COMMONWEALTH OF MASSACHUSETTS

Global Warming Solutions Act
10-Year Progress Report

Massachusetts Global Warming Solutions

Executive Office of Energy and Environmental Affairs

ACKNOWLEDGEMENTS

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LETTER FROM THE SECRETARY

I am pleased to present the Executive Office of Energy and Environmental Affairs' (EEA) Ten-Year Progress Report on the implementation of the Global Warming Solutions Act of 2008 (GWSA). This report fulfills an important mandate of the GWSA, and highlights Massachusetts nation-leading progress towards reducing greenhouse gas emissions.

Ten years ago, Massachusetts signed into law the nation's most ambitious greenhouse gas reduction legislation. In 2016, at Governor Baker's direction, EEA expanded and integrated its greenhouse gas mitigation efforts with its work to increase the resiliency of our communities against the impacts of climate change. This Progress Report highlights the significant progress the Commonwealth has made toward reaching the dual goal of a resilient Commonwealth and a 25% reduction in greenhouse gas emissions below the 1990 baseline by 2020 – as well as where we still have more work to do. We are confident that each agency within EEA and partnering Secretariats, under the leadership of the Baker-Polito Administration, will continue to implement the policies of the 2015 Update of the Clean Energy and Climate Plan for 2010 (2015 CECP Update) and meet our 2020 emissions limit.

Reducing energy demand provides a critical foundation for our work to reduce emissions. The Mass Save® and municipal-led energy efficiency programs have reduced electricity demand, even as Massachusetts population has steadily grown. More than just energy and emissions, these efficiency programs have also saved consumers billions of dollars on their utility bills. Specifically, the electricity generation sector has rapidly shifted away from carbon-intensive fuels, declining by 52% through a range of policies from energy efficiency deployment, growth of renewable resources, and retirement of carbon-intensive generators. These clean energy technology industries have led to more than 100,000 new jobs and have contributed more than $11 billion *per year* to the Massachusetts economy.

In the Transportation Sector, forward-looking motor vehicle standards have saved Massachusetts drivers at the pump and reduced our dependence on imported petroleum products. Moreover, these standards have dramatically reduced the emission of harmful pollutants from vehicle exhaust, with enormous public health benefits. However, there is more work to do to reduce transportation emissions which continue to grow as our population and economy have grown. To address this challenge, the Baker-Polito Administration has taken a number of steps over the last year to convene stakeholders through the Commonwealth, hold interstate dialogues, and study the best science and data in order to better understand and evaluate the most feasible strategies to reduce transportation sector emissions. Building on these efforts, Governor Baker created the Commission on the Future of Transportation to provide recommendations to support future efforts to deliver a cleaner, more resilient, and reliable transportation system for all residents. Their report, released in December 2018, will inform our analysis and development of a roadmap to meet the GWSA emissions limit in 2050.

In the last ten years, the Commonwealth has led the nation in reducing greenhouse gas emissions and fueled a new economy built on innovation and technology. Most of the policies contained within the 2015 CECP Update have led to emissions reductions. In some cases, the impacts of these policies have simply been masked by other changes as the economy has moved to embrace clean and efficient technologies. As we look to 2020 and beyond, Massachusetts has an opportunity to continue its leadership, working with regional states and partners through programs like the Regional Greenhouse Gas Initiative, the Transportation and Climate Initiative, and the U.S. Climate Alliance. Global warming is not isolated to Massachusetts; only by engaging and working with our partners in New England and across the world will we be able to reduce greenhouse gas emissions, preserve our natural resources, continue to grow our economy, and protect our residents and communities from the impacts of climate change.

Sincerely,

Matthew A. Beaton
Secretary of Energy and Environmental Affairs

ABBREVIATIONS

2015 CECP Update – 2015 update of the Massachusetts Clean Energy and Climate Plan for 2020

APS – Alternative Energy Portfolio Standard

Btu – British thermal unit

CECP – Massachusetts Clean Energy and Climate Plan for 2020, published in 2010.

CEP – Comprehensive Energy Plan

CES – Clean Energy Standard

CHP – Combined Heat and Power

CO_2 – carbon dioxide

CO_2e – carbon dioxide equivalents

DOER – Massachusetts Department of Energy Resources

DPU – Massachusetts Department of Public Utilities

EEA – Massachusetts Executive Office of Energy and Environmental Affairs

EEAC – Massachusetts Energy Efficiency Advisory Council

EIR – Environmental Impact Report

EISA – Energy Independence and Security Act

E.O. 569 – Executive Order 569

EPA – Environmental Protection Agency

EV – electric vehicle

EVSE – electric vehicle supply equipment

FHWA – Federal Highway Administration

GCA – Green Communities Act of 2018

GHG – greenhouse gas

GWSA – Global Warming Solutions Act of 2008

MAPC – Metropolitan Area Planning Council

MassCEC – Massachusetts Clean Energy Center

MassDEP – Massachusetts Department of Environmental Protection

MassDOT – Massachusetts Department of Transportation

MassEVIP – Massachusetts Electric Vehicle Incentive Program

$MMTCO_2e$ – million metric tons of carbon dioxide equivalents

MMBtu – million British thermal units

MOR-EV – