ethanol is not anticipated until after 2020.

As to the regional CFS, no significant reductions are anticipated by 2020. An initial reporting-only requirement could provide information and experience to inform future development of a CFS requiring emission reductions. In the longer term, a CFS could support reduction in the GHG emissions profile of fuels beyond levels required by RFS.

Finally, it is important to note that reductions forecast from this policy are based on the production of cellulosic ethanol from waste materials and crops without large land use impacts due to the difficulty of accounting for life-cycle impacts and indirect changes in land use when calculating the carbon intensity of plant based fuels.

GreenDOT

GreenDOT, the Sustainability Initiative of the Massachusetts Department of Transportation (MassDOT), has as one of its three primary goals reducing GHG emissions. This CECP Update anticipates that GreenDOT will result in a 1.0 $MMTCO_2e$ reduction in 2020, consistent with the reduction level set in the original CECP. While GreenDOT related GHG reductions identified by MassDOT appear to be short of this mark, the Baker-Polito Administration will enumerate transportation sector emission reduction measures sufficient to meet this goal.

As it is now the largest emissions sector, transportation sector measures and initiatives that are either directly MassDOT's responsibility or subject to their influence are critically important to attainment of required GHG reductions. MassDOT's GreenDOT Policy Directive and Plan implement a variety of legislative and regulatory requirements, including 310 CMR 60.05, which requires MassDOT to demonstrate that its GHG reduction target in the CECP is achieved. The Directive commits MassDOT to "be a national leader in promoting sustainability in the transportation sector." GreenDOT is focused on three related goals: reduce GHG emissions; promote the healthy transportation modes of walking, bicycling, and public transit; and support smart growth development.

The 2010 GreenDOT Implementation Plan serves as the framework for embedding the sustainability principles of GreenDOT into the core business practices of MassDOT. GreenDOT requires consideration of GHG impacts in statewide and regional transportation planning, and in the selection of particular projects that receive funding in the regional and statewide transportation plans. GreenDOT also specifies several other efforts, such as enhanced support for alternative modes of transportation and promotion of "eco-driving" (fuel-saving auto maintenance and driving practices), and enabling more efficient roadway operation through the use of intelligent transportation systems.

Smart Growth

Households in smart growth consistent development drive almost one third less miles than those in single use subdivisions distant from jobs and services. Massachusetts will pursue a variety of policies and program to promote smart growth, which were estimated by EEA's consultants to produce a 1.7% reduction in vehicle miles traveled (VMT) over business as usual. This corresponds to approximately 0.4 $MMTCO_2e$ reduction in 2020.

The amount of driving is greatly influenced by patterns of housing and business development in the Commonwealth. The more spread out development is, the more driving people must do to get to work and school, to shop and to participate in other activities. Although development decisions are primarily made by local governments through their zoning, as well as the private market, the Commonwealth has a variety of tools it can use to influence where and how growth occurs. The Massachusetts Sustainable Development Principles guide state agency programs, as well as investments in land and infrastructure. The Principles, also intended as an example for cities and towns to follow, encourage building homes near jobs, transit, and where services are available, and promote the creation of pedestrian friendly neighborhoods.

The Commonwealth will pursue a variety of policies in five broad categories: 1) Plan for Success, produce and implement Land Use Priority Plans to coordinate state actions and make state intentions explicit; 2) Reform state planning, subdivision, and zoning statutes to provide a better framework for land use planning and regulation; 3) Use state investments, particularly in land, buildings, and infrastructure, to promote growth that is consistent with the Sustainable Development Principles; 4) Offer strong fiscal and regulatory incentive to plan and zone for, invest in, permit, and build smart growth; and 5) Provide grants and other tools to communities to zone and otherwise regulate for smart growth.

2.3 Electricity Generation and Distribution

2.3.1 Sector Overview

This CECP Update includes a number of policies that affect emissions from combustion of fuels at electric power plants. Taken together, these policies are projected to reduce GHG emissions by 13.3 $MMTCO_2e$ by 2020. Notably, this total reflects the replacement of coal-fired power plants with natural-gas fired power plants whose fuel has a lower carbon content, and whose generation technology is more efficient. This trend is expected to continue through 2020, though constraints on the natural gas supply have the potential to result in increased reliance on oil, eroding the full potential benefits of fuel switching. Increasingly, renewable energy and energy efficiency are also contributing, as is imported hydroelectric power. Most of the policies discussed in this section serve the longer-term need to move to zero-carbon generation. These policies include the Baker-Polito Administration's efforts to develop financing mechanisms to support the construction of additional capacity to import hydroelectricity and wind power.

The following policies in this CECP Update will affect emissions from this source category by reducing or increasing demand for electricity. Policies that directly affect energy generation and distribution are discussed in detail in this section, while several policies that affect energy generation are discussed in detail elsewhere in this CECP Update, either because they affect energy generation indirectly, or because they have impacts in other sectors.

- ***All Cost Effective Energy Efficiency*** – the many measures implemented through this policy will reduce demand for electricity.
- ***Appliance and Product Standards*** – This policy will reduce demand for electricity from appliances.
- ***Advanced Building Energy Codes*** – This policy will reduce demand for electricity by reducing the amount of electricity used by air conditioners, and by heating systems that use electricity.
- ***Tree Retention and Planting to Reduce Heating and Cooling Loads*** – This policy will reduce demand for electricity through the same mechanisms as Advanced Building Energy Codes.
- ***Building Efficiency Rating and Labeling*** – This is a supporting policy (with no explicit reductions assigned to it) that will reduce demand for electricity through owner and tenant interest in occupying buildings with lower ongoing energy costs.
- ***Electric Grid Modernization*** – This is a supporting policy (with no explicit reductions assigned to it) that will result in a more efficient and reliable electric grid, while also increasing our ability to integrate greater amounts of renewable energy into the electric grid.
- ***Clean/Electric Vehicle Incentives*** – This policy will increase demand for electricity, as electricity is needed to charge electric vehicle batteries.
- ***Smart Growth*** – This policy will reduce demand for electricity if it changes the type and/or reduces the average size of housing units, including by shifting housing demand toward multi-unit buildings. Smaller homes and those with common walls require less electricity for air conditioning, lighting, and, in some cases, heating.

Notably, while the contribution of the electricity sector to statewide GHG emissions is declining rapidly, the importance of maintaining a clean electric grid will increase over time. Electric vehicles can only contribute to deep reductions in GHG emissions over the long term if they can be powered by low-carbon energy resources. The same is true of modern ccASHP, a rapidly growing technology that, while very efficient, requires electric power. The importance of the electric sector in the context of long-term planning is discussed further in Chapter 4.

2.3.2 Electric Sector Policies

Clean Energy Imports and/or Clean Energy Standard (CES)

The *Clean Energy Imports* policy would deliver additional clean electricity to Massachusetts, most likely through the development of new transmission lines to deliver hydroelectric power and wind power from northern New England. As imported hydropower is already a significant source of energy for New England's electric power grid, it is certain that this particular energy source is viable, affordable, and available at scale. The *Clean Energy Imports* policy has not yet been implemented, but enabling legislation has been proposed, and the Baker-Polito Administration is actively working with other New England states to ensure success.

In the event the above proposed legislation is not passed, a lesser preferred alternative to implement the *Clean Energy Imports* policy is a *Clean Energy Standard*, as discussed in the policy appendix. A properly developed CES could provide additional incentives and extend the existing clean energy tracking and crediting framework beyond RPS-eligible renewable resources.

As noted above, because of the large quantity of anticipated emission reductions, implementation by 2020 is important to ensure compliance with the 2020 emission limit and to make progress toward longer-term goals. In the context of this CECP Update, the estimated quantity of GHG emissions that will be avoided by this policy is 4.0 $MMTCO_2e$.

Coal-Fired Power Plant Retirements

Coal has the highest carbon content of all fossil fuels. For this reason, as coal fired power plants have retired in Massachusetts, large emission reductions have been realized. Additional reductions are expected by 2020 as the last coal-fired electric generating units in Massachusetts come off line and are replaced by lower emitting resources such as natural gas and renewable energy. These retirements are driven by many factors, including reductions in the price of natural gas, increased reliance on renewable energy, and the age and low efficiency of the plants themselves. The quantity of emission reductions attributable to this policy is 2.7 $MMTCO_2e$. This estimate also accounts for the closure of the Pilgrim nuclear power plant, which significantly reduces the quantity of emission reductions attributable to this policy.

Renewable Portfolio Standard (RPS)

The RPS is a cornerstone of Massachusetts' efforts to transition to a low carbon electricity sector. It supports the deployment of renewable energy technologies, particularly wind and solar power. While the rate of increase is gradual, at one percent each year, the impact over time is significant, with the requirement reaching 15 percent of electric load by 2020. The impact on emissions, resulting from avoided natural gas generation, is estimated at 1.1 $MMTCO_2e$. Because new transmission capacity could be used to import wind energy to Massachusetts, the *Clean Energy Imports* policy may also have a role to play in facilitating RPS compliance. This would reduce the potential that RPS compliance will occur through the use of alternative compliance payments. While alternative compliance payments do support the development of clean electricity over the long term, they do not necessarily translate directly into megawatt hours (MWh) of new renewable energy delivered to the electric grid by 2020.

Regional Greenhouse Gas Initiative (RGGI)

The Regional Greenhouse Gas Initiative (RGGI) is a regional program that reduces greenhouse gas emissions from power plants in nine northeastern states. RGGI includes two key components. First, an environmental regulation limits the aggregate amount of carbon dioxide emissions across the nine states to an agreed upon “cap.” This limit is achieved through a requirement to hold “allowances,” each of which allows the emission of one short ton of carbon dioxide. Second, the allowances are sold by the RGGI states in auctions. Massachusetts uses the majority of its auction proceeds to fund investments in energy efficiency, further reducing emissions. Ongoing implementation of RGGI will continue through 2020 and beyond, with program changes likely to address the requirements of federal Clean Power Plan regulations.

The impacts of RGGI on the power sector are pervasive, but hard to quantify. In particular, the cost of allowances creates an incentive for generators to reduce emissions. In addition to funding energy efficiency, this incentive supports fuel switching from coal to natural gas and increases the cost-effectiveness of investments in renewable energy. However, because the allowance price has been moderate and is expected to remain so through 2020, the observed changes in the electric sector are mostly attributable to other policies. For this reason, no additional reductions, beyond those captured in other policies described above, are attributed to the RGGI program in this CECP Update.

Electric Grid Modernization

In August 2015, each of the three electric distribution companies in the Commonwealth filed a Grid Modernization Plan (GMP) with the Department of Public Utilities (DPU). As required by the DPU, each company’s ten-year GMP outlines how the company proposes to make measureable progress towards the following grid modernization objectives: (1) reducing the effects of outages; (2) optimizing demand, which includes reducing system and customer costs; (3) integrating distributed resources; and (4) improving workforce and asset management.

Electric grid modernization has the potential to contribute GHG emissions reductions in the Commonwealth both directly, by saving energy through reduced line loses and improved electric grid operation, and indirectly, by enabling the increased safe interconnection of distributed resources such as solar power, electric vehicles, and energy storage.

2.3.3. Emissions Projection Methodology

Several information sources were used to project emission reductions from the electric sector policies. For specific fossil-fuel fired power plants that will shut down by 2020, actual historic emissions data were used to determine the amount of reductions that will occur when they no longer operate. As discussed above, natural gas-fired generation has compensated for these changes. The same is true of other policies that affect the net balance of electricity supply and demand. Therefore, an emission rate reflective of natural gas-fired power plants currently operating in Massachusetts was used to estimate emissions impacts of the policies listed below. Additional analysis was completed to better understand impacts in the context of MassDEP's GHG emissions inventory, which accounts for the fact that Massachusetts is a net importer of electricity.

In order to fully understand how these policies affect electricity sector emissions, it is useful to consider them in categories.

- The *Coal-Fired Power Plant Retirements* policy is the only one that directly reduces emissions, because GHGs will no longer be emitted from power plants that have retired. This policy also affects emissions indirectly, as other power plants must generate additional electricity to compensate for the loss of coal-fired generation. As discussed above, this compensating emissions increase is assumed to come from power plants that use natural gas as their primary fuel, as these are typically the "marginal" units that ramp generation up and down as needed to meet demand on the electric grid.

The second, third, and fourth categories below all affect generation indirectly, so their impacts are quantified using the "marginal" unit approach described above. These categories are:

- Two policies increase generation from non-emitting energy resources, thereby causing compensating reductions in natural gas-fired generation. The *Renewable Portfolio Standard (RPS)* and *Clean Energy Imports* policies are in this category.

- Several policies reduce electricity demand: *All Cost Effective Energy Efficiency*, *Appliance and Product Standards*, *Advanced Building Energy Codes*, *Tree Retention and Planting to Reduce Heating and Cooling Loads*, *Building Efficiency Rating and Labeling,* and *Electric Grid Modernization*. These policies reduce emissions by reducing the need to operate natural gas-fired power plants.

- The *Clean/Electric Vehicle Incentives* policy will over time increase electricity demand and, therefore, could potentially increase emissions from natural gas-fired power plants between 2015 and 2020.

Table 4 lists policies that have significant and quantifiable impacts, and quantifies those impacts. For clarity, known power plant retirements are listed separately to represent the *Coal-Fired Power Plant Retirements* policy.

Detailed list of electric sector emission changes

Table 4

Electric Sector Change Anticipated by 2020, Relative to 2009	$MMTCO_2e$
Somerset Shutdown	-0.3
Salem Shutdown	-0.8
Mount Tom Shutdown	-0.5
Brayton Point Shutdown	-3.4
Pilgrim Shutdown	+2.3
Coal-Fired Power Plant Retirements	-2.7
Renewable Portfolio Standard	-1.1
Clean Energy Imports	-4.0
All Cost Effective Energy Efficiency	-4.4
Appliance and Product Standards	-0.9
Reducing GHG Emissions from Plastics Combustion	-0.3
Clean/Electric Vehicle Incentives	+0.2
Net Change in Emissions	**-13.3**

This estimation method does not account for the fact that a portion of the compensating changes in natural gas-fired generation are likely to occur in states other than Massachusetts. Therefore, the magnitude of the compensating change in natural gas-fired generation in the chart above is likely to be larger than the amount that will ultimately be reflected in MassDEP's GHG inventory. While difficult to evaluate with any precision, any associated error is likely to be small relative to the overall size of the change in electricity sector emissions.

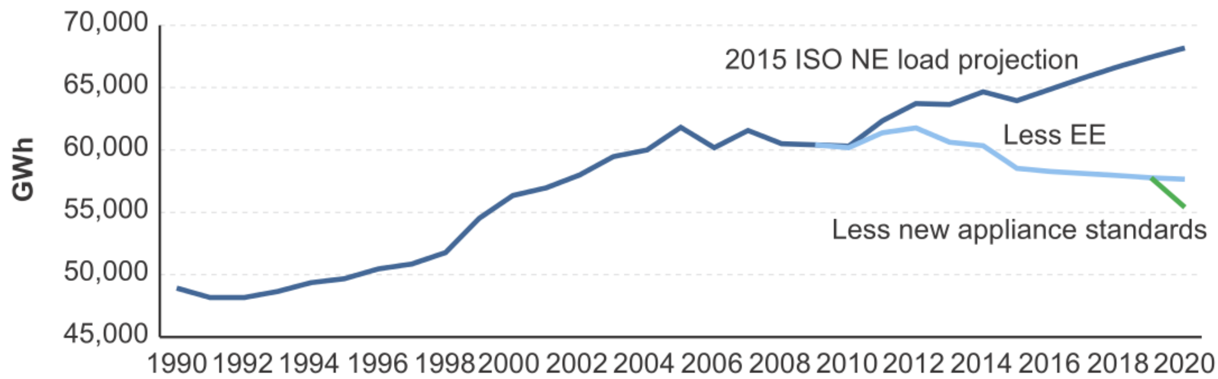
Figure 9 depicts the Massachusetts electricity demand from 1990 through 2020. The top line in the figure is based on New England ISO's Massachusetts load projection in the absence of policies,[27] increased to account for the demand expected from an increase in electric vehicle

[27] http://iso-ne.org/static-assets/documents/2015/05/isone_fcst_data_2015.xls tab 9.

charging. The lower lines in the figure depict expected load after implementation of the electric sector policies in this CECP Update.

Massachusetts electricity demand changes due to implementation of the CECP Update policies

Figure 9

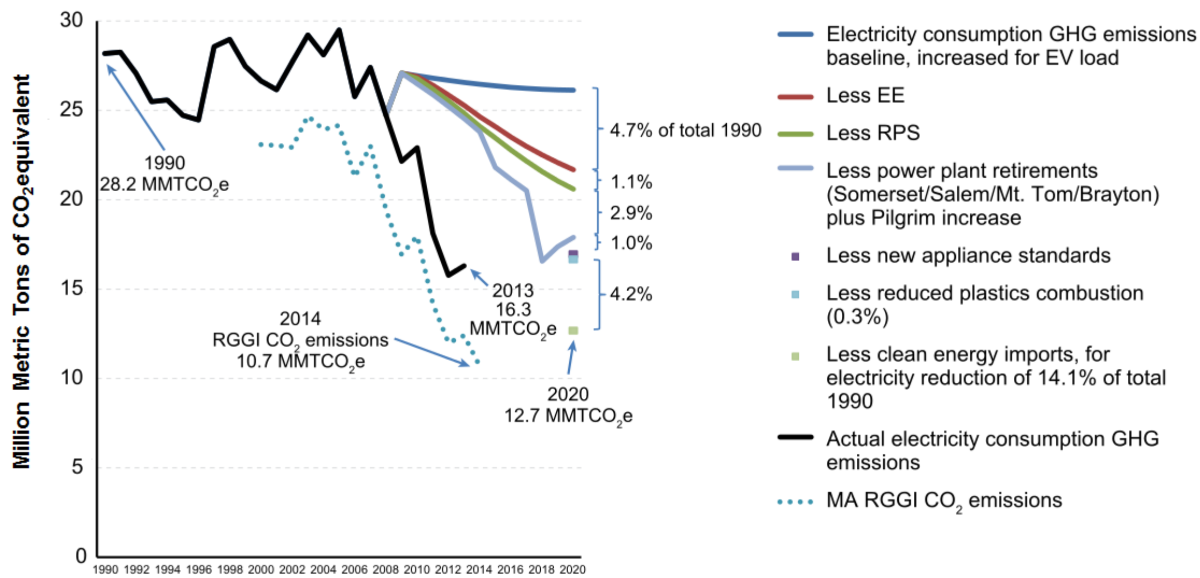


Source: MassDEP (2015).

Figure 10 depicts the amounts of GHG reductions due to the electric sector policies discussed in this CECP Update. Figure 10 also depicts CO_2 emissions from Massachusetts power plants subject to *RGGI*. As can be seen in the figure, RGGI emissions constitute the major portion of the annual emissions associated with the use of electricity in Massachusetts. Since there was a decrease in Massachusetts RGGI power plants' CO_2 emissions from 2013 to 2014, it is expected that there will also be a decrease from 2013 to 2014 in the total emissions associated with the use of electricity in Massachusetts.

GHG emissions due to the generation of electricity to meet Massachusetts electricity demand

Figure 10



Source: MassDEP (2015).

Additional information about all of these policies is included in the appendix.

2.4 Non-Energy Emissions

2.4.1 Sector Overview

Non-energy emissions occur through processes other than energy generation. While the GHGs emitted are much more potent than carbon dioxide on a ton-for-ton basis, their overall contribution is not great because they are emitted in much smaller quantities than carbon dioxide.

2.4.2 Non-Energy Sector Policies

Reducing GHG Emissions from Plastics Combustion

This policy will result in an increase in the recycling of plastic (largely manufactured from petroleum) in municipal solid waste, thus removing it from the waste stream and resulting in lower emissions from municipal waste combustors when municipal solid waste is combusted. Using emission factors specific to the combustion of plastic, potential reductions from the policy in 2020 are estimated as 0.3 $MMTCO_2e$.

Reducing SF_6 Emissions from Gas-Insulated Switchgear

The *Reducing SF_6 Emissions from Gas-Insulated Switchgear* policy is being implemented through a new MassDEP regulation. Sulfur hexafluoride (SF_6) is a potent greenhouse gas that leaks from high voltage electric distribution equipment. Beginning with emissions that occurred in 2015, owners of large inventories of this equipment are subject to a limit on annual emissions, with the limit declining annually to a level of one percent in 2020. The regulation also requires that newly purchased equipment be certified by the manufacturer to be compliant with the one percent leak rate.

Emission reductions from this policy are estimated to be 0.4 $MMTCO_2e$ by 2020. Reports due to MassDEP from equipment owners in April 2016 will provide additional data that can be used to refine this estimate.

Stationary Equipment Refrigerant Management

Synthetic fluorinated gases are used as working fluids in refrigeration systems. Refrigeration system leaks of these gases are accumulating in the atmosphere, and contributing to global warming. The first generation of these gases (chlorofluorocarbons or CFCs) is being phased out worldwide because they destroy ozone in the stratosphere, allowing harmful ultraviolet radiation to reach Earth's surface. While the most commonly used replacement gases (hydrofluorocarbons or HFCs) do not harm the ozone layer, they are similarly harmful to Earth's climate.

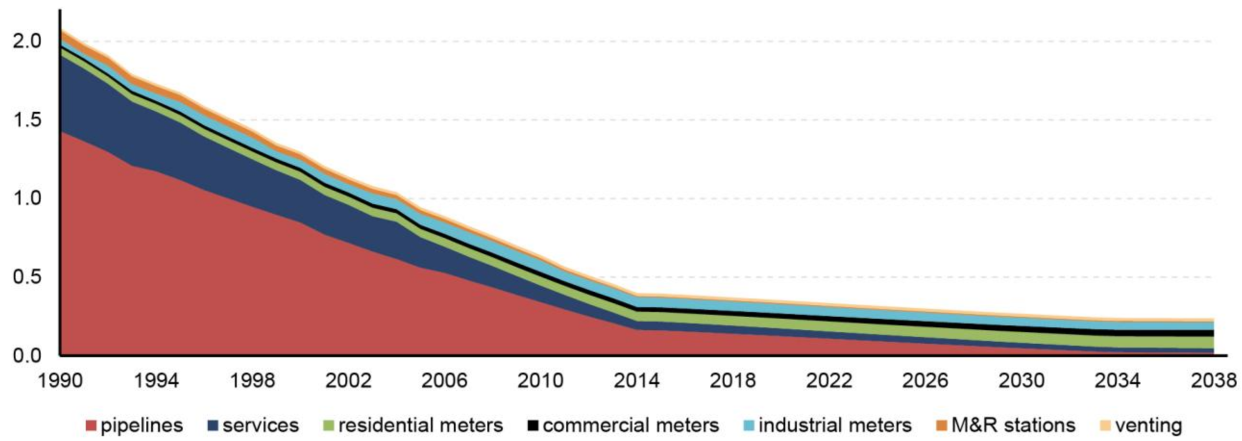
The *Stationary Equipment Refrigerant Management* policy would reduce emissions of HFCs by requiring actions that will reduce the amount of refrigerant that leaks from refrigeration systems, buying time while less harmful replacement compounds are developed. A federal regulation proposed in 2015 will reduce refrigerant leaks by a modest amount, estimated at 0.1 MMTCO2e in Massachusetts by 2020. Depending on how these regulations are finalized and implemented, MassDEP may consider Massachusetts-specific regulations in the future. However, it is very unlikely that such state action could be implemented in time to provide additional reductions by 2020.

Reducing Emissions from the Natural Gas Distribution Network

The *Reducing Emissions from the Natural Gas Distribution Network* policy is included in the non-energy section of this CECP Update because it addresses natural gas that is released without being combusted to generate energy. Methane, a potent GHG, is the primary component of natural gas, and is present in the natural gas supply at concentrations of more than 95%. This new policy reflects recent orders of the Massachusetts Department of Public Utilities helping to minimize risks to health and public safety by reducing leaks from underground pipes that deliver natural gas to homes and businesses in Massachusetts. The orders reduce leaks by requiring that aged steel and iron pipes be replaced on an accelerated schedule. The amount of reductions attributed to this policy is 1.7 $MMTCO_2e$.

Historical and projected emissions ($MMTCO_2e$) from leaks in the natural gas distribution system

Figure 11



Source: MassDEP (2015).

2.5 Cross-Sector Policies

2.5.1 Overview

Massachusetts has adopted several policies to promote clean energy that produce energy savings that are primarily quantified in the *All Cost-Effective Energy Efficiency* policy. However, in addition to promoting building energy efficiency they also impact electricity supply, transportation and non-energy emissions. Given that these are state actions that drive clean energy adoption across multiple sectors, and in order to avoid double-counting with those sector policies, they are grouped here as Cross-Sector Policies. More details about each of these policies are in the appendix.

2.5.2 Cross-Sector Policies

MEPA GHG Policy and Protocol

The Massachusetts Environmental Policy Act (MEPA) Office conducts the environmental review process for all large development projects including power plants. The MEPA environmental review requires proponents to explicitly assess the GHG impact of a project and analyze and consider alternatives in an effort to avoid, minimize and mitigate damage by reducing project GHG emissions in the proposed projects relative to a building code compliant (or, in the case of a power plant, a BACT) project baseline. By necessity, this analysis includes the buildings, energy supply, and transportation impacts of a project, and in the case of power plants, includes the efficiency of the generation equipment.

Leading By Example (LBE) and Green Communities

The Commonwealth's Leading By Example (LBE) program requires state agencies to reduce energy costs and lower emissions in state buildings, in vehicle fleets, and through green procurement. The Green Communities Division of DOER works closely with municipalities to help cities and towns lower their energy costs and adopt energy efficient technologies, add renewables to their energy mix, and make their fleets more fuel efficient. Greenhouse gas reductions from LBE and Green Communities projects are accounted for within the appropriate sections in this CECP Update to avoid double-counting.

Consideration of GHG Emissions in State Permitting, Licensing, and Administrative Approvals

The GWSA requires all state agencies, departments, boards, commissions and authorities to consider climate change impacts, such as GHG emissions, when they issue permits, licenses and other administrative approvals. Consideration of GHG emissions in various state actions is achieved through the implementation of the *MEPA GHG Policy and Protocol*, Green Communities grant program, LBE program, regulation 310 CMR 60.05 "Global Warming Solutions Act Requirements for the Transportation Sector and the Massachusetts Department of Transportation," and other initiatives including MassDOT's Healthy Transportation Directive and the Massachusetts Department of Public Utilities' consideration of methane leaks and repair in their review of the natural gas local distribution companies' annual pipeline replacement plan.

Chapter 3: RESEARCH AND ANALYSES ON LAND USE GHG FOR FUTURE POLICY AND PLANS

Conversion of land from one use to another is nearly always associated with changes in carbon storage or other GHG emissions.[28] Land use change itself can be an important contributor to both GHG emissions and storage. Moreover, our choices in land use have significant influence on how much we drive and the type and location of new buildings, which in turn shape energy use in the Commonwealth.[29] Finally, as noted in Harvard Forest's recent study (2014) of land use trends in Massachusetts, conversion of forests and fields to development and roads is much harder to reverse than the historic clearing of land for farms and pastures.

As such, a better understanding of the relationship between land use change and GHG emissions can point to additional mitigation opportunities within the Commonwealth's climate planning efforts. This chapter describes insights from recent analyses conducted by EEA's consultants on GHG emissions and storage in both terrestrial and wetlands ecosystems, and identifies additional research needed to support future policy development.

A major contribution of these analyses is that they address the potential for enhancing carbon storage in Massachusetts terrestrial landscapes beyond just forests. Including the full suite of land cover types in the analyses—lawns, playing fields, pastures, and wetlands—shows that forests are still the largest contributor to carbon storage in the Commonwealth. Other types of land cover also store significant amounts of carbon, and offer opportunities for improved management of GHG emissions.

In addition, the Commonwealth is taking a leadership role as one of the first states to invest in tools for evaluating changes in GHG emissions associated with the management of coastal, riverine, and inland wetlands. The Massachusetts Division of Ecological Restoration (MassDER), which has implemented over 100 aquatic ecosystem restoration projects, collaborated with EEA on the development of a methodology and a first-generation "Blue Carbon Calculator"[30] for estimating changes in GHG emissions from wetland ecosystems in Massachusetts. The Calculator allows MassDER to incorporate GHG considerations into the process of selecting ecosystem restoration projects alongside other ecosystem service benefits associated with ecological restoration such as improving water quality, habitat, and flood protection.

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[28] Terrestrial carbon storage is also commonly referred to as carbon sequestration. Terrestrial ecosystems can also be a source of GHG emissions—losses in forest carbon through deforestation and forest degradation account for an estimated 15 to 20 percent of global GHG emissions annually.

[29] As noted by the Harvard Forest study (Thompson, J. et al. 2014), the recent trend of forest loss represents the first time since the mid-1800s that Massachusetts (and other New England states) began losing net forest cover.

[30] "Blue carbon" refers to carbon found in coastal and riverine wetland ecosystems.

3.1 Measuring GHG Emissions from Land Use Change in Massachusetts: Forests and Terrestrial Ecosystems

Forest cover makes up about 61 percent of Massachusetts' total land base, and the Commonwealth's forests have long served as a major 'sink' of GHG emissions.[31,32] Although Massachusetts forests have recovered substantially since their nadir at the start of the 20th century,[33] the more recent trend in Massachusetts has been a sustained decline in forested land area, while developed land has been increasing. During the last 30 years, the pace of land use change reached its highest level in the Commonwealth during the 1980s and 1990s, when approximately 15,000 acres of forest and other non-developed lands were converted to other land uses each year.[34] Between 1999 and 2005, the rate of land use change in the Commonwealth slowed to an annual average of approximately 7,300 acres. Since 2005, the area of forest converted to other land use slowed to 4,800 acres per year on average.[35]

[31] Butler, Brett J. 2013. Forests of Massachusetts. Resource Update FS-20. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 4 p.

[32] In 2012, the Massachusetts GHG Inventory estimated net sequestration from Massachusetts forests and shrubs at 11.2 $MMTCO_2e$, based on an EEA methodology. MassDEP and EEA will work to incorporate the findings in this CECP Update into the Massachusetts GHG inventory.

[33] The height of forest clearing in Massachusetts occurred between 1830 and 1885, when 70 percent of land was cleared for pasture, cropland, orchards, and buildings (Cretaz, A. et al., 2010). http://www.mass.gov/eea/docs/dcr/stewardship/forestry/assessment-of-forest-resources.pdf

[34] Massachusetts Audubon (2014). Losing Ground: Planning for Resilience (Fifth Edition). Last accessed at: http://www.massaudubon.org/our-conservation-work/education-community-outreach/sustainable-planning-development/losing-ground-report/losing-ground-fifth-edition

[35] Massachusetts Audubon (2014). This trend is consistent with the timing of the economic recession in 2008, when annual housing starts nationally and in Massachusetts began a significant decline. As the economy continues to recover from the 2008 recession, land use change could begin to increase from recent rates.

Summary of Key Findings: Forests and Terrestrial Ecosystems

- This assessment evaluated carbon storage in all terrestrial ecosystems in Massachusetts, and found that in 2011, forests, wetlands, farms, and fields stored an estimated 365 million metric tons of carbon. Approximately 67 percent of total terrestrial carbon storage in Massachusetts is in forests, 17 percent of carbon is stored in wetlands, and 16 percent of carbon is stored in other types of land cover (e.g., crops, playing fields).
- Over 90 percent of terrestrial carbon storage in 2011 occurs in Massachusetts' rural and suburban communities, at 116 and 215 million metric tons of carbon, respectively.
- Historical land use change in Massachusetts from 1990 to 2011 resulted in a loss of 7 million metric tons of carbon. The majority of this loss in carbon storage occurred in forests and wetlands, while all other types of land cover experienced a slight gain in carbon storage over this period.
- Future carbon storage associated with "smart growth" development patterns modeled in this analysis showed an increase in terrestrial carbon storage above current trends of 2 million metric tons, for a total of 367 million metric tons of stored carbon in 2040.

To estimate changes in carbon storage associated with historical land use change, carbon storage estimates for each land cover type were applied to changes in land cover revealed by historical land cover data for the time period 1992–2011.[36] To estimate potential changes in terrestrial carbon storage in Massachusetts in the future, two different scenarios of land use in Massachusetts were developed for the 2011 to 2040 timeframe:[37,38] 1) The "Business-as-Usual (BAU)" land use scenario illustrates an extension of Massachusetts' recent historical trends in land use change into the future, i.e., approximately 4,500 acres per year of forests and 'greenfields' are converted to other land uses, mostly in suburbs; 2) A "Smart Growth" scenario locates 50 percent of new growth in households by 2040 in or near existing urban centers.[39]

The next section describes results of the analysis of terrestrial carbon storage for both Massachusetts historical land use change and scenarios of future land use.

[36] National Land Cover Data for 1992-2011.

[37] To build up the geographic basis and other assumptions for the two land use scenarios, this analysis used the following sources: 1) Metropolitan Area Planning Council's Massachusetts Community Types (MAPC 2008), 2) Massachusetts Department of Transportation 2015 projections of population, employment, and households for 2020, 2030, and 2040, by municipality; 3) MAPC's estimates of the density of growth (expressed as no. of new households per acre).

[38] It is important to note that these scenarios are not intended to serve as predictions of future land use change in Massachusetts. Rather, they are meant to be illustrations of two possible outcomes for Massachusetts future land use with contrasting impacts on the future composition of land cover types and corresponding potential for carbon storage.

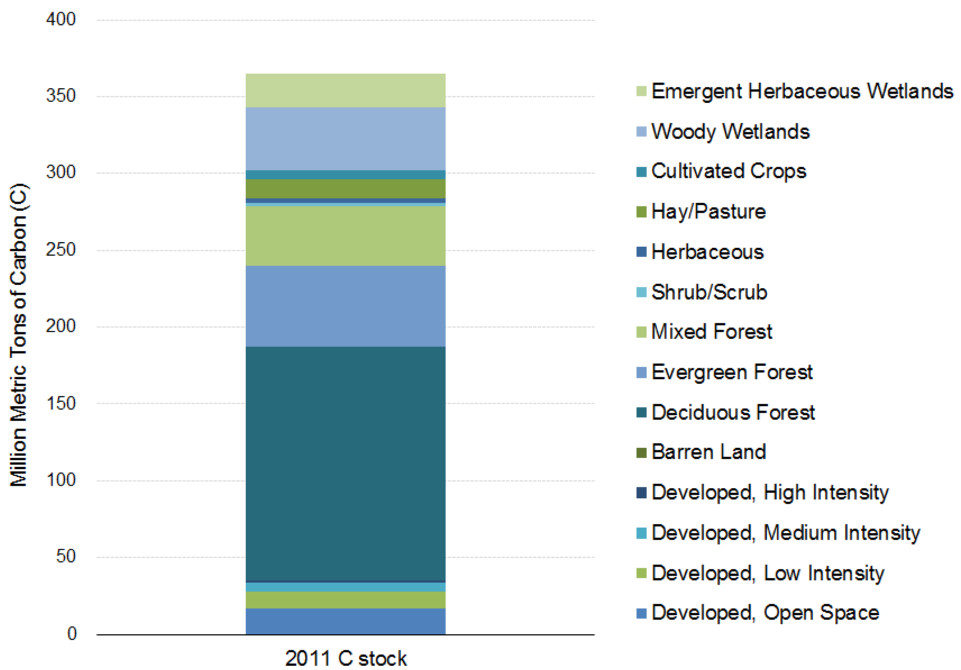
[39] Note that the smart growth development patterns modeled in this analysis is not the same Smart Growth policy in the CECP Update.

3.1.1 Results of Analysis for Forests and Terrestrial Ecosystems

Figure 12 shows that despite losses in carbon storage over the last two decades, forests are still the dominant source of carbon stored in Massachusetts' terrestrial ecosystems, accounting for two-thirds of total carbon storage, or 243 million metric tons of the statewide total of 365 million metric tons of carbon. Wetlands, which includes forested wetlands and herbaceous wetlands (e.g., cranberry bogs), are the second-largest store of carbon behind forests, accounting for 17 percent of the total. Other lands, including open spaces, crops, and pastures, account for 16 percent of the total.

Massachusetts carbon storage by land cover type, 2011

Figure 12



Source: Abt Associates and Applied GeoSolutions analysis (2015).

3.1.2 Impacts on Terrestrial Carbon under Historical and Future Land Use Change

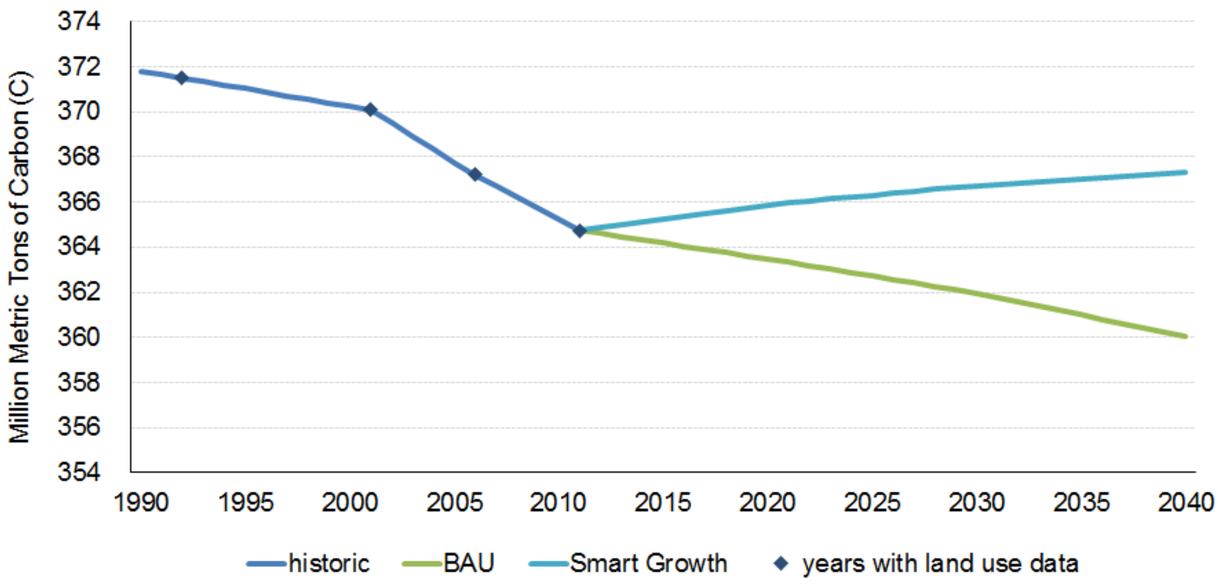
Holding carbon stock per acre constant, carbon stored in land cover types involving crops and pastures increased by 0.6 million metric tons and carbon stored in open space lands also grew by 0.6 million metric tons over the 1990 to 2011 timeframe. Overall, however, the Commonwealth experienced a loss of over 7 million metric tons of carbon storage due to land use change during this time period, equal to a 1.9 percent loss relative to the 1990 base of nearly 372 million metric tons of carbon. The vast majority of historical carbon loss occurred in forests, which lost nearly 10 million metric tons. Carbon stored in wetlands also declined over this period, by 0.5 million metric tons. While the loss of carbon storage to land cover change is a significant concern, ongoing sequestration due to tree growth over approximately 3 million forested acres in the Commonwealth more than offsets carbon lost to development, consistent with MassDEP's GHG inventory. Utilizing a portion of forest growth for local, long-term wood products (such as wood buildings) via sustainable improvement forestry can further increase carbon sequestration and support rural jobs, but was not examined in these analyses. The *Tree Retention and Planting to Reduce Heating and Cooling Load* policy is another method to increase carbon storage provided by land uses.

Figure 13 below shows both historical and future land use scenarios, for illustrative purposes again keeping carbon per acre constant rather than accounting for tree growth. The future BAU scenario from 2011 to 2040 shows continued loss of carbon, but at a less rapid rate of change. Under the BAU, terrestrial carbon storage is 365 million metric tons in 2011, and is projected to decline to 360 million metric tons by 2040. This equals a loss of 5 million metric tons in addition to the 7 million metric ton loss in carbon which occurred from 1990 to 2011. In other words, total carbon loss under typical development patterns in Massachusetts from 1990 to 2040 would be 12 million metric tons if the BAU scenario is realized.

In contrast, under the Smart Growth scenario, future carbon storage under land use characterized by denser development patterns is estimated as 367 million metric tons in 2040, or an additional 2 million metric tons above the carbon storage level in 2011. However, total carbon storage is still 5 million metric tons below the 1990 level.

Changes in MA terrestrial carbon stock resulting from land cover alterations, 1990–2040

Figure **13**



Source: Abt Associates and Applied GeoSolutions analysis (2015).

3.2 Measuring GHG Changes from Ecological Restoration in Massachusetts Wetlands

With a goal of providing a tool for MassDER to incorporate GHG considerations into the process of selecting and prioritizing future ecological restoration projects in Massachusetts wetlands, EEA's consultants developed a methodology and tool referred to as the 'Blue Carbon Calculator,' for estimation of changes in GHG emissions from coastal, riverine, and inland wetland ecosystems.

Summary of Key Findings: Wetlands Ecosystems

- Initial estimates from the Massachusetts Blue Carbon Calculator for seven MassDER ecological restoration projects show a cumulative net reduction in GHG emissions by 2050 of approximately 8,400 metric tons of CO_2e.
- Many opportunities exist to increase carbon storage in soils of Massachusetts coastal, riverine, and inland wetlands, while also delivering other ecological benefits. Even more significant GHG reductions can be realized by restoration activities which reduce methane emissions.
- However, major data gaps need to be addressed before the GHG impacts of ecological restoration and other wetlands management activities can be measured with sufficient accuracy for participation in carbon markets. Improving emissions factors for carbon accumulation in aboveground vegetation and changes in methane emissions from reconnecting tidal waters would significantly improve results.

The Blue Carbon Calculator is a user-friendly, first-generation tool for calculating GHG emissions from soils resulting from wetlands management restoration activities most typical to Massachusetts.[40] The Calculator estimates changes in GHG emissions for two primary categories of restoration activities relevant to Massachusetts wetlands: 1) re-wetting wetlands or restoring wetlands from a drained state (e.g., removal of dams or barriers to restore hydrology); and 2) 'Wetlands remaining wetlands,'[41] or restoration activities occurring on lands that are saturated under both pre-and post-restoration condition, but which may alter GHG emissions on those lands (e.g., conversion of open fresh water to salt (or vice versa)). As additional data and guidance become available, emissions factors for these calculations should be updated.

3.2.1 Results for Selected Massachusetts Wetlands Restoration Projects

The Blue Carbon Calculator was applied to seven MassDER ecological restoration projects located throughout Massachusetts. According to the summary of results shown in Table 5, the majority of restoration activities create net reductions in GHG emissions over a 50-year period,

[40] Because the Calculator derives in part from the IPCC's methodology and data, which includes emission factors associated with loss and/or destruction of wetlands, it is also capable of calculating GHG emissions from loss of wetlands even though such activities are highly uncommon in Massachusetts—Federal and state regulations generally limit activities which result in wetlands destruction.

[41] This is category which uses IPCC's terminology, and methods to Massachusetts restoration projects which do not fall within the activity categories described above.

ranging from a nearly 15 metric ton reduction in CO_2e at Ox Pasture, to almost a 12,500 metric ton reduction at year 50 from the Town Creek project. Eel River is the only restoration project evaluated which is estimated to increase GHG emissions—re-wetting of mineral soils in this cranberry bog restoration could lead to an increase in methane emissions equal to 7,600 metric tons of CO_2e by year 50. In sum, the Calculator estimates the net effect of MassDER restoration activities by year 50 to be a net reduction of 8,400 metric tons of CO_2e.

Table 5

Summary of GHG impacts from wetlands ecological restoration projects in Massachusetts

Restoration Project	Management/ Wetland Change Activity	Cumulative GHG Emissions (metric tons of CO_2e)[A]					
		Years Post Project					
		1	10	20	30	40	50
Damde Meadows	Wetlands remaining wetlands	-22.6	-225.5	-451.1	-676.6	-902.1	-1,127.6
Eel River	Rewetting	152.2	1,521.7	3,043.3	4,565.0	6,086.7	7,608.3
Mill River	Wetlands remaining wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Muddy Creek	Wetlands remaining wetlands	-48.0	-479.8	-959.5	-1,439.3	-1,919.1	-2,398.9
Ox Pasture	Wetlands remaining wetlands	-0.3	-2.9	-5.9	-8.8	-11.7	-14.7
Town Creek	Wetlands remaining wetlands	-249.9	-2,498.9	-4,997.8	-7,496.7	-9,995.6	-12,494.6
Wekepeke Brook	Wetlands remaining wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Total		**-168.5**	**-1,685.5**	**-3,370.9**	**-5,056.4**	**-6,741.9**	**-8,427.4**

[A] Negative values represent net GHG benefits.

3.2.2 Limitations of the Massachusetts Blue Carbon Calculator

Overall, there are major gaps in empirical data describing GHG emissions and reductions for activities on wetlands within Massachusetts and New England. Of particular relevance to the

Massachusetts ecological restoration projects are the remaining data gaps for carbon storage and accumulation rates from adding or improving vegetative cover, and in some cases for methane emissions from tidal wetlands.[42] For many of the entries in the Blue Carbon Calculator, however, there is an absence of data to support calculation.[43] In light of current data gaps, the Blue Carbon Calculator should be considered a first-order tool which is designed to accommodate continuous refinement to improve the accuracy and precision of future estimates as more regionally-specific data become available. Despite these limitations, the Calculator can provide MassDER with initial insights about the magnitude of changes in GHG emissions associated with restoration activities, and enables at least an ordinal ranking of the contribution of future restoration projects to climate goals.

3.3 Implications for Policy and Management

3.3.1 Forests and Terrestrial Ecosystems

Although the rate of conversion of forests and other lands to development in Massachusetts suburban communities has slowed in recent years from its highest levels in the 1990s, ongoing land use change to accommodate new development influences the Commonwealth's climate goals in two important ways—not only will the loss of terrestrial carbon storage from lands converted to buildings and roads be difficult to reverse in the future, this type of development also engenders new GHG emissions from vehicle travel and buildings in the suburban and exurban communities where much of the Commonwealth's growth is projected to take place over the next 25 years.

Given the compound effect of low-density development on future terrestrial carbon storage and energy use in other sectors, policies designed to achieve denser development and VMT reductions could combine with policies that also incentivize retention of terrestrial carbon onsite. Carbon saved via retention of existing trees would be additional to that projected under the Smart Growth Scenario. Additional research leveraging the analytic tools developed under this effort and MassGIS' geospatial data characterizing future land use change can help EEA to prioritize and target geographic areas of greatest concern for potential losses in terrestrial carbon storage. The Green Communities program offers a ready-made means for conducting an outreach campaign to municipalities to describe the duel implications for GHG impacts of clearing remaining forests and landscapes. Green Communities could also serve as a means for establishing and promoting specific incentives and measures aimed at tandem goals of smart growth and terrestrial carbon retention.

[42] Many of these data gaps are being addressed through a number of research projects currently underway. A number of ongoing studies by Federal agencies (e.g., NOAA, NASA) will inform the development of regionally-specific emission factors.

[43] Particular focus on the GHG emissions and removals for restoration activities involving cranberry bogs, standing waters, and inland organic soils (including forested wetlands) would greatly improve results from future applications of the Calculator.

3.3.2 Wetland Ecosystems

Despite the current gaps in data, the Massachusetts Blue Carbon Calculator provides valuable information on the relative direction and magnitude of GHG impacts that can help MassDER to prioritize future ecological restoration efforts. An opportunity for the Commonwealth to elevate the potential role and value of blue carbon management activities (and associated GHG reductions) is to conduct a review of all state policies and regulations which affect wetlands management and restoration. At the Federal level, agencies are reviewing regulations which govern wetland management to assess the potential to include GHG mitigation benefits.[44] Federal agencies are also exploring options to enhance land management activities which fall within their jurisdiction. The application of carbon markets is also being explored as a potential mechanism to provide funding for improved wetlands management activities.

The most attractive opportunity for potential GHG benefits from coastal wetlands comes not through additional carbon storage (which results in positive but small gains in carbon), but through avoiding methane emissions with rewetting drained organic soils, and, particularly for the Commonwealth, reducing methane emissions by reconnecting disconnected tidal waters. Avoiding methane emissions offers an immediate, long-term and permanent benefit that can be recognized for many years after the restoration activity.

California is an example of a state that has made adjustments to policy to include wetlands within the scope of their climate change mitigation plans and activities. In May 2015, the California Department of Fish and Wildlife (CDFW) announced the selection of 12 projects which will receive grant funding to restore wetlands that reduce GHG emissions and provide other ecological benefits. California's Wetland Restoration for Greenhouse Gas Reduction Grant Program focuses on projects with measureable objectives that lead to GHG reductions in wetlands from mountain meadows and coastal lowlands.

Developing emissions factors for certain management activities typical to Massachusetts, such as restoring floodplain and forested wetlands, and cranberry bog naturalization, as well as methane emissions from standing waters behind artificial barriers to drainage, would greatly improve the accuracy and comprehensiveness of the Blue Carbon Calculator. Encouraging additional research by New England-based researchers to address remaining data gaps would not only enable the Commonwealth to improve the Calculator and generate more accurate assessments of the GHG mitigation implications of management activities and restoration of wetlands, it would also improve regional and Federal estimates of GHG emissions associated with wetlands ecosystems.

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[44] Pendleton, L. et al., 2015.

Chapter 4: FUTURE 2030 AND 2050 SCENARIO ANALYSES

The GWSA includes a long term goal of reducing emissions by at least 80%, relative to the 1990 level, by 2050. It also requires EEA to set specific emission limits for 2030, 2040, and 2050. To maintain consistent progress toward the GWSA goal for 2050, it is particularly important to set a 2030 emission limit and finalize a plan for meeting that limit by the end of 2020. Governor Baker took an important first step in August 2015 when he joined fellow New England Governors and Eastern Canadian Premiers in adopting a 2030 GHG emissions reduction marker range of 35–45% below the 1990 level.[45] In looking forward to 2030 and beyond, the Baker-Polito Administration will consider this reduction marker while focusing analytical efforts on identifying policies that have the most potential to cost-effectively reduce GHG emissions in Massachusetts.

The need to achieve large reductions in later years will guide planning for 2030, consistent with the GWSA requirement to establish an emission limit that maximizes the potential to reduce GHG emissions by at least 80% by 2050, relative to 1990 emissions. A common conclusion across past 2050 planning studies, including the study that was completed to support the original CECP, is that the only viable path to deep reductions in GHG emissions is through a combination of reduced energy consumption (through increased energy efficiency in vehicles and buildings), expanded availability of clean electricity, and electrification of the transportation and heating sectors. Electrification poses a particular challenge because of the need for new infrastructure, including transmission lines, storage capacity, and consumer-facing components such as public vehicle charging stations and smart meters. The scope of the challenge can be summarized in three words: reduce, electrify, and decarbonize.

Because electrification requires consumers to replace equipment that can last 20 years or more, and because adoption of electric vehicles and modern efficient electric heating systems is only beginning, electrification must be a particular focus in planning for 2030, even if reductions achieved by that date are modest. Non-electric renewable heating technologies are subject to similar timing constraints. Efforts to decarbonize the electricity supply and reduce energy consumption are no less important, but they are further along, and can likely be achieved at necessary levels through continued focus on existing policies, at least through 2030.

An important part of this work will be to identify policies that are critical for achieving 2030 and 2050 limits because they have the potential to increase rapidly or compound over time. Fortunately, many of the policies included in this CECP Update are in that category. As examples, several such policies are described in more detail below. Note that this list is not comprehensive, and that quantitative information is provided in parenthesis below to emphasize that it is included for illustrative purposes only, and does not necessarily represent EEA's

[45] http://www.coneg.org/Data/Sites/1/media/39-1-climate-change.pdf

expectations regarding policies that will be in place in 2020, or expected reductions from those policies.

- ***Clean Energy Imports*** – Additional clean energy imports are necessary to complement the existing RPS program. The RPS program is necessary to reduce electricity sector emissions, and will continue to deliver increasing amounts of zero-carbon electricity to consumers in Massachusetts each year. However, as the percentage requirement for 2050 is only approximately 50% and many RPS eligible technologies are intermittent resources, more clean energy supply is needed. Likely sources include imported hydroelectric power, or hydroelectric power combined with on-shore wind that is accessed by new transmission infrastructure. As noted elsewhere in this CECP Update, significant progress towards increasing clean energy imports is expected by 2020. More importantly for 2030 and 2050, continued expansion beyond the 2020 level appears viable, providing a possible path to deep reductions by 2030 and a fully decarbonized electric sector by 2050. Additional supply, such as could be provided by advanced nuclear power plants or fossil fueled power plants with carbon capture technology, may also contribute, possibly encouraged by a comprehensive *Clean Energy Standard*, such as is discussed elsewhere in this CECP Update.

- **Large-scale RPS-eligible Resources** – Procurement of large-scale RPS-eligible resources such as on-shore and off-shore wind eventually may be necessary to achieve carbon-free electrification in the region.

- ***Advanced Building Energy Codes*** – The long lifespan of buildings means that the emissions profile in this sector is slow to change, and requires early action to achieve significant cumulative savings. In order for fossil fuels to be available for higher value uses in 2050 such as transporting of goods and people in heavy-duty vehicles and airplanes, demand for low grade uses such as space heating in buildings needs to be dramatically reduced. Fortunately, this is one of the most cost-effective and economically beneficial policy options, particularly in new construction, where we are already beginning to see zero energy buildings being built in Massachusetts.[46]

- ***Federal and California Vehicle Efficiency and GHG Standards*** – Standards are in place to increase vehicle efficiency each year through 2025. Even if standards do not increase after that, reductions will continue as older vehicles are replaced by more efficient new vehicles. (EEA's consultants estimated that improved vehicle efficiency could reduce GHG emissions by approximately 6 MMTCO$_2$e over the 2020–2030 time period.)

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[46] Near zero energy codes have recently been adopted in most European countries (http://ec.europa.eu/energy/en/topics/energy-efficiency/buildings/nearly-zero-energy-buildings), and low and zero net energy low-rise construction is slowly gaining market acceptance in MA.

- ***Clean/Electric Vehicle Incentives*** – In order to achieve the deep reductions required by 2050, it will be necessary to power the transportation sector largely with electricity. As discussed elsewhere in this CECP Update, incentives are in place to initiate this transition. Over time, improving technology and expanding infrastructure will increase the ability of electric vehicles to meet the needs of consumers, especially if accompanied by policies that encourage use of clean vehicles, such as preferential parking. (EEA's consultants estimated that expanded use of electric vehicles could reduce GHG emissions by approximately 1 $MMTCO_2e$ over the 2020–2030 time period, over and above reductions that will be realized through greater vehicle efficiency.)

- ***Smart Growth*** – It takes a long time for new growth to substantially alter existing land use patterns, and the amount of driving that results from those patterns. As new homes and businesses are sited and infrastructure improvements are made over future decades, however, the synergistic effect of applying multiple smart growth techniques can substantially reduce vehicle miles traveled for existing and new households alike.

- ***Appliance and Product Standards*** – Appliance standards that reduce energy consumption from electric and gas-fueled appliances will take time to deliver reductions, and must therefore be in place by 2030 in order to be fully implemented by 2050. (EEA's consultants estimated that improved appliance standards could reduce GHG emissions by approximately 2.0 $MMTCO_2e$ over the 2020–2030 time period.)

- ***Developing a Mature Market for Renewable Thermal Technologies*** – Continued and accelerated renewable thermal installations are required to electrify the buildings sector's heating and cooling loads and utilize Massachusetts' clean electric supply. Renewable thermal policies must continue to be integrated into *All Cost Effective Energy Efficiency* goals. These policies will need to incentivize the creation of a robust and independent renewable thermal market that will deliver cost effective technologies across the state and to all income sectors.

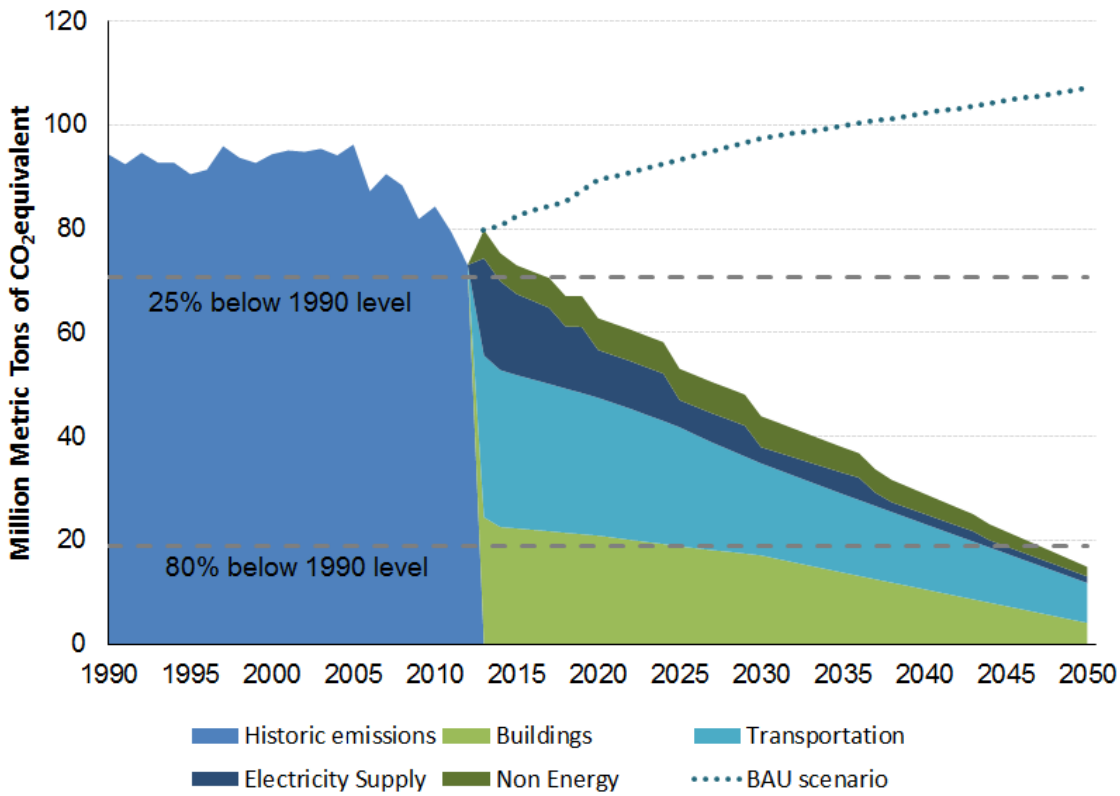
- ***Tree Retention and Planting to Reduce Heating and Cooling Loads*** – While tree retention and planting may not deliver large reductions by 2030 compared to other policies, it is included in this list because it illustrates the value of advance planning. Trees take decades to mature, so planning for 2050 must begin soon.

As noted above, this is not a comprehensive list. In fact, nearly all of the policies included in this CECP Update will need to be retained or expanded to ensure that Massachusetts is on a trajectory to reduce emissions by at least 80% in 2050, relative to 1990, as required by the GWSA. Therefore, developing a 2030 emission limit and plan will require a comprehensive review that is beyond the scope of this CECP Update.

In order to support ongoing efforts to look beyond 2020, the energy sector accounting tool mentioned above is being populated with draft projections for 2030 and 2050 developed by EEA's consultants. For 2030 and 2050, two separate scenarios are being created, based on EEA input and the policy-specific quantitative analyses discussed above. The two scenarios differ in the degree to which they rely on electrification or improved energy efficiency, but are broadly similar because all three components (reduce, decarbonize, and electrify) must be in place by 2050. Figures 14 and 15 are included below to illustrate this analytical approach. Figure 14 depicts how emissions change across sectors over time for one scenario, and Figure 15 shows that the two scenarios deliver similar results. These graphs are intended to illustrate EEA's intended analytical approach to addressing GWSA requirements as they relate to 2030 and 2050, and do not represent EEA's expectations regarding emissions in future years. Further analysis of 2030 and 2050 is underway at EEA, but is beyond the scope of this CECP Update.

Illustrative long term GHG reductions by sector

Figure **14**

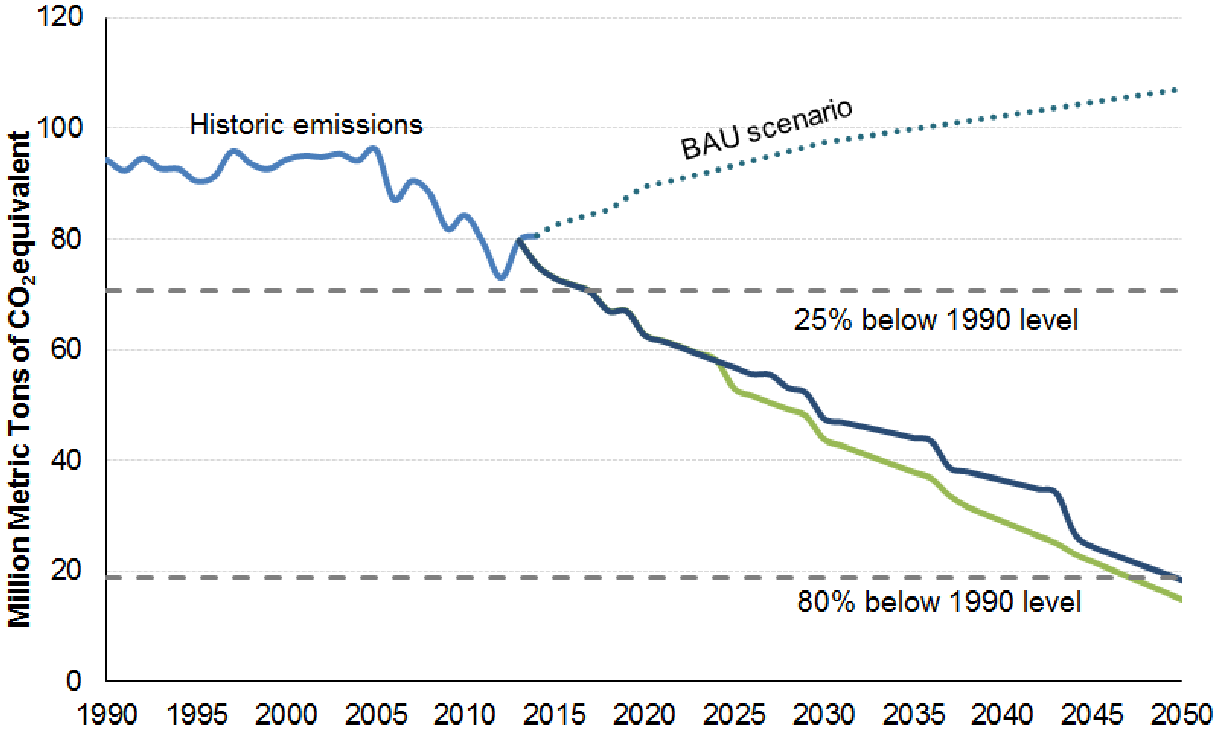


Source: Abt Associates (2015).

Illustrative emission reductions scenarios

Figure

15



Source: Abt Associates (2015).

Appendix: GHG MITIGATION POLICIES

Overview

This appendix includes a summary of each of the policies included in this CECP Update. Table 6 serves as a table of contents for the policy appendix, and also provides a comparison with the original CECP. While all policy summaries have been updated, many policies have not changed significantly. To ease review by readers familiar with the original CECP, additions, subtractions, and name changes are indicated in Table 6.

Policies in the original CECP and the CECP Update

Table 6

Policy in CECP Update	Policy in original CECP – For Reference	Page
All Cost Effective Energy Efficiency	(Retained)	57
Advanced Building Energy Codes	(Retained)	59
Building Energy Rating and Labeling	(Retained)	61
Expanding Energy Efficiency Programs to Commercial and Industrial Heating Oil	(Retained)	64
Appliance and Product Standards	(Retained)	66
Developing a Mature Market for Renewable Thermal Technologies	Developing a Market for Solar Thermal Water and Space Heating	68
Tree Retention and Planting to Reduce Heating and Cooling Loads	(Retained)	70
Federal and California Vehicle Efficiency and GHG Standards (CAFE/Pavley)	(Retained)	74
Federal Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Vehicles	(Retained)	76
Federal Renewable Fuel Standard (RFS) and Regional Clean Fuel Standard (CFS)	Federal Renewable Fuel Standard (RFS) and Regional Low Carbon Fuel Standard (LCFS) (Renamed)	78
Clean/Electric Vehicle Incentives	Clean Car Consumer Incentives	81
GreenDOT	(Retained)	83
Smart Growth	(Retained)	86
Coal-Fired Power Plant Retirement	More Stringent EPA Power Plant Rules (Renamed)	89
Renewable Portfolio Standard (RPS)	(Retained)	90
Clean Energy Imports	(Retained)	92
Clean Energy Standard (CES)	Clean Energy Performance Standard *(Renamed)*	94

Policy in CECP Update	Policy in original CECP – For Reference	Page
Regional Greenhouse Gas Initiative (RGGI)	(Retained)	96
Electric Grid Modernization	(New Policy)	98
Reducing GHG Emissions from Plastics Combustion	(Retained)	99
Stationary Equipment Refrigerant Management	(Retained)	101
Reducing SF_6 Emissions from Gas-Insulated Switchgear	(Retained)	103
Reducing Emissions from the Natural Gas Distribution Network	(New Policy)	105
MEPA GHG Policy and Protocol	(Retained)	107
Leading By Example (LBE)	(Retained)	109
Green Communities	(Retained)	111
Consideration of GHG Emissions In State Permitting, Licensing and Administrative Approvals	(Retained)	114
(Combined with All Cost Effective Energy Efficiency)	“Deep” Energy Efficiency Improvements for Buildings	-
(Combined with Smart Growth)	Sustainable Development Principles	-
(Combined with Federal and California Vehicle Efficiency and GHG Standards (CAFE/Pavley))	Reducing GHG Emissions from Motor Vehicle Air Conditioning	-
(Removed)	Pay As You Drive (PAYD) Auto Insurance Pilot	-

All Cost Effective Energy Efficiency

Policy Summary: The Massachusetts Green Communities Act requires that electric and gas utilities pursue all cost-effective energy efficiency, i.e. eliminating energy waste whenever it is cheaper to do so than to buy additional supply. Since 2010, the utility program administrators (PAs), on behalf of the Commonwealth, have invested more than $8.1 billion, with an anticipated return of over $22 billion in benefits for electric and gas ratepayers. The PA-delivered programs, branded as “Mass Save®,” operate under the guidance of the Energy Efficiency Advisory Council (EEAC), which represents a broad range of stakeholders and is chaired by the Department of Energy Resources (DOER). Plans, budgets, and results are further reviewed and approved by the Department of Public Utilities (DPU).

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	5.4 $MMTCO_2e$	5.8%[47]
Electric savings and GHG reductions in 2020	9,000 GWh[48], 4.45 $MMTCO_2e$	4.7%
Natural gas savings and GHG reductions in 2020	19.7 MMBTU, 0.8 $MMTCO_2e$	0.9%
Heating oil savings and GHG reductions in 2020	3.2 million MMBTU, 0.2 $MMTCO_2e$	0.2%
Cumulative net benefits 2010-2018	$14.4 billion	

In support of this utility program requirement, the Commonwealth has adopted a suite of enabling policies and initiatives that increase participation and savings from the PA-implemented programs. Collectively this suite of energy efficiency policies has earned Massachusetts the number one state ranking for energy efficiency for the past five years.

Enabling state energy efficiency initiatives and cross-cutting policies:

Policy	Sector	Agency(ies)
MEPA GHG Policy and Protocol	Large commercial developments and power plants	EEA/DOER
Leading By Example	State-owned and leased properties and fleets	DOER/DCAMM
Green Communities	Municipal properties[49], fleets and stretch code	DOER/MassDEP

[47] The 5.4 $MMTCO_2e$ and 5.8% is based on the new savings from the efficiency programs since 2009, due to the expansion to ‘all cost-effective’ criteria in the Green Communities Act. The program savings from efficiency spending prior to 2010 are excluded, since the emissions trend in the Business as Usual (BAU) projection is estimated to include them.

[48] Energy savings in 2020 are based on the full value of efficiency programs, including the spending levels that existed prior to 2010, in order to be consistent with DOER required reporting to DPU (this differs from the calculation of GHG savings, as discussed in prior footnote).

[49] Municipal properties include waste water treatment plants, schools and streetlights as well as municipally operated buildings such as town halls and libraries.

Building Energy Rating and Labeling	Existing homes and commercial offices	DOER
Combined heat and power	On-site generation	DOER
Zero Net Energy Buildings	New residential and commercial construction	DOER

Clean Energy Economy Impacts: From 2010 through 2018, the Mass Save program has committed to investments of $8.1 billion in energy efficiency. As a result, energy efficiency accounts for the majority of the clean energy sector jobs in Massachusetts. In addition, the program commitments through 2018 are forecasted to generate $14.4 billion in net benefits, largely in avoided future costs of energy and avoided energy infrastructure costs. These savings will largely stay in the local economy rather than flowing out of the Commonwealth, while reducing living costs for residents and operating costs for businesses.

Rationale: Investment in energy efficiency is generally more cost-effective than investing in building new power plants to serve growing electric service needs, or supplying more gas or oil heating fuel to buildings. However, due to various market barriers, including lack of upfront capital for energy efficiency upgrades and misaligned timing for investment and recouping savings, investments in energy efficiency fall short of optimal, both for an individual organization and for the Commonwealth as a whole.

GHG Impact: The combined electric and gas PA programs will reduce emissions by an estimated 5.4 $MMTCO_2e$ in 2020. This 2015 estimate is updated to reflect the reality that electric energy efficiency measures are saving electricity from generation sources that are substantially less carbon intensive than was forecast in 2010. As a result, emissions savings per MWh are lower, while the level of investment in energy efficiency and savings as a percentage of total customer load are meeting plan goals.

Other Benefits: By reducing fossil fuel combustion, the Mass Save program helps to reduce the clearing wholesale market price for electricity and defer the need to invest in new generation, transmission, and local distribution networks. In addition, these programs are a significant source of in-state jobs, and the fuel savings reduce hazardous air pollutants—providing public health and environmental benefits.

Cost: From 2010 to 2018, the electricity, natural gas, and oil efficiency programs are estimated to generate $22.5 billion of economic benefits at a cost of $8.1 billion, yielding $14.4 billion in net benefits for the Commonwealth largely in avoided future costs of energy and energy system expansion. As such, this program is an excellent investment, rather than a cost to the economy.

Next Steps: Innovation is continuing to transform the market for energy efficiency. Most notably in the lighting sector, Massachusetts has used upstream incentives to accelerate a shift to LED lighting coupled with digital controls, making the Commonwealth an international leader in deploying advanced lighting technology. The emerging “internet of things,” in conjunction with smart grid investments, provides future possibilities for energy efficiency and demand response to meet our electric and heating demands more cost-effectively than from new generation.

Advanced Building Energy Codes

Policy Summary: In 2008, Massachusetts adopted a requirement that building energy codes meet or exceed the latest International Energy Conservation Code (IECC) and stay current with its three-year update cycle. In addition, the Commonwealth developed one of the first "stretch" energy codes. The stretch code moves away from the traditional code approach that prescribes specific energy requirements for new building components (levels of wall insulation, rates of air leakage, etc.), toward a performance-oriented code that mandates a percentage reduction in total building energy use, while allowing developers to make their own design choices on how to achieve that reduction. This policy would continue the transition to performance-based codes by 2020 that go beyond the IECC codes in terms of efficiency while reducing the length and complexity of building code.

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	1.5 $MMTCO_2e$	1.6%[50]
Natural gas GHG reductions in 2020	1.2 $MMTCO_2e$	
Heating oil GHG reductions in 2020	0.3 $MMTCO_2e$	

Clean Energy Economy Impacts: Building design and construction is one of the largest economic sectors in the U.S., and is a major employer of skilled labor, with excellent potential for clean energy job growth. Each year, new construction is estimated to account for 0.5 percent to 1 percent of the total building stock. In addition, major renovations of existing buildings trigger code compliance requirements, and, by 2050, will affect the majority of existing buildings. The avoided fuel and electric costs due to enhanced codes reduce the long-term operational costs of real estate and increase their market value and durability.

Rationale: Massachusetts has historically been at the forefront of energy efficiency in state building codes. This policy position is strongly supported by the underlying economics, emphasized in analyses such as the McKinsey U.S. climate policy studies, which point to modernized energy codes as one of the most cost-effective climate mitigation strategies. Furthermore, given the long lifespan of the building stock, decisions made today affect energy demands of the buildings sector for the rest of the century and beyond.

Design Issues: Building energy codes are relatively complex, particularly for commercial buildings, and there are numerous stakeholders across the design and construction supply chain to factor into the rate of improvement that is possible. The shift from prescriptive codes to performance-based codes that directly measure and reduce energy waste presents a clear opportunity to improve energy codes.

In the residential sector, the Massachusetts Department of Energy Resources (DOER) 'Pathway to Zero' program recently gave awards to approximately 200 homes designed with

[50] Based on updated 2015 analysis of building permits in all towns and cities in MA by Abt Associates.

performance-based Home Energy Rating System (HERS) index ratings of zero or lower. This demonstrates that the Commonwealth has several industry-leading developers who can build and sell 'net zero energy' homes at both market and affordable housing prices today. However, a broader market transition to low energy buildings will take time, requiring incremental improvements to building codes and a supporting framework of training, outreach, incentives and technical assistance. In 2013, more than 6,300 new homes (43% of new units) in Massachusetts used the performance energy code, with an average HERS score of 59. At the end of 2015, there are over 160 towns and cities that have elected to adopt the stretch energy code, which requires HERS ratings on new homes. A gradual ratcheting down of the maximum allowable HERS index for new construction allows home builders and their subcontractors the time to retrain and modernize their design practices to meet performance targets without significant changes to the cost of construction.

Costs: On average, up-front design and construction costs are likely to increase marginally as energy code performance increases. To date, cost estimates have been in the 1 percent to 3 percent range for both residential and commercial buildings that achieve a 20 percent improvement over the base code. In return for this upfront investment, the developer is able to more clearly differentiate new construction as higher-performance than existing buildings, and the tenants of the building receive significant energy cost savings that outweigh the upfront costs.

Legal Authority: The building energy code is governed by the independent Board of Building Regulation and Standards (BBRS). The Massachusetts Department of Public Safety (DPS) and DOER will continue working together to craft future energy code provisions for consideration by the BBRS.

Implementation Issues: The buildings sector has followed a market-led transition to performance-based energy codes using HERs ratings and LEED/ASHRAE energy modeling remarkably smoothly. However, as energy code requirements change, there is an ongoing need for training and technical assistance. In order to support and improve energy code compliance, Mass Save® utility funding has been committed beginning in late 2014 to provide ongoing training in best practices to builders, designers, and subcontractors working in the new construction and retrofit markets for both commercial and residential sectors.

Uncertainty: With the baseline energy codes in Massachusetts now tied to decisions of the International Code Council (ICC), there is a delegation of authority to this national body. The uncertainty inherent in relying on the ICC could be reduced by laying out an energy code road map at the state level. The impact of energy codes on GHG emissions in any particular year also depends greatly on the weather.

Building Energy Rating and Labeling

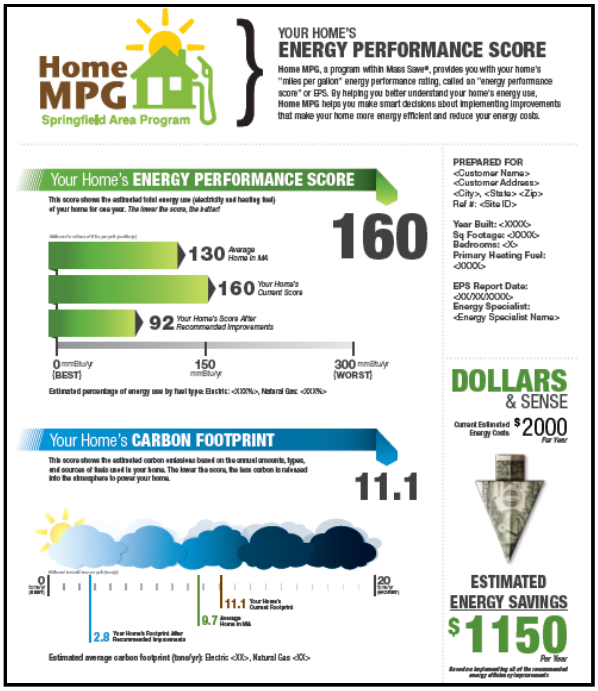
Policy Summary: The current real estate market operates without the explicit consideration of energy performance of the property—a significant factor in future operating costs. Potential building owners or tenants of either residential or commercial buildings make major investments without the ability to compare the energy performance of the buildings they are interested in. This policy would address this market barrier by introducing an energy rating program designed to facilitate "apples-to-apples"‖ comparisons between buildings, i.e., the buildings equivalent of the EPA MPG rating on cars and light trucks. This policy complements existing efforts to track actual energy use through utility billing data, but the energy ratings provided through this policy would be based on the physical characteristics of the building (e.g., level of insulation, efficiency of the HVAC system), and are intended to be independent of tenant or user behavior. Such ratings are known as "asset" ratings. The Massachusetts Department of Energy Resources (DOER) implemented pilot programs from 2012 to 2014 that provided "asset ratings" for both residential and commercial buildings in collaboration with the Mass Save programs.

Clean Energy Economy Impacts: Building energy labeling is anticipated to enable significant additional investments in energy efficiency as a path to identify energy savings opportunities in buildings. This investment in turn leads to large reductions in fuel expenses, and creates and supports clean energy jobs in residential and commercial remodeling and construction. Less spending on imported fuel will keep more money in the state economy and thereby create additional jobs.

Rationale: At present, the market is providing a glimpse of the potential for an "MPG rating" for buildings. Boston and Cambridge have implemented building energy disclosure ordinances that require commercial buildings to share annual energy use data with the city via Portfolio Manager, and the city then makes this information publicly available. However, this data reflect the energy usage of a building, and does not reflect the building assets or identify energy savings opportunities.

A similar story is apparent for the residential market. The use of home energy scorecards is gaining traction nationally within both state energy efficiency programs and the real estate industry. At the time of this writing, several states, including Vermont, Connecticut, Rhode Island, New York, New Jersey, and Oregon, are implementing scorecards. The Federal Housing Authority (FHA) recently announced that buyers of homes with an above-average energy score (measured by Department of Energy's (DOE) "home energy score") will be eligible for a slightly higher loan amount as compared to buyers of average or below average homes.

Design Issues: Any energy benchmarking and rating metric needs to be clear, transparent, and trusted if it is to support increased energy efficiency investment. However, residential and commercial real estate markets face different design issues. For the relatively homogenous residential market, a comparison of total annual energy needs (based primarily on heating and standardized electric plug loads) is likely to be the most intuitive metric. As shown below, the total annual home energy needs (expressed in MMBtu) was the primary metric on the energy performance scorecard piloted in Home MPG. The scorecard also included the home's source-based carbon footprint, expressed as tons of CO2 emissions. The scorecard presented these metrics for the home in its current state, as well as the expected metrics if recommended efficiency improvements were made and a comparison to the average home in the pilot communities.



For the more diverse commercial real estate market, an accurate comparison of energy needs per square foot (primarily heating, cooling, ventilation, lighting and plug loads in office/retail/lab spaces) is the generally accepted metric.

The DOER, in collaboration with a public and private sector team, undertook a pilot program for commercial asset rating focused specifically on office buildings in Eastern Massachusetts.

GHG Impact: The GHG impact for this policy is indirect, in that it enables larger and more targeted energy efficiency investments in the covered real estate markets. Two major constraints to energy efficiency investment are the lack of awareness and identification of potential savings, and the lack of credible metrics to support financing from lenders, including lenders that follow the FHA's recent decision to make buyers of homes with an above-average energy score (measured by DOE's "home energy score") eligible for a slightly higher loan amount as compared to buyers of average or below average homes. This policy tackles both of these market failures, and enables smarter real-estate investment decisions.

Costs: The primary costs of energy asset rating and labeling programs is in the initial building assessments. The groundwork laid by the recent pilot programs implemented by the Commonwealth will reduce implementation costs associated with any broader statewide deployment.

In the commercial sector, DOER's Building Asset Rating (BAR) program found that whole building energy assessments done using streamlined energy modeling methods can be done at one-quarter to one-third of the cost as a traditional ASHRAE level 2 audit, with comparable results. In Home MPG, important strides were made regarding the capability of energy audit software to generate scorecards.

Potential Next Steps: The Commonwealth may opt to put such a requirement in legislation in order to provide longer term certainty for investors and businesses in the real estate marketplace. In fact, there is currently proposed legislation to incorporate home energy ratings into the Mass Save program, and to encourage integrating home energy rating and labeling into the residential real estate process.

Implementation Issues: If energy labeling pilot programs are subsequently expanded to a statewide level, having a large number of existing buildings to assess means that it will necessarily take many years to fully implement this policy. As a result, the timing of market coverage will likely vary in different market segments and different geographic areas around the Commonwealth.

Expanding Energy Efficiency Programs to Commercial and Industrial Heating Oil

Policy Summary: At present the electric utilities provide funding for heating-related efficiency measures in homes that use oil heat. There is no funding available for commercial and industrial (C/I) buildings that use fuel oil for heating. Expanding the programs to such customers could yield significant cuts in energy use and GHG emissions.

The Commonwealth took a small first step in the implementation of this policy when the Massachusetts Department of Energy Resources (DOER) decided to amend a regulation to allow a sliver of the commercial heating oil market (multifamily buildings) to participate in energy efficiency programs. Regulatory compliance is expected in 2016. The savings associated with this step are accounted for in the *All Cost Effective Energy Efficiency* policy.

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	<<0.1 $MMTCO_2e$[51]	<<0.1%
Oil savings in 2020	350,000 MMBtu	

Clean Energy Economy Impacts: These programs could result in increased employment in efficiency audits and installation of efficiency measures, and reduced spending on fuel oil imports, which keeps more money in the Commonwealth and thereby helps to provide jobs throughout the Commonwealth's economy. Companies using fuel oil could see lower operating costs, which increase their ability to continue operating in Massachusetts.

Rationale: The exclusion of C/I customers from oil heating efficiency programs is a significant missed opportunity for reducing energy use and GHG emissions. Given that heating oil is a relatively high-carbon fuel, and that the lack of programs in the past means that such buildings will typically have low efficiency levels, the savings both in energy and GHG should be relatively high per dollar of funds spent.

Design Issues: Although the statutory basis exists for the electric utilities to provide funding to C/I customers in the same way that they do for residential customers, DOER must promulgate a new regulation to realize this goal.

GHG Impact: A reduction in GHG emissions is estimated to be less than 0.1 $MMTCO_2e$ in 2020, assuming that C/I customers participate at the same rate, relative to their total use of heating oil, as do residential customers starting in 2018.

[51] The GHG reduction is shown as <<0.1 $MMTCO_2e$ (<<0.1%), because no significant reductions are expected by 2020.

Other Benefits: Non-CO_2 air pollutants from fuel oil will be reduced due to lower consumption, including reductions in SO_2, NO_x, and particulates.

Costs: Costs are relatively small since C/I customers constitute only about one-quarter of total heating oil consumption in Massachusetts, with the rest being residential.

Equity Issues: Heating oil customers do not pay into a specific efficiency funding pool, as do electricity and natural gas customers. However, in almost all cases, they are also electricity ratepayers who do not receive the heating efficiency incentives received by other non-gas heated electric customers.

Uncertainty: Measures to improve the efficiency of building shells, heating systems, and heating distribution systems are well known and there is extensive experience with them. Thus, there is little risk of not being able to achieve cost-effective energy and GHG savings. The primary source of uncertainty for C/I non-regulated fuel efficiency funding is the time required to generate savings once the policy is adopted.

Appliance and Product Standards

Policy Summary: The federal government, through the Department of Energy (DOE), is authorized to set energy efficiency standards for most major appliances, electronics, and other products. The DOE accelerated the rulemaking schedule for setting new standards between 2009 and 2013 which yielded several new standards, though the majority of savings will occur after 2020. In 2015, progress continues in setting new federal appliance standards. Nationwide, these are expected to yield major savings in both electricity and fuel costs for homeowners and businesses, and commensurate reductions in greenhouse gas emissions, with Massachusetts getting its proportional share.[52]

Massachusetts also has the option of setting its own appliance efficiency standards on the modest set of products not covered by federal action. State-level efficiency standards could generate a smaller set of additional savings on energy bills and emissions. These would require new legislation, and a couple of years to introduce. As a result, the energy savings would primarily accrue in the decades following 2020.

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	1.0 $MMTCO_2e$	1.1%
Electric savings and GHG reductions in 2020	2,105 GWh[53] 0.9 $MMTCO_2e$	1.0%
Natural gas savings and GHG reductions in 2020	1,628 billion Btu 0.1 $MMTCO_2e$	0.1%%

Clean Energy Economy Impacts: The reduction in lifetime costs by 2020, estimated by the Appliance Standards Awareness Project (ASAP) at over $350 million, are spread broadly across residents and businesses in Massachusetts. These energy savings will improve the cost of living for residents and reduce operating costs for businesses, making those funds available for more productive investments that help to keep jobs in the Commonwealth.

Rationale: As with most efficiency measures, appliance and product efficiency faces market barriers that result in consumers making short-term purchasing decisions that don’t reflect optimal financial decisions long-term. To some degree, this occurs because products, particularly appliances, are often bought on an emergency basis when an old item has failed. By updating product specifications based on producer best practices that reduce lifecycle costs without substantial capital cost increases, federal and state standards reward manufacturer innovation. In turn, consumers save through both lower capital costs for higher performing equipment and on energy costs over the lifetime of the equipment. Over time as the existing

[52] http://www.appliance-standards.org/sites/default/files/Progress_toward_3_billion_CO2_reduction_Sept_2015.pdf

[53] 2015 update from Marianne DiMascio of the Appliance Standards Awareness Project

stock of appliances turns over, these appliance standards drive large energy and greenhouse gas savings.

Policy Design and Issues: The federal government sets nationwide standards but, in some cases, those standards do not meet the climate-specific needs of individual states. Due to our colder climate and market demand for higher efficiency equipment, Massachusetts applied for a federal waiver to set a standard for gas furnaces higher than the 80 percent federal standard. The DOE denied Massachusetts' waiver request, but is now in the process of developing a higher national standard that is expected to provide future savings once implemented.

GHG Impact: The ASAP forecasts that the standards already adopted since 2010 or scheduled to take effect before 2020 will collectively reduce annual GHG emissions by over 1.1 $MMTCO_2e$ in 2020. The Massachusetts GHG inventory uses more state specific emission factors for 2020, and, accordingly, the forecast GHG emission benefits has been revised to 1.0 $MMTCO_2e$ to reflect this.

Other Benefits: The standards yield large savings in electricity, and spread costs broadly across the economy. The avoided criteria air pollution emissions also have significant public health benefits.

Costs: Incremental costs of production vary for each product, and are required to be less than the lifetime energy savings in each case in order for DOE to set a standard. Sample allowable incremental production costs are $52 for a refrigerator, $50 for a clothes dryer, and $2 for microwave ovens. Actual manufacturer implementation costs typically turn out to be significantly lower than the estimates forecasted by DOE as manufacturers and suppliers innovate.

Experience in Other States: Most standards are applied either nationally or regionally. California employs a policy of setting appliance efficiency standards not set by the federal government. Most state-level activities involve passing legislation to adopt standards based on California's standards and analyses.

Potential Next Steps: The federal government has preempted authority over all of Massachusetts' historical efficiency standards for products. Unless the Commonwealth applies for a waiver from a federal standard, Massachusetts must pass legislation to take further action on the topic. A bill based on California's most recent analysis on energy savings has been filed in the Massachusetts General Court in 2015, and this or similar legislation would need to be passed in order to add state appliance standards to the larger set of federal standards.

Uncertainty: Although the pace of federal rulemaking has hastened considerably, uncertainty remains about the effective dates of scheduled Federal rules or the likelihood of state legislation.

Developing a Mature Market for Renewable Thermal Technologies

Policy Summary: Policies are being implemented and designed to achieve a mature and self-sustaining market for renewable thermal technologies in both residential and commercial buildings. This support for the renewable thermal market, with such technologies as clean biomass, ground source heat pumps, and solar thermal, builds on work promoting solar hot water, and will facilitate a market transition to renewable fuels as the dominant fuels for heating purposes by 2050. The policy will also establish robust job and business growth in the renewable thermal sector in the Commonwealth.

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	1.0 $MMTCO_2e$	1.1%

Clean Energy Economy Impacts: Large reductions in fuel costs in exchange for investments in renewable thermal heating equipment will reduce the cost of living for residents and the cost of business for commercial customers. New installations will result in the growth of the renewable thermal industry in Massachusetts, and to a lesser extent, local maintenance work. Directly offsetting spending on imported fuel will keep more money in the region, and thereby create additional jobs in the broader state economy.

Rationale: Hot water and space heating are large energy users that do not require very high grade fuels (unlike motor vehicles for example). This makes them excellent candidates for active solar heating and other renewable fuels and technologies, including biomass and ground source heat pumps. The technology for active solar thermal heating, biomass, and ground source heat pumps has matured and comes with decade-long warrantees to protect the up-front investment. The relatively small market for renewable thermal in New England can benefit from industry support to accelerate its growth to the scale needed to maintain continued growth and provide a realistic option to interested customers.

Design Issues: Similar to the Solar PV industry in Massachusetts prior to its recent exponential growth, the small size of the renewable thermal market burdens it with high levels of soft costs in sales and marketing (finding customers and designing and installing well-sized systems). This forms a barrier to consumer awareness and competitive pricing in comparison to the dominant market share of fossil fuel-based heating systems. The hard costs of quality equipment are being driven down by global market growth. Once Massachusetts can develop a significant demand, entrepreneurial companies will likely be able to bring turn-key pricing down considerably.

GHG Impact: The CECP Update forecasts a 1.0 $MMTCO_2e$ reduction in emissions due to these renewable thermal technologies. More robust reductions are predicted from renewable thermal air-source heat pumps, but these reductions are included in *All Cost Effective Energy Efficiency* goals. Greenhouse gas emissions from biomass and biofuels used for thermal energy are important to consider, but Massachusetts policies will limit the eligibility of feedstocks (advanced biofuels and residue woody biomass) to those which demonstrate real and rapid GHG benefits, such as advanced biofuels and residue woody biomass.

Other Benefits: Expanding renewable thermal energy will create and expand businesses in Massachusetts in a manner similar to our early stimulation of the solar PV market. Jobs will include system marketing, design, finance, installation, and maintenance, along with manufacturing and fabrication of renewable thermal system components. In addition, a mature renewable thermal market complements *All Cost Effective Energy Efficiency* and *Advanced Building Energy Codes* policies.

Costs: In order to accelerate the market for renewable thermal systems, the Commonwealth should support either technology rebates or market based incentives.. Any state incentive should leverage existing incentives primarily from federal tax credits and the utility managed zero-interest HEAT loan program.

Equity Issues: As with any upfront capital intensive investment, the early adopters of renewable thermal systems are often relatively affluent homeowners, large well capitalized businesses, and the public sector that have the resources to take advantage of the long term benefits of renewable heating both for their bottom-line and co-benefits. As these early actors bring down the costs associated with marketing, these technologies become increasingly accessible and desirable to the broader market. Renewable thermal systems are often incentived and utilized in affordable multifamily complexes where energy savings impact the low income communities. Further promotion of renewable thermal technologies in the moderate and low income sector will be an active policy priority.

Experience in Other States: Eleven states and the District of Columbia have renewable thermal technologies as part of their Renewable Portfolio Standard.

Legal Authority: The Act Relative to Credit for Thermal Energy Generated with Renewable Fuels of 2014 directed “useful thermal energy” to be added to the alternative energy portfolio standard. The Massachusetts Clean Energy Center will continue to be authorized to provide technology based incentives as mandated in the Green Communities Act of 2008.

Implementation Issues: The perceived barriers to renewable thermal adoption can be summarized in the following four areas: (1) Upfront cost of system, (2) Lack of consumer education and confidence, (3) Shortage of experienced system designers and installers, and (4) Permitting costs and inspections. As the use of renewable thermal technologies continues to grow, especially in incentivized demonstration projects, these barriers will decrease.

Uncertainty: The market for renewable thermal technologies will be based on the savings these technologies can provide. Therefore, their market will vary as natural gas, electricity, and fuel oil costs fluctuate. As the need for these technologies and the savings they can provide grows, the technologies may continue to become more efficient and effective.

Tree Retention and Planting to Reduce Heating and Cooling Loads

Policy Summary: Since the Clean Energy and Climate Plan for 2020 was released, EEA—in partnership with the Department of Conservation and Recreation (DCR), the Department of Energy Resources (DOER), the Department of Housing and Community Development (DHCD), UMass Amherst, and several Gateway Cities and local non-profit organizations—has launched the Greening the Gateway Cities (GGC) urban tree planting program. The funding for this program is a mixture of DOER's Alternative Compliance Fund and the state capital and operating funds. At the 2016 investment rate of $8 million per year, the 57,000 target urban acres in the 26 Gateway Cities will have 5 trees per acre planted by 2026.

The EEA has recently worked with consultants to research and propose recommendations for a tree retention program. Retaining shade trees that otherwise would be removed during development or re-development is attractive, because research shows that removal of mature tree canopy around residences can quickly cause increased energy use. A tree retention program would provide best practices for tree retention during construction of housing within forested areas and within existing neighborhoods. It would provide model bylaws to municipalities, and propose incentives for municipalities and housing developers to encourage the retention of trees on construction sites using proven best practices.

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	<<0.1 $MMTCO_2e$[54]	<<0.1%

Clean Energy Economy Impacts: At full implementation in 2016, the GGC program will create 132 jobs for tree planters, foresters and administrative staff. It is anticipated that these jobs will be maintained from 2016 to 2026 to complete the Gateway City plantings. Tree planting is one of the only energy efficiency tools where all investments go to the local economy (tree nurseries are close by, tree planting crews are hired from the cities where planting occurs, etc.). A USDA economic study of tree planting reported a 2:1 economic multiplier when direct and indirect economic benefits are calculated. For an $8 million annual investment, this will result in $16 million of economic benefit to the Gateway Cities economies (and surrounding nurseries and their suppliers) per year for a 10 year period for a total of $160 million economic benefit. A benefit/cost analysis for the energy savings for this program found a 2.2 to 1 benefit to cost ratio over the 30 years of the program (present value at 4% discount rate and 1.5% increase in energy costs), and does not take into account economic or other benefits of tree planting.

Rationale: Many modeling studies conclude that planting trees in residential areas reduces summer cooling and winter heating costs. A large-scale tree planting program by the electric

[54] The GHG reduction is shown as <<0.1 $MMTCO_2e$ (<<0.1%), because no significant reductions are expected by 2020.

utility in Sacramento, CA planted over 500,000 trees since the 1990's, and has seen significant reductions in summer cooling energy, including peak load reductions. The EEA and DCR utilized the Asian Longhorned Beetle disaster in Worcester, MA to measure electricity usage before and after tree removal. This study showed that each 1% of canopy cover reduced summer electric usage by over 1%. A study in Hutchinson, MN measured neighborhood canopy cover and actual home energy usage, and found a similar correlation.

The benefit-to-cost ratio for retaining a mature tree that under business as usual would be removed is even more beneficial than planting trees. It takes an average of 30 years to grow a mature tree that will occupy about 550 square feet. Retaining mature trees when new homes are built would provide immediate heating and cooling savings.

Design Issues: The implementation of energy efficiency measures is more challenging in low income communities where there are high percentage of renters, old housing stock, and challenges with matching rebate offers. Neighborhoods where the majority of residents are renters have a unique challenge as both tenants and landlords must see the benefits to energy efficiency tools. The GGC has successfully implemented tree planting in high renter neighborhoods due to the unique appeal of new trees. The challenge with a tree density goal involves buy-in by many residents, especially renters and landlords, as most of the trees are planted in private yards where they can be cared for by residents and planting conditions are preferable to city streets. Based on research and the results of pilot implementation of the GGC program in three cities over the past four planting seasons, the program has adopted a goal of planting 5 trees per acre. This intensity of planting will result in approximately 5% of new urban tree canopy within the 57,000 target acreage in 30 years, when trees are fully grown. The GGC is the first of such program to have a neighborhood per-acre tree density target to reach energy efficiency goals.

Tree retention has several challenges to be effective. A baseline for business as usual needs to be established via tree inventories within the municipalities and a database for avoidable tree loss. Model best practices for construction approaches that can avoid tree damage or removal during construction typical of Massachusetts communities need to be developed utilizing well-tested best practices from other similar regions. Based on examination of similar programs across the country, EEA's consultants have developed a model by-law that includes commonly employed tree retention strategies such as requirements for minimum tree density, tree removal fees, and requirements for developers to place bonds on certain trees. Another outstanding design issue is how to structure an incentive program that could encourage developers to maintain tree cover beyond the minimum required level. This could be done by increasing density bonuses or adjusting setback requirements for developers who maintain tree cover beyond the required levels. A few communities do have tree retention bylaws, and there needs to be further examination of their effectiveness.

GHG Impact: The GGC program is scheduled to expand to eleven cities by the end of 2016 and will plant 8,800 trees per year. At this rate, the 57,000 acres will be planted by 2026. Based on tree size by 2050, it is estimated that the GGC program will be responsible for a reduction of

473,600 metric tons of CO_2e per year by 2050. The EEA is not projecting measureable GHG reductions by 2020.

Each average mature tree that is retained instead of being removed under business as usual represents about 1% of the canopy on an acre of residential land. Research by EEA shows that each 1% of canopy cover in a neighborhood will save 0.1 $MMTCO_2e$.

Other Benefits: Urban tree planting and retention have been demonstrated to have additional benefits including reducing air pollution, reducing stormwater and flooding, extending pavement life, reducing summer “Heat Island Effect” impacts, reducing peak load energy demand, and increasing property values and municipal tax revenues.

Costs: The GGC program will cost $8 million per year when fully implemented at the end of 2016. From 2014 to 2016, the program will expend $10 million. From 2017 to 2026, the program will cost $80 million. Thus, the total program cost will be $90 million. These costs assume a mix of program administration, direct costs (principally with DCR tree planting crews but also including local non-profits, private firms, and municipalities) that leverage the program with assistance with street tree planting and tree care.

More analysis is needed before piloting a tree retention program geared at reducing a significant amount of GHG emissions when compared to the business as usual.

Equity Issues: The GGC program focuses only on Environmental Justice (EJ) neighborhoods within the poorest cities in the Commonwealth. The program will provide 132 jobs per year for over 10 years. Crews are hired from the neighborhoods where planting is occurring so additional economic benefits accrue from this program in EJ neighborhoods. Early results indicate that many tree crew members are able to get full time jobs in the landscaping industry or local city DPW’s due to training received.

Environmental Justice neighborhoods have the lowest tree canopy cover across the state. For example, Chelsea has just 9% canopy cover while the average suburban neighborhood has more than 40% canopy cover. With less access to open space and parks in the Gateway Cities, the GGC program will measurably enhance the quality of life for Gateway City residents.

While tree retention would principally focus on suburban neighborhoods, a companion tree retention program could assist the Gateway City EJ neighborhoods in protecting existing tree canopy from a largely different set of threats.

Experience in Other States: The GGC program has reviewed other significant urban tree planting programs across the U.S. such as New York, Philadelphia, and Washington D.C. Staff have also contacted other energy saving tree planting programs such as the well established program in Sacramento, CA. The GGC program has utilized the experiences of other urban tree planting programs in designing the approach and best practices of the program.

The EEA's consultants conducted a thorough literature review of other states and municipalities that have implemented tree retention programs for housing development and re-development.

Legal Authority: The Massachusetts Public Shade Tree Law G.L. Chapter 87 gives guidance to tree planting in cities and towns and municipalities authority over shade trees within the right of way of municipal streets.

Implementation Issues: Unique issues with tree planting and retention are described in the Design Issues section above. There are also a number of questions about how to structure a tree retention program, which could be addressed through a pilot educational program that would encourage a range of model best practices and bylaws and test a range of incentives to determine their effectiveness.

Uncertainty: There is a high degree of certainty regarding the positive results that will occur when a significant number of mature trees are retained in a municipality. There is uncertainty as to how to measure positive results compared with the baseline and which educational or incentives programs will be the most effective. These uncertainties can be resolved via a carefully thought out pilot program.

The EJ neighborhoods within the Gateway Cites were chosen because they have the oldest, least insulated housing stock that would benefit the most from an extensive tree planting program. The average housing stock in the Gateway Cities dates from 1939 to 1963. Given the lack of insulation in this housing stock and the challenges with implementing energy efficiency, it is uncertain if the results of tree planting and retention could exceed the predicted GHG reductions, because the two study areas (Worcester, MA and Hutchinson, MN) have newer housing stock than the average Gateway City housing stock. Another uncertainty is the impacts of climate change. With predictions for significant increases in the number of above 90 degree days and the amount of air conditioning predicted to be installed, the GHG savings may be greater than is predicted in the current climate.

Federal and California Vehicle Efficiency and GHG Standards (CAFE/Pavley)

Policy Summary: Beginning with model years (MY) 2009-2011, Massachusetts adopted California light-duty vehicle GHG emission standards. Subsequently, the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) have set harmonized standards for light-duty vehicle miles per gallon (MPG) and GHG emissions in two phases, for MY 2012 through 2016 and MY 2017 through 2025 vehicles. The standard is raised from 27.5 MPG in 2011 to 35.5 MPG in 2016, and then to 54.5 MPG in 2025, if the automotive industry were to meet EPA's requirement entirely through fuel economy improvements. California has harmonized its standards with the federal standards through 2025, and Massachusetts law requires the Commonwealth to adopt and implement the California motor vehicle emission standards as long as those standards are at least as protective as the federal standards. In combination, the EPA and California standards are forecast to yield a 34 percent reduction in GHG emissions in 2025 (primarily from lower gasoline consumption, but also with some reduced emissions from vehicle air conditioning systems), resulting in a fleet wide average decrease from about 251 grams of carbon dioxide per mile (gCO_2/mi) for MY 2016 to about 166 gCO_2/mi in 2025.

	Savings from full policy implementation	**% of 1990 level**
Economy-wide GHG reductions in 2020	3.7 $MMTCO_2e$	3.9%
Phase 1 for MY 2012-2016: Cumulative net benefits discounted, 2012-lifetime of vehicles (fuel savings and other social benefits, less increased vehicle costs)	$8.0 billion	
Phase 2 for MY 2017-2025: Net lifetime fuel savings for consumers	$12 billion	

Note: benefits are calculated over the lifetimes of vehicles purchased from 2012 through 2020, which extend beyond 2020.

Clean Energy Economy Impacts: The vast majority of spending on motor fuel goes out of Commonwealth, so reducing those expenditures by billions of dollars means more money can be spent on in-state businesses, stimulating the economy and creating jobs.

Rationale: The Federal Corporate Average Fuel Economy (CAFE) standards were first enacted in 1975 but have been relatively stagnant since the 1980s. Federal law raised the standards in 2007, but the Obama administration proposed an accelerated schedule through 2025 by establishing a joint EPA/NHTSA National Program to harmonize its rules with the California Air Resources Board's rules. California amended its regulations and adopted the key elements of the National Program. Improving the fuel economy of vehicles is one of the most effective tools to reduce energy consumption and GHG emissions.

Design Issues: The federal regulations continue the practice of having different standards for cars and light trucks, although two-wheel drive SUVs have been reclassified as cars. As a result, in MY 2011, approximately 1.5 million 2WD SUVs formerly classified as light trucks have been classified as passenger automobiles, which are estimated to produce an average increase of 0.3 MPG in the combined passenger car and light truck standards for MY 2011. However, specific fleet differences are such that this change leads to more lifetime fuel consumption of approximately 0.03 billion gallons and more carbon dioxide emissions of approximately 0.06 million metric tons than under the standards that would apply under the former definitions. This is due to the fact that the reassignment of vehicles changed the shapes of the passenger car and light truck target curves, which caused different results for different manufacturers depending on their fleet mixes.

GHG Impact: Reductions in GHG emissions is estimated to be 2.5 $MMTCO_2e$ in 2025 for Massachusetts for the second phase of standards, based on California projections. The first and second phase standards combined are expected to reduce GHG emissions by 3.7 $MMTCO_2e$ in 2020.

Other Benefits: EPA's benefit calculations include lower air pollution from vehicles, less time spent refueling, security benefits of lower petroleum imports, and the social value of lower carbon emissions.

Costs: About $8.5 billion in additional vehicle costs through 2025, far outweighed by $28.5 billion in reduced fuel costs (all in net present value).

Equity Issues: Both higher initial capital costs and subsequent fuel savings will accrue first to purchasers of new vehicles. Lower income drivers more commonly buy used vehicles, and will only be affected in later years as the new models are sold on the used car market.

Experience in Other States: The federal regulations are required in all states. Massachusetts and a number of other states have adopted California's stricter standards in the past, with no implementation problems.

Legal Authority: The federal government has authority over vehicle efficiency and air emissions. However, there is an exemption under the 1970 Clean Air Act (CAA) for California to adopt standards stricter than EPA's (if awarded a waiver by EPA) and for other states to adopt California's standards under Section 177 of the CAA.

Implementation Issues: None.

Uncertainty: See discussion under the Design Issues section above concerning the distribution of sales between cars and light trucks.

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

Policy Summary: In September 2011, the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) finalized a first phase of complementary programs to reduce GHG emissions and improve fuel efficiency, respectively, for medium- and heavy-duty vehicles, such as the largest pickup trucks and vans, combination tractors, and all types and sizes of work trucks and buses in between, for model years (MY) 2014-2018. In June 2015, EPA and NHTSA jointly announced a proposed second phase of GHG emissions and fuel efficiency standards for medium- and heavy-duty vehicles, building on the success of the Phase 1 standards. The proposed standards would apply to certain trailer types beginning in MY 2018 for EPA's standards, and would be voluntary for NHTSA from 2018 to 2020, with mandatory standard beginning in 2021. The proposed CO_2 and fuel consumption standards for combination tractors and engines would start in MY 2021, increase incrementally in MY 2024, and phase in completely by MY 2027. The proposed standards differ by vehicle weight class, roof height, and cab type (sleeper or day). The fully phased-in standards would achieve up to 24 percent lower CO_2 emissions and fuel consumption compared to the Phase 1 standards. The proposed tractor standards could be met through improvements in the engine, transmission, driveline, aerodynamic design, lower rolling resistance tires, extended idle reduction technologies, and other accessories of the tractor.

	Savings from full policy implementation	**% of 1990 level**
Economy-wide GHG reductions in 2020 from Phase 1 Economy-wide GHG reductions in 2020 from Phase 2 for trailers	0.2 $MMTCO_2e$ 0.2-0.5 $MMTCO_2e$	0.2% 0.2-0.5%
Motor fuel savings in 2020[55]	$140 million	
Cumulative net benefits (discounted) 2011-lifetime of vehicles	$240 million	
Jobs gained in 2020 (direct and indirect)	1,000 jobs	

Clean Energy Economy Impacts: Using commercially available technologies, a payback period of one to two years was estimated for the majority of vehicles for the Phase 1 standards. Vehicles with lower annual miles would have payback periods of four to five years. For example, an operator of a semi truck could pay for the technology upgrades in under a year, and have net savings up to $74,000 over the truck's useful life. For the Phase 2 standards, payback periods for truck owners would continue to be favorable: the typical buyer of a new long-haul truck in 2027 would recoup the extra cost of the technology in under two years through fuel savings.

[55] At $3.34/gallon gasoline, $3.51/gallon diesel, in 2008$. Energy Information Administration, Annual Energy Outlook 2010.

Large reductions in fuel use will improve air quality. Less spending on imported fuel will keep more money in the Massachusetts economy and thereby create jobs.

Rationale: Transportation accounted for 42 percent of total GHG emissions in Massachusetts in 2012, with medium- and heavy-duty vehicles accounting for 11 percent of total emissions. These vehicle standards will reduce fuel consumption and GHG emissions while providing regulatory certainty for manufacturers.

GHG Impact: The Phase 1 and Phase 2 standards are estimated to reduce 0.4–0.7 percent of statewide GHG emissions in 2020, based on a 3–8 percent improvement in CO_2 emissions and fuel consumption over the MY 2017 baseline from improved trailer aerodynamics.

Equity Issues: The federal regulations are carefully designed to set efficiency standards that are appropriate and cost-effective for different sizes and types of vehicles. There are no significant predicted equity issues with the promulgation of this second phase of federal regulation.

Uncertainty: Current projections of the impact of these standards by the EPA and NHTSA may not turn out to be correct, in terms of fuel savings and costs and benefits, as the regulation is not yet final. In addition, if manufacturers cannot meet the standard and pay penalties instead, then GHG and fuel consumption goals will not be met.

Federal Renewable Fuel Standard (RFS) and Regional Clean Fuel Standard (CFS)

Policy Summary: Title II of the federal Energy Independence and Security Act of 2007 creates a renewable fuel standard, which requires that the volume of renewable fuels used in the U.S. rise from 4.7 billion gallons in 2007 to 36 billion gallons in 2022. In a similar fashion, Massachusetts' biofuels law, passed in 2008, instructs the state to pursue development of a low carbon fuel standard (LCFS) on a regional basis throughout the Northeast. In order to address this requirement, Massachusetts and other states have studied the potential implementation of a regional Clean Fuel Standard (CFS) in the Northeastern U.S.

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	0.1 $MMTCO_2e$	0.1%

Clean Energy Economy Impacts: To the degree that imported petroleum used in Massachusetts can be replaced by feedstocks such as solid waste, forest residues, and other cellulosic material, money that would otherwise go overseas is retained in the regional economy. If advanced fuels (including electricity powering plug-in hybrid and all-electric vehicles) eventually become less expensive than petroleum fuels, consumer costs are expected to fall. There are significant economic development opportunities in growing feedstocks, converting those into fuel, and in research and development.

Rationale: The carbon intensity (or GHG emissions per unit of energy used) of fuel is one of the three main ways that emissions from motor vehicles can be reduced. Under certain conditions, if crops or other plants are used to produce fuel, the emissions from burning the fuel can, to some degree, be canceled out as the growth of plants on the same land absorbs carbon dioxide. In addition, if electric vehicles become prominent, they would reduce the carbon intensity of fuels, since electric motors are far more efficient at powering motor vehicles than are gasoline engines.

Policy Design and Issues: The Federal RFS includes a variety of national biofuel blending mandates, the most important of which is a target of 16 billion gallons of low carbon cellulosic ethanol in 2022, or about 10% of the fuel supply. However, the technology required for large-scale production of cellulosic ethanol has not matured as quickly as anticipated, and the cellulosic biofuel target will not be achieved until well after 2022. For the purposes of this CECP Update, achievement of the national goal is assumed to be delayed until at least 2030, with only minimal production by 2020.

Implementation of a regional CFS has also been delayed, so the CFS is unlikely to deliver significant reductions by 2020. A CFS would complement the federal RFS by providing an incentive to reduce the carbon intensity of cellulosic ethanol below the level required by the RFS, ensuring delivery of fuel to Massachusetts, and providing a market signal to support other low carbon fuels such as electricity.

A major issue for the RFS and the CFS is calculating the carbon intensity of different fuels. This requires examining the entire lifecycle of a fuel, including, for example, how electricity is generated and how crops are grown—calculations that are difficult to do with any degree of precision. Important numerically, and controversial, are the carbon impacts from what is known as indirect land use change (ILUC). Large amounts of food crops being used for fuel (corn for ethanol, soybeans or rapeseed for biodiesel) may cause the need for more food production. Forests may be cut down to expand the amount of land on which crops can be grown, causing reductions in the CO2 sequestered by trees and soil. The U.S. EPA and the California Air Resources Board (CARB), along with the European Union and specific European countries, are currently calculating ILUC for each fuel, but each source has published different numbers. One reason that this policy focuses on cellulosic ethanol is the expectation that it can be produced using waste materials and crops that do not result in significant ILUC.

A significant obstacle affecting the potential of cellulosic ethanol to displace petroleum in the gasoline supply is often referred to as the "blend wall." The blend wall refers to the fact that most existing gasoline engines are not certified to accept gasoline that contains more than 10% ethanol—the current composition of gasoline. Therefore, in order to realize reductions from cellulosic ethanol, it will be necessary to make higher ethanol blends (likely 15%, which can be used in new vehicles, and 85%, which can be used in certain "flex-fuel" vehicles) widely available.

GHG Impact: With the production of low carbon cellulosic ethanol assumed to be minimal by 2020, the RFS is expected to reduce GHG emissions by 0.1 $MMTCO_2e$ in 2020.

Costs: In 2011, NESCAUM published an economic analysis of a regional CFS that projected small but positive economic impacts. Because of the complexity of fuel markets and the incentives created by the RFS, it was not possible to determine the impact on gasoline prices.

Equity Issues: Any price impacts from the RFS and CFS will be spread across all drivers in proportion to the amount of fuel that they use.

Experience in Other States: California's low carbon fuel standard is similar to the CFS, and has operated successfully since 2010.

Legal Authority: Massachusetts' biofuels law gives the Commonwealth the authority to implement the CFS. As noted above, EPA is required by federal law to implement the RFS.

Implementation Issues: Regarding a regional CFS, as with any interstate policy, achieving agreement on how to implement a uniform policy among a number of states presents many complexities. For example, distribution infrastructure for new fuels and vehicles may be needed. This would require large capital investments, and it is unclear whether the incentive system created by the CFS will be sufficient to draw out that investment. Complementary policies may be necessary for all parts of the system to be developed in tandem.

One possible approach to implementing a CFS would be to begin with a reporting-only requirement. This approach would provide information and experience to inform development of a CFS that would require emission reductions in later years.

Uncertainty: The pace at which technology and infrastructure needed to manufacture and distribute large quantities of cellulosic ethanol can be developed is highly uncertain.

Policy Websites: http://www.epa.gov/OTAQ/fuels/renewablefuels/ and http://www.nescaum.org/topics/clean-fuels-standard.

Clean/Electric Vehicle Incentives

Policy Summary: Massachusetts signed a Memorandum of Understanding (MOU) with seven states on October 24, 2013, to coordinate their efforts for adoption of zero emission vehicles (ZEVs). The eight states have committed to having at least 3.3 million ZEVs in operation by 2025. Massachusetts' portion of the MOU target is approximately 300,000 vehicles. In May 2014, the eight states released a "Multi-State ZEV Action Plan" indicating 11 key actions needed to advance the adoption of ZEVs. In June 2014, a formal Zero Emission Vehicle Commission was created in Massachusetts by Section 205, Chapter 165 of the Acts of 2014. The Commission will make recommendations to the Administration on an action plan and report findings including draft legislation to the Massachusetts Legislature. Massachusetts has initiated several programs to provide charging infrastructure, incentives and education. For example, a program was established in June 2014 that offers rebates to consumers to shift their vehicle purchases to more fuel-efficient (or lower GHG) models, currently plug-in electric- and hydrogen-fueled vehicles. Massachusetts has a clean vehicle grant program for medium and heavy-duty alternative fuel vehicles. Funding has also been made available for municipalities, public and private colleges and universities, and state agencies to purchase plug-in electric vehicles and install charging stations for workplace charging. Massachusetts has focused on the development of publically available charging infrastructure throughout the Commonwealth, and coordinated with neighboring states for major travel corridors with funding for fast charging systems. To complement the infrastructure development, Massachusetts developed a hands-on Mass Drive Clean test drive program at employer locations and public events throughout the Commonwealth. New complementary policies are necessary to achieve our GHG reduction and MOU goals including: planning for the future to facilitate at-home vehicle charging; non-financial consumer incentives; and increasing consumer awareness of ZEVs via outreach and education with dealers and NGOs as well as highway sign logos that identify charging infrastructure.

	Savings from full policy implementation	**% of 1990 level**
Economy-wide GHG reductions in 2020	0.1 $MMTCO_2e$	0.1%

Clean Energy Economy Impacts: Large reductions in fuel and maintenance costs for consumers, and less spending on imported fuel, keep more money in the Massachusetts economy and thereby create jobs. The ZEV and alternative fuel infrastructure deployment create employment opportunities for various sectors of the economy from electricians to construction workers.

Rationale: Transportation accounted for 42 percent of total GHG emissions in Massachusetts in 2012, with light-duty vehicles (cars, SUVs, minivans, pickups) emitting approximately 26 percent of total emissions. To achieve the GWSA's 2050 limit, electrification of the transportation sector is necessary, and this policy supports that long term goal.

Design Issues: Under the current design of the consumer rebate program, rebates are issued based on the battery size for new vehicles. A complementary future incentive should take the growing fleet of older ZEVs into account by possibly allowing used ZEVs to be eligible for the incentive.

GHG Impact: Based on projections of meeting the MOU target in 2025, a reduction of 0.1 $MMTCO_2e$ are expected in 2020.

Other Benefits: Reduced fuel usage will reduce emissions of other air pollutants that cause human health damage.

Costs: Incentive programs have been funded through federal Congestion Mitigation and Air Quality improvement program funds, Regional Greenhouse Gas Initiative (RGGI) auction proceeds, an Inspection and Maintenance program vehicle trust account, and supplemental environmental program (SEP) funding sources.

Equity Issues: Lower-income households tend to buy used cars. A pilot program is being devised to provide incentives to lower-income households in addition to existing consumer rebates for new or used ZEVs. Virtually all drivers whose vehicle choice is modified by the incentive mechanism will see substantial savings in gasoline costs over time.

Experience in Other States: California has successfully implemented a rebate program for zero emission vehicles that has fostered rapid adoption by consumers. Many states across the U.S. have placed a wide range of policies in place, from HOV lane access, rebate programs and tax incentives for ZEVs, to rebate programs and tax incentives for infrastructure.

Legal Authority: Massachusetts has been implementing grant programs using existing state authorities.

Implementation Issues: All rebate and incentive programs need to be altered and keep pace as alternative fueled vehicles and associated infrastructure markets change. A concerted effort needs to be made to ensure universal access to all alternative fuel infrastructure. Reducing the cost to retrofit buildings to enable at-home charging would require building and electric code changes.

Uncertainty: The degree of consumer response after incentives and rebates is being evaluated.

GreenDOT

Policy Summary: GreenDOT is the Massachusetts Department of Transportation's (MassDOT) sustainability initiative, announced through a Policy Directive in June 2010. The GreenDOT Implementation Plan, also from 2010, serves as the framework for embedding the sustainability principles of GreenDOT into MassDOT's core business practices. GreenDOT is intended to fulfill the requirements of several state laws, regulations, Executive Orders, and MassDOT policies, including the Global Warming Solutions Act, the Green Communities Act, the Healthy Transportation Compact, and Leading by Example Executive Order. The original CECP anticipated that various measures implemented by MassDOT pursuant to the GreenDOT Plan would produce approximately a 1 $MMTCO_2e$ reduction in 2020, and this CECP Update maintains this assumption.

	Savings from full policy implementation	**% of 1990 level**
Economy-wide GHG reductions in 2020	1.0 $MMTCO_2e$	1.1%

In January 2015, after a public process in which MassDOT worked closely with the Massachusetts Department of Environmental Protection (MassDEP) to determine the best regulatory framework for achieving the goals set forth in the Policy, MassDEP issued regulations, 310 CMR 60.05, intended to assist the Commonwealth in achieving the GHG emissions reduction goals adopted pursuant to the Climate Protection and Green Economy Act. The regulations require MassDOT to demonstrate that its GHG reduction commitments and targets in the CECP are achieved. They also require metropolitan planning organizations (MPOs) to evaluate and track the GHG emissions and impacts of Regional Transportation Plans (RTPs) and regional Transportation Improvement Programs (TIPs); and in consultation with MassDOT, to develop and utilize procedures to prioritize and select projects in RTPs and TIPs, based on factors that include GHG emissions and impacts. In addition, under the regulations, MassDOT must evaluate and track the GHG emissions and impacts of Statewide Transportation Improvement Programs (STIPs) and state-funded projects that are not included in these Programs.

Based on interagency consultation, it appears that the regulatory requirements have been met, with the exception of identification of existing or supplemental measures sufficient to demonstrate that the required 1 $MMTCO_2e$ reductions will be achieved. In order to address any shortfall between the projected GHG reductions and the GHG reduction target in the CECP, the regulations require MassDOT to identify, quantify, and implement supplemental measures and initiatives within the transportation sector and/or areas of MassDOT's responsibility that will achieve the GHG reduction shortfall by 2020. Pending submission by MassDOT of a GHG Assessment—as required under 310 CMR 60.05—that had not been received by MassDEP as of the issuance of this CECP Update, it appears that MassDOT will be short of its required GHG reductions.

Once the final GHG Assessment is received, and the projected shortfall confirmed and quantified, the Baker-Polito Administration will identify transportation sector emission reduction measures sufficient to close the gap between the required 1 $MMTCO_2e$ in 2020 and the GreenDOT related emissions reductions identified by MassDOT. The importance of reducing emissions from transportation—now the largest emissions sector—is recognized and a priority for the Administration.

GreenDOT Implementation: GreenDOT is focused on three related goals: reduce GHG emissions; promote the healthy transportation modes of walking, bicycling, and public transit; and support for smart growth development. GreenDOT encompasses a number of different program areas, which are described briefly below: statewide and regional long-range transportation planning, transportation project prioritization and selection, Complete Streets, rail transportation, bicycle and pedestrian transportation, promotion of eco-driving, sustainable design and construction, system operations, facilities management, generation and use of renewable energy, and travel demand management.

Transportation Long-Range Planning and Project Prioritization and Selection: Long-range planning documents, including statewide planning documents (e.g., the Strategic Plan, State Freight Plan, and MassDOT Capital Investment Plan), as well as the long-range RTPs from the MPOs, must address MassDOT's three sustainability goals and evaluate, track, and plan for reducing GHG emissions over time. Similarly, the shorter-range TIPs and STIPs, under which particular projects are chosen for funding in the coming four years, must be consistent with the Commonwealth's GHG reduction target. This will require that the MPOs and MassDOT minimize highway system expansion projects and balance their impact with other projects that support smart growth development and promote public transit, walking, and bicycling. In addition, the project programming mix included in the RTPs, TIPs, and STIPs can contribute to GHG reduction through prioritizing roadway projects that enable improved system operational efficiency without expanding overall roadway system capacity. All of these goals and requirements will be addressed as MassDOT and the MPOs incorporate the recommendations of the Project Selection Advisory Council for a more data-driven, transparent, and uniform project selection process into MassDOT's capital planning.

Over the long term, both long-range planning and project selection will affect where new development in the Commonwealth is located and how that development is spatially configured. These choices affect the degree to which future development represents smart growth, or clustered development patterns that facilitate walking, bicycling, riding public transit, and driving shorter distances, which would minimize the number of motor vehicle miles that people must travel in order to go about their lives.

Project Design and Construction: The MassDOT Highway Division Project Development and Design Guide requires that all projects must adhere to a Complete Streets design approach, meaning that new and redesigned roads must provide appropriate accommodation for all users, including pedestrians, bicyclists, and public transit riders. These modes of transportation will also be promoted by several other means. These include taking steps to see that more alternative transportation projects move forward, extending the Bay State Greenway, improving accommodations for bicycles and pedestrians on bridges, and improving bicycle parking facilities at MBTA stations.

Several efforts will continue to improve rail transportation in the state. The MBTA is striving to both improve service on existing subway and commuter rail lines and to develop new service, such as the Green Line Extension and the South Coast Rail Project. Other projects will improve long-distance rail service for both passengers and freight.

MassDOT project design and construction will also reduce GHG impacts through measures such as the use of recycled content in paving materials, use of warm mix asphalt paving, implementation of stormwater remediation and use of best management practices, and requirements for diesel engine retrofits for construction contractor vehicles.

Travel Demand Management and Travel Information: MassDOT will continue to promote and deliver travel demand management (TDM) information and services, including a ride-matching/trip planning system to facilitate carpooling, vanpooling, and mode shifting from automobile travel; traveler information; real-time bus tracking; and other measures for the general public and among MassDOT employees.

Eco-driving: Fuel efficiency can be improved greatly by maintaining vehicles properly, driving within the speed limit, and accelerating more gently. The EPA estimates that smart driving can improve fuel efficiency by up to 33 percent, and EcoDriving USA estimates that Massachusetts' drivers, with 5.4 million registered autos, could save about 4 $MMTCO_2e$ emissions annually if eco-driving practices were followed. MassDOT will promote eco-driving through: internal education for staff and contractors; external education of all Commonwealth drivers through website content, RMV manual and testing content, signage, and brochures; and development of a plan to improve tire inflation infrastructure.

System Operations: MassDOT, along with the MBTA and other regional transit authorities, will continue to take a variety of steps to minimize fuel use and GHG emissions from vehicles and facilities. This includes retrofitting diesel buses with emission control devices, truck stop electrification, using solar and wind power at MassDOT facilities and rights-of-way, improving energy efficiency in MassDOT facilities, and increasing the share of low-emission transit vehicles in the MBTA fleet.

MassDOT will also facilitate more efficient roadway system operations, improvements that can reduce GHG emissions by reducing congestion and time spent idling in traffic. MassDOT will do this through the effective management of roadway capacity, using intelligent transportation systems—which may include such measures as real-time traveler information and management of traffic flow through improved traffic signal operations—ramp metering, and variable speed limits. MassDOT will also continue to address roadway system bottlenecks or points of localized capacity constraints, improvements that can reduce GHG emissions when traffic flow is improved without expanding overall system capacity.

Smart Growth

Policy Summary: Development patterns significantly influence vehicle miles traveled (VMT), which could be substantially reduced by additional "smart growth" that makes it easier for households and businesses to decrease the number and distance of motor vehicle trips. Diffusing single-use development accessed by cars results in 30%[56] more VMT than compact mixed-use growth. Massachusetts has policies promoting smart growth, but enhanced emphasis as well as new, complementary policies that focus on state and local plans, regulations, and investments are necessary to achieve our smart growth targets and the resulting VMT and GHG reductions.

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	0.4 $MMTCO_2e$	0.4%
VMT reduction below Business-As-Usual in 2020	1.7%	

Clean Energy Economy Impacts: Reductions in transportation costs can be expected for residents and businesses due to reduced vehicle ownership and fuel consumption. High density mixed-used development will increase building efficiency, and make district energy and combined heat and power more feasible.

Rationale: Reducing or eliminating projected VMT increases via better land use patterns is important to realizing GHG reductions from the transportation sector, which is expected to account for over 40% of total GHG emissions in MA in 2020, with light-duty vehicles (cars, SUVs, minivans, pickups) accounting for about 70% of transportation sector emissions. An enhanced level of commitment to current policies along with the implementation of new policies and programs will be necessary to realize the 2020 and 2050 GHG emission limits.

Design Issues: Existing state policies include (1) GreenDOT, which prioritizes transportation projects that preserve the existing system, support denser "smart growth" development, and promote increased ridership, walking, and biking; (2) the MassWorks Infrastructure Program, which provides a one stop shop for infrastructure funds via six separate programs, and promotes consistency with other state initiatives, such as smart growth, Chapter 40R, and the 43D Expedited Permitting Program; and (3) completion and implementation of Land Use Priority Plans to guide state actions & investments consistent with the South Coast Rail Executive Order, which supports the South Coast Rail Economic Development and Land Use Plan by ensuring that agencies review their policies, actions, and investments to support and implement Plan recommendations including priority development and preservation areas. Complementary policies are needed in order to achieve the 80% smart growth target. These include:

[56] See *Growing Cooler* by the Urban Land Institute

- **Reform state planning, subdivision, and zoning statutes –** Pass legislation that provides a better framework for planning and zoning, enhanced tools to plan for and manage growth, and incentives to reduce VMT and GHG emissions through better development, increase housing production consistent with smart growth, and achieve other state goals.
- **Provide technical assistance and undertake a smart growth promotional campaign –** Expand efforts to help establish zoning and other land use regulations that reduce VMT. Provide direct technical assistance by state employees, tools such as model zoning, and grants to hire professional assistance. Also, use public appearances, the media, etc. to promote smart growth by pointing out its many benefits.
- **Require state infrastructure and vertical construction programs to include a strong preference for smart growth development in their criteria for funding decisions –** State investments, particularly those in infrastructure and buildings, influence where and how growth occurs. Enhanced use of these investments to promote mixed-use, high-density development and housing growth near services and transit is critical to attainment of targeted VMT reductions resulting from better land use. This could be accomplished via an Executive Order or through legislation that codifies the Sustainable Development Principles, and requires all agencies permitting, building, or funding infrastructure projects to take a set of smart growth criteria into account.
- **Significantly increase incentives to municipalities to plan and zone for development that reduces VMT –** Much as the Community Compact Cabinet and Green Communities Program have succeeded in convincing many communities to adopt desired best practices, strengthening existing incentives and offering new ones can persuade communities to use their regulatory authority in ways that reduce VMT. Enhance existing incentives, such as Chapter 40R, and implement new ones that recognize the GHG reduction benefits of development practices that encourage smart growth and preserve forest and other natural land cover. Preference for grants could be awarded to communities that reduce land consumptive low density development through techniques, such as natural resource protection zoning, or that zone for transit oriented development, mixed-use city or town center development, or another smart growth consistent land use.

GHG Impact: The CECP Update assumes that aggressive implementation of current land use policies can result in 0.4 $MMTCO_2e$ reductions in 2020, based on getting 50% of forecasted population growth to occur in the next highest density community type and increasing the land use mix and household density.

Equity Issues: Smart growth increases affordability by reducing the amount households spend on both housing and transportation. It further reduces housing costs by increasing the variety of housing types available and decreasing the amount of land and infrastructure needed per housing unit. It also enhances access to jobs and services for the young and infirm as well as those without a car. Finally, smart growth provides a higher percentage of new jobs in urban areas where unemployment tends to be high.

Other Benefits: Urban sprawl costs the American economy more than $1 trillion annually, according to a recent study by the New Climate Economy. These costs include greater spending on infrastructure, public service delivery, and transportation. The study finds that Americans living in sprawled communities directly bear $625 billion in extra costs.[57] Smart growth is as much as 70% cheaper for governments than the same amount of sprawl. It simply costs less to provide infrastructure and services to denser, more contiguous households than to far-flung, low-density communities.[58] It enhances public health by reducing air pollution and increasing physical activity, and improves quality of life by improving neighborhoods, reducing travel times, and lowering costs. This in turn enhances economic competitiveness by appealing to prospective employees. Finally, smart growth reduces development of open space, including forested land that sequesters carbon.

Costs: Existing and proposed smart growth policies outlined herein have little cost as they rely almost entirely on enhanced use of existing funding. For example, state transportation funds would shift toward investments in support of desired development without increasing the amount expended. Similarly, financial incentives anticipate the use of existing state funding sources rather than creation of new ones. Modest additional funds are needed for technical assistance to municipalities and other entities to implement better zoning and other land use practices.

Experience in Other States: Delaware, Maryland, New Jersey, New York, Rhode Island, Vermont, and others have implemented smart growth programs that improved growth patterns and thereby reduced VMT. California is in the forefront with legislation (SB375) requiring each Metropolitan Planning Organization to attain an established GHG reduction target through the implementation of a Sustainable Community Strategy.

Legal Authority: Legislation (or an Executive Order) could codify and require agencies to implement the Sustainable Development Principles. It may also be needed to permit certain funding programs to implement municipal incentives and to authorize additional funding for incentives and technical assistance.

Implementation Issues: Smart growth requires a sustained, disciplined, and collaborative focus, particularly by the Commonwealth and local governments, on building communities consistent with the Sustainable Development Principles. The allure of short term gains, narrow self-interest, shifting priories, and leadership changes complicates efforts to realize smart growth consistent land conservation and development across Massachusetts.

Uncertainty: While state investments in infrastructure and buildings will help to steer growth to desirable locations and forms, communities can ignore state incentives and developers can still finance their own projects and build in ways that result in excessive VMT.

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[57] See *Analysis of Public Policies that Unintentionally Encourage and Subsidize Sprawl* by the Victoria Transport Policy Institute

[58] Research by the Real Estate Research Corp., Robert Burchell, and others

Coal-Fired Power Plant Retirement

Policy Summary: As recently as 2009, four coal-fired power plants were generating electricity in Massachusetts. By 2020, none of them will be operational. Three have already ceased operation: Somerset Station, Salem Harbor Station, and Mt. Tom Station. The owner of the Brayton Point Station in Somerset has indicated that it expects the plant to close in 2017. While recent federal regulations have played a role in the plant owners' decisions to retire their facilities, the primary driver of this change has been the availability of relatively inexpensive natural gas.

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	5.0 $MMTCO_2e$	5.3%[59]

Rationale: Emissions from coal combustion are significantly higher than other fossil fuels for a given amount of electricity production.

Policy Design: In addition to fuel prices, several existing or upcoming federal regulations may have influenced decisions to retire these power plants. For example, limits on emissions of SO_2 and mercury have come into force or been revised downward in recent years, and new air quality standards issued in 2015 may require additional reductions in NO_x pollution. While the recently finalized Clean Power Plan—EPA's regulation to reduce carbon dioxide emissions from existing electric power plants—will not take effect until 2022, it could also have influenced the owners' decisions about the long term viability of coal-fired power plants in Massachusetts.

In addition to air pollution regulations, cooling water regulations under the federal Clean Water Act also affect coal-fired power plants. For example, cooling towers installed at Brayton Point Station impose significant operating costs. Along with the costs of operating air emission control equipment, these costs have reduced the ability of coal-fired power plants to compete with cleaner natural gas in electricity markets.

GHG Impact: If the closure of these four power plants results in them being displaced by natural gas-fired power plants, there would be a net 5 $MMTCO_2e$ in 2020.

Other Benefits: Reduced exposure to fine particulates and ozone will have health and environmental benefits.

[59] Note: The announced closure of the Pilgrim power plant would lower 2020 reductions to 2.7 $MMTCO_2e$ or 2.9% of the 1990 emissions level.

Renewable Portfolio Standard (RPS)

Policy Summary: The Massachusetts Renewable Portfolio Standards (RPS) was created as part of electricity restructuring in Massachusetts in 1997, expanded in the Green Communities Act of 2008 and modified in the Competitively Priced Electricity Act of 2012. The RPS requires retail electricity suppliers—both distribution companies and other retail suppliers—to buy a percentage of their portfolio of electricity sales from eligible resources.

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	1.1 $MMTCO_2e$	1.1%

Clean Energy Economy Impacts: The Massachusetts Clean Energy Center's Clean Energy Industry Report estimates that there are 26,850 Massachusetts jobs in renewable energy. The renewable energy sector grew 28% in the last 12 months, with jobs spanning installation, legal, marketing, and finance services. In 2014, the Massachusetts renewable energy sector received over $232 million in investment.

Rationale: Because of low prices for fossil fuels, the lack of a market price for the negative impacts of pollution from fossil fuels (externalities), and other market barriers, the private market is not, on its own, supplying as much renewable, low-carbon power as society needs. By creating market demand, the RPS drives investments in renewable energy supply.

Policy Design: The Massachusetts RPS stimulates new renewable development through the Class 1 New Renewables, Class 1 Solar Carve-Out, and Class 1 Solar Carve-Out II. Suppliers meet their Class I commitments by buying Renewable Energy Certificates (RECs) and Solar Renewable Energy Certificates (SRECs), the accounting mechanism for ensuring that every unit of renewable energy generated is counted exactly once in terms of state requirements. Fifteen percent of electricity supply must be from new Class 1 renewable resources, such as wind, solar, small hydro, and eligible biomass and anaerobic digestion, by 2020.

GHG Impact: 1.1 $MMTCO_2e$ can be avoided in 2020 from the expansion of the RPS, not including the RPS requirements that existed prior to the Green Communities Act.

Other Benefits: As with other electric sector policies, the RPS results in reduced burning of fossil fuels and therefore reduced local air pollution and improved public health. For example, a study by the independent National Research Council found that coal use around the country resulted in 20,000 premature deaths annually.

Cost: There is a great deal of variability in the REC prices over the last 5 years because of variations in fuel prices, federal policies, and rapidly changing technology. The SREC market has operated separately from the Class I REC market. The SREC incentives have been substantially higher than the market value of Class I RECs. The incentives were initially set high because installation costs were substantially higher than they are today. While SREC values have generally declined since 2010, they still remain substantially higher than the market value of Class I RECs, and have not necessarily kept pace with the decline in solar installation costs over that same time period. Since the cost of installing solar has substantially declined, there is a significant opportunity to reduce the cost of future solar incentives and still retain a robust solar market. The RPS also can reduce wholesale energy prices throughout New England, due to the price suppression effects of the inclusion of low or zero fuel cost generation in the regional electric energy market. However, a white paper recently published by the ISO-NE suggests that over the long term, this would cause a shift in the cost of electricity from the wholesale energy market to the capacity market, offsetting to some extent the long-term savings in the wholesale market, as generators bid higher capacity prices to make up for lost revenue in the energy market.

Experience in Other States: Thirty states plus the District of Columbia have some type of Renewable Portfolio Standard. Key features of successful programs are those which provide transparency, longevity, and certainty to the market. Repeated changes to the program design create concern in the market.

Legal Authority: RPS authority derives from electricity restructuring statues from the late 1990s as well as the Green Communities Act and the Competitively Priced Electricity Act of 2012.

Implementation Issues: The RPS (Class I) program compliance began in 2003. Apart from some modest shortages in 2011 and 2012, the Class I obligation has been successfully met since 2007 with the retirement of RECs. In 2014, the minimum standard of 9 percent was met. While the share of imports from New York and adjacent Canadian provinces into the New England region increased significantly between 2003 and 2009, it has since fallen, with two-thirds of all generation coming from within New England in 2012-2014. It is particularly noteworthy that the share of RPS Class I generation coming from Massachusetts itself has increased from 9% in 2010 to 24% in 2014, an increase that is largely attributable to the growth stimulated by the Commonwealth's Solar Carve-Out programs. Since the restructuring of energy markets in Massachusetts in 1997, supply contracts between the electric distribution companies and power generators have typically been for only three months to one year, far too short a period to allow financing of the high capital costs involved in developing renewable generating facilities. This has been a contributing factor in limiting supplies of RPS-eligible renewables in Massachusetts. To rectify this problem, the Green Communities Act required that the distribution companies solicit proposals from renewable energy developers and enter into cost-effective long-term contracts for at least a limited amount of renewable energy, in order to facilitate the financing of renewable energy generation. Such contracts can assist renewable energy developers in obtaining financing by providing assurance of revenues from sales of RECs and electricity over a number of years.

Uncertainty: Siting constraints both for generation nearby or for transmission to remote resources could constrain the renewable supply. In addition, restructured markets like New England lack parties to enter into long-term power purchase agreements that are typically required for financing of large-scale renewable energy projects with substantial up-front capital investment.

Clean Energy Imports

Policy Summary: Canada has substantial hydro-electric resources, which have very low emissions and may be available at relatively low cost compared to other low emissions generation resources. There may also be opportunities for RPS-eligible resources to be combined with large-scale hydro over transmission lines accessing northern New England. The amount of Canadian hydro has risen to 11 percent of New England's electric consumption, but transmission lines that deliver this resource to southern New England are at or near full capacity, preventing additional Canadian hydro from getting to our market. There are several competing transmission projects that have the potential to bring low emissions resources into Massachusetts: a 1,000 MW project referred to as the "Northern Pass" transmission line; the New England Clean Power Link in Vermont, the Maine Green Line project, and the Northeast Energy Link in Maine, among other potential projects.

Clean Energy Economy Impacts: While none of the transmission projects are actually sited in Massachusetts, bringing lower cost clean resources into Massachusetts can help to stabilize electric rates for consumers in the Commonwealth.

	Savings from full policy implementation	**% of 1990 level**
Economy-wide GHG reductions in 2020	4.0 $MMTCO_2e$	4.2%

Rationale: Canadian hydro resources are extensive, and have low operating costs and lifecycle greenhouse gas emissions well below natural gas power generation. New lines constructed to address this policy may also have a role to play in delivering RPS-eligible wind power to Massachusetts.

Policy Design: The Baker-Polito Administration has proposed legislation that would authorize Massachusetts utilities to enter into long-term contracts for transmission and power from clean energy resources in New England and Canada.

GHG Impact: Replacing 1,000 MW of fossil fuel with clean energy would result in approximately 4.0 million metric tons of emissions reduction between now and 2020, depending on what types of fossil generation are displaced and how much of the power is utilized in Massachusetts versus other states.

Other Benefits: Like other electric sector policies, by incentivizing the reduced operation of fossil fuel plants, these additional low-emissions electricity imports would help reduce emissions of pollutants that cause smog and affect public health. In addition, additional hydro imports will significantly improve the region's fuel diversity, improving energy security and price stability.

Cost: As discussed above, Canadian hydro has the potential to be a low cost clean energy resource. If long-term contracts are used to finance projects and ensure delivery to Massachusetts, a competitive bidding process will be used to minimize costs to ratepayers.

Experience in Other States: Massachusetts and other Northeastern states already have transmission lines to Canada and have imported hydro power for years. In fact, additional hydro power imports have been a significant contributor to a cleaner New England electricity grid in the last decade.

Legal Authority: As discussed above, the Baker-Polito Administration has introduced legislation to address this policy. New legislation is necessary to ensure implementation of this policy.

Uncertainty: Transmission lines involve federal, state and local permitting, and often raise siting concerns, with potential delays from legal action.

Clean Energy Standard (CES)

Policy Summary: Over the past decade, the electricity portfolio serving Massachusetts became much cleaner. The major changes came from the substitution of natural gas for coal and oil, and the tripling of imports of hydro power from Canada into New England. This demonstrated that technologies that are not eligible for crediting under the Massachusetts *Renewable Portfolio Standard (RPS)* have made a significant contribution to a cleaner electricity grid. They can have an important role to play moving forward.

An additional policy under consideration is a market-based framework that could be used to provide a signal to the electricity market to improve upon the cleaner energy portfolios of the last few years and to provide additional revenue to support investment in transmission projects that can reach large-scale clean energy resources in Canada, northern New England, or other regions (see *Clean Energy Imports*). One such framework under consideration is the Clean Energy Standard (CES), which would require Massachusetts energy suppliers to purchase certificates similar to renewable energy certificates from eligible clean resources. At least initially, the standard would likely focus on large-scale hydroelectric power. Whether CES is necessary to secure additional hydroelectric power depends in large part on whether clean energy resources can be obtained at reasonable cost through other long-term contracting requirements without employing this additional purchase obligation.

The existing RPS fits neatly into this framework as a technology-specific means of meeting the standard.

Clean Energy Economy Impacts: The CES is a market-based framework that could provide market incentives and could enable making investments that otherwise would not occur.

Rationale: The CES would qualify technologies based on an emissions threshold, allowing the market to find the least-cost approach to achieving a cleaner energy portfolio. In addition, it could empower electricity suppliers to manage their portfolios, akin to the CAFE standard for vehicles, offering cleaner products to interested customers to help meet their portfolio targets.

Policy Design: A CES program, similar to the mechanics of the RPS, could be designed to promote a different set of clean energy technologies with retail electricity suppliers required to obtain clean energy credits, where such credits could be generated by new clean energy generators that deliver electricity to ISO-NE for use in Massachusetts. Facilities would qualify based on a technology-neutral emission threshold that would exclude natural gas generators unless carbon emissions were captured and permanently sequestered. While hydroelectric power is the primary short term focus of the CES, the CES could also create a framework for other technologies that could meet the emissions threshold, including next-generation nuclear power or carbon capture and sequestration, if such technologies were to become viable options over the longer term. The policy design could include a study of potential strategies to ensure that new clean energy displaces existing fossil generation, not existing clean energy.

The policy would also build on the tracking system used by RPS to ensure that clean energy developed to serve customers in Massachusetts is appropriately attributed to Massachusetts for the purpose of demonstrating compliance with the GWSA. However, since statutory requirements that mandate long-term contracts have proved critical to RPS implementation, it is not clear that a CES absent additional legislative authority for long term contracts would incent development of large-scale clean energy resources.

GHG Impact: Emission reductions in 2020 are estimated in the *Clean Energy Imports* policy description.

Other Benefits: Like other electric sector policies, by replacing polluting power plants with clean ones, a CES might serve as a catalyst to further reduce the emissions of harmful pollutants. These reductions would have public health and environmental benefits. A CES might furthermore assist the region in becoming less reliant on imported fossil fuels and increase energy diversification.

Cost: Suppliers would be required to either purchase certificates from eligible resources or make alternative compliance payments, which likely impact energy costs. A CES could present an opportunity to acquire clean energy resources at a lower cost than other existing clean energy alternatives that may be available.

Experience in Other States: The CES would build on the experience of Massachusetts and other states with similar programs that address renewable and alternative energy.

Legal Authority: The draft CES would be implemented by the Massachusetts Department of Environmental Protection (MassDEP) under the following authority: M.G.L. c. 111, sections 142A and 142B, and M.G.L. c. 21N.

Policy Website: http://www.mass.gov/eea/agencies/massdep/climate-energy/climate/ghg/ces.html

Regional Greenhouse Gas Initiative (RGGI)

Policy Summary: Massachusetts is one of the 9 Northeast and Mid-Atlantic states participating in a regional effort to limit carbon dioxide emissions from electric generating units in the region. The program, which began in January 2009, establishes a region-wide cap on CO2 emissions from fossil fuel-fired power plants in the region. The current program design calls for the cap to fall by 2.5% each year until 2020, at which time regional CO_2 emissions will be at least 50% below the 2005 level.

By the end of each three-year compliance period, facilities covered under the program are required to have purchased allowances—a limited authorization to emit one ton of CO_2— equal to their total emissions; the allowances are then retired so they cannot be used again. Allowances are made available by the states for purchase in quarterly auctions. Massachusetts is investing over 80 percent of its auction proceeds in energy efficiency, with smaller amounts for renewable energy and other consumer benefit programs.

Clean Energy Economy Impacts: Over $250 million in auction proceeds has been invested in energy efficiency projects across the Commonwealth since 2009, creating jobs in the clean energy economy. In addition, the efficiency investments will reduce electricity and fuel costs for property owners, leaving them with savings to be invested elsewhere in the local economy.

Rationale: The electric generating sector represents approximately 17% of total GHG emissions in Massachusetts at present. The RGGI program provides a transparent and stable signal to the electricity sector to plan for a cleaner energy future. In addition, improvements in building energy efficiency reduce the demand for electricity and help keep emissions below the cap, reducing the cost of compliance.

Policy Design: The RGGI states are reviewing EPA's final Clean Power Plan (CPP), which will require states to plan for and realize reductions in emissions of CO_2 from power plants in 2030. Potential changes to the RGGI program to align RGGI with the CPP are currently under study and will likely be implemented in 2017. However, these changes are not likely to significantly impact projected emissions in 2020.

GHG Impact: The RGGI has a regional emissions cap, providing for annual 2.5% reductions in CO_2 emissions across the 9-state region through 2020, and there is no specific limit on emissions deriving from the power plants in a particular state. Massachusetts' significant policies for electrical energy efficiency and renewable electricity are supported, in part, by proceeds from the RGGI auctions. Therefore, in this Massachusetts-specific analysis, emission reductions are attributed to all of these programs in combination.

Other Benefits: By providing incentives for reduced operation of the dirtiest plants and greater operation of cleaner ones, the RGGI program also reduces criteria and hazardous pollutant emissions (NO_x, SO_2, mercury, and fine particulate matter). These reductions have public health and environmental benefits.

Costs: Since funds received from sale of RGGI allowances are largely invested in the state's utility-administered energy efficiency programs, RGGI's costs in fractionally higher electricity prices are offset by reductions in the costs of the efficiency program.

Experience in Other States: California has implemented a similar cap on carbon emissions.

Legal Authority: Massachusetts RGGI regulations derive from authority under the Green Communities Act.

Uncertainty: A range of factors affect emissions from power plants. Some factors are under the control of power plants or the Commonwealth, and some are not, ranging from the weather and relative prices of fuels used to generate electricity to the aggressiveness of the implementation of energy efficiency programs.

Electric Grid Modernization

Policy Summary: In August 2015, the three electric distribution companies in the Commonwealth each filed a Grid Modernization Plan ("GMP") with the Department of Public Utilities (DPU). As required by the DPU, each company's ten-year GMP outlines how the company proposes to make measureable progress towards the following grid modernization objectives: (1) reducing the effects of outages; (2) optimizing demand, which includes reducing system and customer costs; (3) integrating distributed resources; and (4) improving workforce and asset management.

Grid modernization has the potential to contribute GHG emissions reductions in the Commonwealth both directly, by saving energy through reduced line loses and improved electric grid operation, and indirectly, by enabling the increased safe interconnection of distributed resources such as solar power, electric vehicles, and energy storage.

Rationale: Grid modernization will help make the electric grid more efficient and reliable, and will empower customers to manage and reduce their energy costs. The modern electric system will help maximize the integration of solar, wind, and other local and renewable sources of power. It will minimize outages by automatically re-routing power when lines go down, and immediately alert the utility when customers have lost power. Because customers will have new tools and information to enable them to use less electricity when prices spike, the electric system will be appropriately sized and less expensive.

Policy Design: In August 2015, the electric distribution companies filed a GMP with the DPU that laid out each company's 10-year plan to make measureable progress towards the four grid modernization objectives. Each GMP was required to contain a detailed 5-year capital investment plan, supported by a business case showing that the benefits of each plan justify the costs. In addition, each GMP was required to include a: (1) research, development, and deployment plan; (2) customer education and outreach plan; (3) cybersecurity plan; and (4) proposal for performance metrics. The DPU is currently conducting an adjudicatory proceeding for each plan.

GHG Impact: This policy is a cross-cutting policy with no direct GHG emission reductions.

Other Benefits: Grid modernization will help improve the reliability and resiliency of the electric grid. In addition, grid modernization will give customers new tools and information that will, among other things, provide them with incentives to reduce energy usage at times of peak demand, thereby reducing electric system costs.

Legal Authority: The DPU implemented the requirements for grid modernization in a series of Orders under its general supervisory authority to ensure the electric customers are provided with the most reliable electric service at the lowest possible cost.

Reducing GHG Emissions from Plastics Combustion

Policy summary: Solid waste is generated by residences and businesses across Massachusetts. Diverting high-carbon-content materials, such as plastics, from the waste stream can reduce emissions released after materials are discarded, and, for some part of the waste stream, incinerated. These diverted materials can then be recycled into other products. Diverting plastics from the waste stream under this CECP Update will result in materials with a lower carbon content being combusted at Massachusetts municipal waste–to-energy facilities, reducing emissions of CO_2.

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	0.3 $MMTCO_2e$	0.3%
Annual $ savings statewide in 2020	$8 to $11 million	
Cumulative $ savings statewide 2009-2020[60]	$69 to $92 million	

Clean energy economy impacts: Recycling yields greater local employment than does waste combustion. Currently, industries associated with recycling support 14,000 jobs in Massachusetts. Increased recycling of plastics would spur growth.

Rationale: The Commonwealth periodically prepares a Solid Waste Master Plan in accordance with Massachusetts General Law Chapter 16 Section 21. The solid waste sector includes sources of GHG emissions, such as landfills and municipal waste combustors, and plastics constitute a significant portion of the emissions. The Solid Waste Master Plan states, "diverting more material from disposal is:

- An *environmental opportunity* that will help Massachusetts reduce greenhouse gas emissions, conserve natural resources, and supplement energy conservation;
- An *economic development opportunity* that can spur the expansion of businesses and jobs in the Commonwealth, using materials diverted from waste to make new products and competing the global marketplace; and
- An *opportunity to reduce disposal costs* for waste generators and municipalities."

GHG impact: Looking only at in-state emissions reductions, the Massachusetts Department of Environmental Protection (MassDEP) conservatively estimates the reduction potential from diverting a portion of plastics from solid waste disposal in 2020 at 0.3$MMTCO_2e$.

Costs: According to the Solid Waste Master Plan, diverting material from disposal, whether through upfront waste reduction, reuse, recycling, or composting, can save significant disposal costs. Current disposal fees in Massachusetts typically range from $60 to $80 per ton. If the goal of reducing disposal by 2 million tons per year by 2020 is achieved, that would result in

[60] Based only on reduced disposal costs.

annual avoided disposal costs of $120–$160 million. Plastics diversion alone constitutes some $8 million to $11 million of the total $120 million to $160 million in annual avoided disposal costs.

Implementation issues: The “Massachusetts 2010-2020 Solid Waste Master Plan: A Pathway to Zero Waste” was published in April 2013.[61] MassDEP is currently implementing the strategies in that plan, including a number of action items to reduce the disposal of plastic materials in combustion facilities.

[61] http://www.mass.gov/eea/docs/dep/recycle/priorities/swmp13f.pdf

Stationary Equipment Refrigerant Management

Policy summary: This policy aims to minimize emissions of high Global Warming Potential (GWP) refrigerants used in stationary non-residential equipment through leak detection and monitoring, leak repair, system retrofit and retirement, and required service practices.

Recent developments on national and international efforts on reducing refrigerant leakage include:

- A U.S. EPA proposal published November 9, 2015 to more fully implement the prohibition under the federal Clean Air Act against knowingly venting, releasing, or disposing of ozone-depleting and substitute refrigerants. It would accomplish this by updating the existing requirements that currently apply to ozone-depleting refrigerants and then extending the requirements to non-ozone-depleting substitute refrigerants, such as hydrofluorocarbons (HFCs).[62]
- The announcement that the international Montreal Protocol framework that successfully reduced emissions of ozone depleting substances would be extended to address refrigerants.[63]

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG emissions reduced 2020	0.1 $MMTCO_2e$	0.1%

Clean energy economy impacts: There could be additional jobs in companies that engage in refrigeration system leak detection and repair, and cost savings to affected facilities from lower use of chemicals to refill systems.

Rationale: Common refrigerants include several types of hydrofluorocarbons. Emissions of HFC have been growing steadily since their introduction in the 1990s as replacements for chlorofluorocarbons (CFC) that damage the ozone layer. Like CFC, HFC can have global warming potentials thousands of times more potent than CO_2.

Design issues: California Air Resources Board (CARB) finalized a regulation in 2010, phasing in requirements for a leak detection and repair program for refrigeration units containing a charge of 50 pounds of refrigerant or greater. As mentioned above, EPA proposed regulations in 2015 to reduce refrigerant leakage. Massachusetts is reviewing the proposed EPA regulations to see whether they adequately address this policy. If not, the Massachusetts

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[62] See http://www2.epa.gov/snap/608-proposal

[63] See http://yosemite.epa.gov/opa/admpress.nsf/bd4379a92ceceeac8525735900400c27/c489a7d31ef941ee85257ef50049921d!OpenDocument

Department of Environmental Protection (MassDEP) will consider implementing a regulation modeled after California's.

GHG impact: This policy anticipates a reduction of 0.1 $MMTCO_2e$ in 2020.

Implementation issues: A potential issue with the EPA regulations is that reporting requirements may not be adequate to allow emission reductions in Massachusetts to be documented. If Massachusetts relies on EPA's program instead of implementing its own regulation, data sharing with EPA will be critical to ensure reductions are realized.

Costs: Based on information published by EPA, the policy is not expected to be a financial burden on facilities, especially when savings resulting from the reduced need to purchase refrigerants are considered.

Legal authority: MassDEP has authority to promulgate a regulation under M.G.L. c. 111, sections 142A and 142B, and M.G.L. c. 21N to create an enforceable refrigerants control program to prevent air pollution.

Uncertainty: Technical risks associated with leak detection and repair are expected to be relatively small. The practices promoted by the policy are already established. Implementation risks relate to the number and diversity of facilities that may be affected by the policy, which could complicate compliance assistance, verification, and enforcement. The effectiveness of the policy depends on facility owners actually implementing the practices called for in the policy, which may in turn depend on ensuring that technicians are trained and aware of the requirement. Though coordinated national and international actions to address refrigerant emissions are desirable to achieve the greatest reductions, it is possible that the majority of such reductions will not take effect until after 2020.

Policy web page: http://www.mass.gov/eea/agencies/massdep/climate-energy/climate/ghg/stationary-equipment-refrigerants.html

Reducing SF_6 Emissions from Gas-Insulated Switchgear

Policy summary: This policy aims to minimize emissions of sulfur hexafluoride (SF_6) from leakage of gas insulated switchgear (GIS) used in electricity transmission and distribution systems by setting limits on leakage rates (declining to 1 percent leakage allowed in 2020) and implementing best management practices for the recovery and handling of SF_6.

In 2013, Massachusetts finalized a regulation to implement this policy. The regulation requires large electric utilities to gradually reduce emissions beginning in 2015, such that the 1 percent leakage rate is achieved by 2020. Other key requirements ensure that all new SF_6-containing GIS meets the 1% leak rate, and that SF_6 is not released when GIS is discarded.

	Savings from full policy implementation	% of 1990 level
Economy-wide GHG reductions in 2020	0.4 $MMTCO_2e$	0.4%

Clean energy economy impacts: There could be an increase in in-state employment for companies engaged in SF_6 leak detection and repair, and potential for technological innovation.

Rationale: While emitted in relatively small quantities, SF_6 is a GHG that is 23,500 times more potent than CO_2 and has an atmospheric life of 3,200 years. One pound of SF_6 has the same global warming impact as 11 metric tons (24,251 pounds) of CO_2. Leakage from GIS is the largest source of SF_6 emissions in Massachusetts, with significant quantities also emitting from electronics manufacturing. Mitigation options for GIS focus on reducing leakage and handling losses, and replacing equipment. Best practices include SF_6 leak detection and repair, and recovery and recycling.

Policy design: Massachusetts' regulation is designed to allow flexibility for the regulated community with regard to how emissions are reduced. For example, emission rates may be averaged across a large number of GIS, GIS owners may choose between repair and replacement for problem GIS, and any disposal method is acceptable for used SF_6, provided that it is not released into the atmosphere. Additional information, including regulatory text, background documents, and reporting instructions, is available at the web address listed below.

GHG impact: This policy is expected to reduce 0.4 $MMTCO_2e$ in 2020.

Costs: The background document published when the regulation was proposed includes the following discussion of costs: "GIS owners could incur some additional costs to comply with the regulation, especially in the later years during which emission rates must be reduced relative to current levels for GIS owners subject to an emission reduction requirement. To some degree, these costs would be balanced by savings associated with the reduced need to purchase SF_6. Not enough information is available about likely costs and savings in the later years to explicitly estimate the magnitude of any economic impacts associated with the regulation. MassDEP notes that all known GIS owners are generally large businesses, such as power plants and electric utilities (either privately or municipal owned), and that California estimated the likely costs to electricity consumers of a similar but broader regulation to be less than $0.000025 per kilowatt-hour (kWh). As typical retail residential electricity prices in Massachusetts have ranged from $0.13 to $0.18 per kWh, this would correspond to an increase of 0.02% or less."

Legal authority: The Massachusetts Department of Environmental Protection (MassDEP) promulgated the regulation as 310 CMR 7.72, under the following regulatory authority: M.G.L. c. 111, sections 142A and 142B, and M.G.L. c. 21N.

Implementation: The policy promotes greater implementation of current industry best practices. The maximum emission rate set for the early years is already being achieved by Massachusetts utilities that have taken voluntary measures to reduce their emissions. Achieving the 1 percent limit in later years may require the use of relatively more expensive measures but these measures already exist.

Policy web site: http://www.mass.gov/eea/agencies/massdep/climate-energy/climate/ghg/reducing-sf6-emissions.html.

Reducing Emissions from the Natural Gas Distribution Network

Policy Summary: There are over 6,000 miles of aged non-cathodically protected steel, cathodically protected steel, cast-iron, and wrought-iron natural gas distribution pipelines in the Commonwealth. While calculations associated with lost and unaccounted for gas and its resulting GHG emissions are difficult to ascertain with certainty, a recent study commissioned by the Department of Public Utilities (DPU) estimated that natural gas escapes constructed distribution systems for a host of reasons at a rate of 0.6 to 1.1 percent.[64] While regulators and operators work to minimize leaks on the distribution system to minimize risks to health and public safety, gas leaks can also be a contributing source of GHG emissions.

In October 2014, seven of the eight natural gas local distribution companies (LDCs) in the Commonwealth filed plans with the DPU to replace all aged non-cathodically protected steel, cathodically protected steel, cast-iron, and wrought-iron natural gas distribution infrastructure in their service territories within a 20 to 25 year timeframe. The recent study referenced above concluded that replacing this infrastructure would result in a dramatic reduction in the amount of methane emissions from the natural gas distribution system.

	Savings from full policy implementation	**% of 1990 level**
Economy-wide GHG reductions in 2020	1.7 $MMTCO_2e$	1.8%

Rationale: Natural gas typically contains some 98% methane. Methane is a powerful GHG, over 20 times stronger than the most common GHG, carbon dioxide, and can be released from operational transmission, distribution, and natural gas storage systems.[65] Aged natural gas distribution infrastructure prevalent in the Commonwealth is more prone to experiencing such leaks than more modern infrastructure. As a result, an emphasis on repairing or replacing this infrastructure is expected to reduce the amount of natural gas lost during distribution.

Policy Design: In October 2014, LDCs filed initial plans with the DPU which specified a timeline for replacing all eligible aged infrastructure in their service territories. Eligible infrastructure includes mains, services, meter sets, and other ancillary facilities composed of non-cathodically protected steel, cast iron, and wrought iron. To accomplish the repair or replacement of this eligible infrastructure, as required by legislation, LDCs are required to file annual plans that lay out: (1) a schedule of replacement over the subsequent calendar year, (2) an anticipated timeline for the completion of each project, (3) the estimated cost of each project, (4) rate

[64] For a distribution system, those factors would include, but are not limited to: system leakage, metering variances, theft of service, purging during construction activities, and third-party damages.

[65] Transmission networks emit methane from compressors, pneumatic device vents, routine maintenance and pipeline venting, station venting, and meters/regulators. Natural gas storage emits methane from compressors, liquefaction of natural gas for storage, and re-gasification of stored gas for distribution.

change requests, (5) a description of customer costs and benefits under the plan, and (6) any other information the DPU considers necessary to evaluate the plan. The DPU evaluates each plan to determine if it reasonably accelerates eligible infrastructure replacement and provides benefits to customers. The DPU will complete its review of each plan within six months. Once approved, the gas distribution company may begin recovering the estimated plan revenue requirement associated with the repair or replacement work. Subsequently, on or before May 1st of the following year, the gas distribution company must file final project documentation for construction completed the previous calendar year in order to demonstrate substantial compliance with the plan, and to demonstrate that the costs were reasonably and prudently incurred. The DPU must complete a prudence review of final documentation within six months.

GHG Impact: This policy is expected to reduce GHG emissions by 1.7 $MMTCO_2e$ from 1990 through 2020.[66]

Other Benefits: Eliminating leaks associated with aged and eligible natural gas distribution infrastructure will increase health and public safety by reducing the number of natural gas leaks in the Commonwealth. In addition, customers will save money, as gas that is lost during distribution must still be procured by the LDCs and paid for by customers. Finally, this policy will have an economic benefit, as accelerating the replacement of natural gas infrastructure will lead to the creation of jobs.

Experience in Other States: There is much experience in Massachusetts and other states with the repair and replacement of the natural gas distribution network.

Legal Authority: M.G.L. c. 164, § 145 permits the gas distribution companies to submit plans to the DPU to repair or replace certain aging natural gas distribution infrastructure on an accelerated basis.

[66] Based on plans filed with DPU and see also the discussion of "Natural Gas Systems" on pages 17-19 of MassDEP's *Statewide Greenhouse Gas Emissions Level: 1990 Baseline and 2020 Business As Usual Projection Update* at http://www.mass.gov/eea/docs/dep/air/climate/gwsa-update-15.pdf

MEPA GHG Policy and Protocol

Policy Summary: The Massachusetts Environmental Policy Act (MEPA) requires that all major projects proposed in the Commonwealth that have state involvement (in the form of state permits, land transfers, or financial assistance, for example) 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. Building on this general requirement, the MEPA GHG Policy requires that certain projects undergoing review by the MEPA office quantify their GHG emissions and identify measures to avoid, minimize, and mitigate such emissions. In addition to quantifying project-related GHG emissions, the MEPA GHG Policy also requires proponents to evaluate project alternatives that may result in lower GHG emissions, and to quantify the impact of proposed mitigation in terms of emissions and energy savings. The MEPA GHG Policy is primarily applied to commercial and residential real estate development projects, but also applies to industrial and energy generation projects.

Clean Energy Economy Impacts: By requiring project proponents to evaluate all feasible measures to reduce their GHG emissions, such as energy efficiency upgrades, fuel switching, incorporation of renewable energy measures, and reduction of vehicle miles traveled, the MEPA GHG Policy supports the development of industries and jobs to supply these technologies. In addition, the avoided fuel and electricity use, due to enhanced efficiency of projects, reduce long-term operational costs of the projects.

Rationale: The principal purpose of the MEPA GHG Policy is to require project proponents to undertake a thorough analysis of a project's primary sources of GHG emissions at an early stage of project planning, and to examine all feasible alternatives that may have lower GHG emissions potential. By conducting this early-stage impacts and alternatives analysis, project proponents can integrate directly into project planning sustainable design considerations that will allow the project to achieve GHG emissions reductions in the most economical manner.

Policy Design and Issues: For the majority of projects subject to the MEPA GHG Policy, the Policy requires comparison of emissions associated with the proposed project design to the emissions that would result from construction of an identical building code-compliant project. In this way, the MEPA GHG Policy is closely related to issues surrounding the adoption of *Advanced Building Energy Codes* and other energy efficiency improvements for buildings. Similarly, where the MEPA GHG Policy encourages adoption of renewable energy components, it is closely related to issues involved in the implementation of incentives for generating renewable energy (see the *Developing a Mature Market for Renewable Thermal Technologies* policy). The MEPA GHG Policy also aims to reduce vehicle miles traveled in coordination with other state policies.

GHG Impact: To date, more than 200 projects have initiated review in accordance with the MEPA GHG Policy, and more than 100 projects have completed MEPA review with a finding that their completed GHG analysis was consistent with the MEPA GHG Policy. Projects that had completed review have achieved an average reduction of 19 percent in stationary-source GHGs below an equivalent code-compliant project and an average reduction of 5%

percent in mobile sources. In total, the MEPA GHG Policy has resulted in commitments to reduce GHG emissions by over 190,000 metric tons of CO_2e per year. However, reductions associated with the MEPA GHG Policy may be duplicative of the reductions achieved by other state policies designed to increase efficiency, encourage renewable energy generation, and reduce vehicle miles traveled.

Costs: The upfront costs of incorporating GHG reduction measures will vary widely depending upon the project, and many costs will be offset through energy savings. Because the MEPA GHG Policy does not mandate a specified level of reductions, but rather asks project proponents to adopt ”feasible" measures, measures that are considered infeasible from a cost perspective may be eliminated from consideration.

Experience in Other States: The MEPA GHG Policy is a nation-leading policy. Other states, including California and New York, have adopted similar policies, and the White House Council on Environmental Quality, which oversees implementation of the National Environmental Policy Act (NEPA) by federal agencies, has also released a draft policy concerning consideration of GHG emissions as part of the NEPA review of individual projects.

Legal Authority: The Global Warming Solutions Act specifically amended the MEPA statute to provide that:

In considering and issuing permits, licenses, and other administrative approvals and decisions, the respective agency, department, board, commission, or authority shall also consider reasonably foreseeable climate change impacts, including additional GHG emissions, and effects, such as predicted sea level rise. See M.G.L. c. 30, §61.

The MEPA GHG Policy was introduced and is being applied through MEPA review to address the Commonwealth’s obligations under the GWSA.

Implementation Issues: The MEPA GHG Policy has become a routine part of the environmental impact review process. For real estate development projects, the assessment and review of a project’s GHG analysis has become generally accepted by the regulated industry and the public.

Leading by Example (LBE)

Policy Summary: The Leading by Example (LBE) Program, established in April 2007 by Executive Order (EO) No. 484, works to lower costs and reduce environmental impacts at all Executive Branch agencies, as well as the 29 public institutions of higher education and several quasi-public authorities. The program oversees efforts to reduce energy use at the Commonwealth's 80 million square feet of buildings and fuel use of the light and heavy duty vehicle fleets, expand recycling programs, reduce water consumption, promote environmentally preferable purchasing, facilitate the construction of high performance state buildings, and reduce GHG emissions across state government.

The EO 484 sets the following targets for state government:

- 40 percent reduction from a 2002 baseline in GHG emissions by 2020, and 80 percent by 2050;
- 35 percent reduction from a 2004 baseline in energy use intensity by 2020; and
- 30 percent of total electric use to come from renewable sources by 2020.

The EO also established a "Massachusetts LEED Plus" building standard for new construction and major renovation projects that require all state government projects to achieve LEED certification and perform 20 percent better than the Massachusetts energy code.

Clean Energy Economy Impacts: Leading by Example efforts that include broad and comprehensive energy efficiency projects, as well as small and large-scale renewable project installations, will continue to create significant numbers of clean energy jobs in the construction and retrofit markets. Additionally, these efforts will result in a stabilization and potential reduction of state government energy costs, and will continue to reduce the amount of more expensive and dirtier fuels used in public buildings.

Rationale: With approximately 80 million square feet of buildings, state government operations result in significant amounts of fuel consumption annually, including more than 1 billion kWh of electricity from the grid, 77 million therms of natural gas, 6.7 million gallons of fuel oil, and more than 8 million gallons of diesel fuel and gasoline. This consumption results in over 990,000 metric tons of GHG emissions and expenditures exceeding $260 million. Given this large impact, there is clearly a huge opportunity to reduce energy usage and associated carbon emissions. Such efforts will also demonstrate to other institutions and the private sector that large-scale energy reduction and renewable energy efforts are both feasible and fiscally desirable.

Design Issues: Although significant clean energy programs are underway at state facilities, efforts to sustain such programs at the current scale once federal stimulus dollars are no longer present are needed. Also, efforts to streamline and simplify bidding and construction timelines have taken place, but more work will most likely be needed to ensure that projects are undertaken and completed in a timely fashion.

GHG Impact: Greenhouse gas emission impacts are directly related to energy reduction and renewable energy efforts at state facilities. If the 2020 targets in EO 484 are met, this would result in a reduction of approximately 380,000 metric tons of CO_2e.

Other Benefits: Additional benefits include reduced energy costs for Massachusetts taxpayers. The installation of new equipment also minimizes facility maintenance costs and needs, and improves comfort for the thousands of employees, residents, and visitors who work or live in, or visit, state facilities. Leading By Example projects also provide important piloting for new technologies and system management initiatives that could be adopted by other institutions and cities and town, as well as the private sector.

Costs: Although exact costs are unknown, it is anticipated that over $400 million worth of clean energy projects will be implemented by 2020, many of which are in the study, design, or implementation phase. Project costs will, for the most part, be funded through the Massachusetts Clean Energy Investment Program (CEIP), which provides low-rate bond financing paid for out of project savings. This program results in a positive cash flow early in the project and overall simple paybacks of between 10 and 20 years. Additional financing will be obtained through 3rd party financing, forward capacity market payments, Renewable Energy Credits, utility incentives, grants, and, where available, renewable energy rebates.

Experience in Other States: Many other states have undertaken “leading by example” efforts, including California, Colorado, Illinois, Indiana, New York, North Carolina, Pennsylvania, and Utah. Success has varied, but all efforts recognize the impact to the state budget of reducing energy costs, as well as how such efforts are critical to the success of statewide clean energy goals, where applicable.

Legal Authority: The EO 484 provides the legal authority to those entities overseen by the Governor. Other independent entities, such as the Massachusetts Water Resources Authority, the Massachusetts Port Authority, and the Massachusetts Bay Transportation Authority, frequently participate on a voluntary basis in the LBE Program and undertake similar efforts, but they are not subject to the specific targets in the order.

Implementation Issues: Successful implementation is dependent upon state resources, including financial and staffing. The LBE staff will continue to work with key agencies, in particular the Division of Capital Asset Management and Executive Office for Administration and Finance, to ensure that such resources are available.

Uncertainty: Given the success of past efforts, and the ongoing collaboration between key agencies, it is likely that a significant number of clean energy projects will be initiated and completed over the next several years. However, meeting the energy and GHG emission reduction targets will depend on the extent to which energy reductions are sufficient to overcome new construction and expansion of services—particularly at the public institutions of higher education, which have seen a significant increase in enrollment and hours of operation. Additionally, ensuring that adequate funding exists to implement large-scale projects is critical to meeting the targets.

Green Communities

Policy Summary: Created by the Green Communities Act of 2008, the Green Communities Division of the DOER is intended to help municipalities become more sustainable, control rising energy costs, and incubate the clean energy technologies and practices that will put Massachusetts cities and towns—and the Commonwealth as a whole—at the center of the 21st century clean energy economy. Envisioned as a way to encourage municipalities to make clean energy decisions, the Division is mandated to offer grant opportunities to municipalities designated as "Green Communities."

Clean Energy Economy Impacts: The five required criteria to be designated as a Green Community help municipal governments to reduce their own energy costs and help to achieve siting of wind, solar, and other renewable energy installations.

Rationale: Municipal governments are substantial consumers of fossil-fuel energy for their buildings, vehicles, street lighting, and water and wastewater treatment. An Energy Reduction Plan, along with a Fuel Efficient Vehicle Policy, are required for designation as a Green Community. These documents chart a municipal roadmap to reducing the energy consumption from municipal operations by 20 percent after five years or more. Through zoning and a streamlined approval process, Green Communities designation can have a major impact on the ability of renewable energy facilities to find suitable locations. Additionally, by adopting the "stretch" energy code (see the *Advanced Building Energy Codes* policy)—another requirement for Green Communities designation—the energy efficiency of new construction and major renovations is assured.

Policy Design and Issues: The Division provides technical assistance to all 351 MA communities to help them qualify for Green Community designation and/or to apply for other state energy grants. To become Green Communities, municipalities must meet five criteria:

- Adopt a local zoning bylaw or ordinance that allows "as-of-right-siting" for renewable and/or alternative energy generation, research & development, or manufacturing facilities;
- Adopt an expedited application and permit process for as-of-right energy 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, whenever such vehicles are commercially available and practicable; and
- Set requirements to minimize life-cylce energy costs for new construction; one way to meet these requirements is to adopt the Board of Building Regulations and Standards (BBRS) Stretch Code.

The Green Communities Act allows funding of up to $10 million per year for the designation and grant program from the proceeds of *Regional Greenhouse Gas Initiative* (RGGI) allowance auctions and other sources. The Green Communities Division also serves all Massachusetts cities and towns as a one-stop shop for education on the benefits of energy efficiency and renewable energy. It provides guidance and technical assistance for energy questions and projects. It promotes collaboration through shared best practices among municipalities, and funding opportunities for clean, affordable, and resilient energy projects and initiatives.

To achieve the goal of serving all municipalities, regional school districts, and water and wastewater districts in Massachusetts, the Green Communities Division offers a number of programs and services in addition to its signature Green Communities Grant Program. Other services include administering a variety of grant programs. They include, but are not limited to: funds for energy efficiency programs for customers of municipal light plants; seed funding for municipalities to hire on-staff energy managers; monies for clean energy projects at Drinking Water and Wastewater Facilities; and funding of independent third parties to aid municipalities, regional school districts, or water/wastewater districts in the study, negotiation, development and/or management of clean energy projects.

Technical assistance for energy savings performance contracting is also provided. The DOER hosts an easy-to-use web-based energy information management and reporting tool (MassEnergyInsight) that benchmarks the energy performance of all municipally owned and operated buildings, as well as streetlights and vehicles. It hosts webinars, and has created guidance documents, educational materials, and other tools to assist with energy management and efficiency efforts. The Division collaborates with electric and gas utilities to administer energy efficiency services to local and regional government entities. It provides a website and listserv for disseminating information; and employs four Regional Coordinators to provide direct support to cities and towns.

GHG Impact: GHG emissions are directly related to energy reduction and renewable energy efforts in municipalities. The current 155 Green Communities are committed to reducing their energy consumption by 2,153,992 MMBtus in five years from energy efficiency measures alone. This is equivalent to the energy used to heat and power 16,698 homes, with a resulting GHG reduction of 184,647 metric tons of CO_2e, equivalent to taking 38,866 cars off the road each year.

Other Benefits: Additional benefits include reduced energy costs, creation of a clean, affordable, and resilient energy future of the Commonwealth, and a lower burden on Massachusetts taxpayers. Projects funded through the Green Communities Division can pilot new technologies and system management. In addition, the work done by municipalities to become designated as a Green Community requires buy-in of its residents, with some of the criteria requiring a Town Meeting vote. This has resulted in a major grassroots movement to educate the larger citizenry on the benefits of reducing energy consumption and creating clean, renewable energy projects. Benefits include an uptick of local volunteer activity resulting in the establishment of new Energy Committees and hiring of on-staff energy managers. Additionally, increased municipal awareness and leadership in clean energy has led to local events such as energy fairs, and outreach programs to residents including workshops, energy saving campaigns, rebates programs for implementation of energy efficiency or renewable measures (for example, costs not covered by a Mass Save audit).

Costs: Up to $10 million per year, funded through the proceeds of RGGI emissions allowance auctions and other sources.

Equity Issues: There are no known equity issues. There are 155 designated communities from the Berkshires to Cape Cod, ranging in population from 392 to 645,966 residents, representing 54% of the Massachusetts population. Initial Designation Grants are based on a $125,000 base for each designated Green Community, plus additional amounts tied to per capita income and population, and for municipalities that provide as-of-right siting for renewable energy generation. Subsequent grants are awarded on a competitive basis. Grant programs, in addition to its signature Green Communities Grant Program, support clean energy activities in municipal light plant communities, regional school districts, and other regional entities.

Experience in Other States: The Green Communities Division was the first of its kind in the nation. Several other states have consulted with DOER's Green Communities Division regarding development of similar programs. To date, we are aware of similar programs, modeled at least partially after the Massachusetts program, launched in Rhode Island and New York.

Legal Authority: The Green Communities Act of 2008 created the Division and the designation and grant program, and authorized funding for it. The BBRS approved the Stretch Code as an option for municipalities to adopt.

Implementation Issues: As of December 2015, 155 communities had attained designation as Green Communities, thereby qualifying for funding from the Division. In addition, as of December 2015, 161 cities and towns had passed the Stretch Code.

Uncertainty: As the program has seen adoption of 155 communities through 2015, there still is excitement among our cities and towns to attain the Green Community Designation. It will be important in the coming years to continue to engage the remaining 196 communities to achieve the goal of 351 Green Communities, a fully clean and green Commonwealth. Additionally, many of the current Green Communities are eager to reach beyond the existing goal of reducing their municipal energy use by 20 percent in five or more years in order to bring clean energy opportunities to their residents and businesses and to pursue additional greenhouse gas emission reductions.

Consideration of GHG emissions in State Permitting, Licensing, and Administrative Approvals

Policy Summary and **Rationale:** Section 7 of the Global Warming Solutions Act states, "In considering and issuing permits, licenses and other administrative approvals and decisions, the respective agency, department, board, commission or authority shall also consider reasonably foreseeable climate change impacts, including additional GHG emissions..." in the context of environmental review. Consideration of GHG emissions in various state actions is achieved through the implementation of the MEPA GHG policy and protocol, Green Communities grant program, Leading By Example program, regulation 310 CMR 60.05 "Global Warming Solutions Act Requirements for the Transportation Sector and the Massachusetts Department of Transportation" (MassDOT), and other initiatives including MassDOT's Healthy Transportation Directive and the Massachusetts Department of Public Utilities' consideration of methane leaks and repair in their review of the natural gas local distribution companies' annual pipeline replacement plan.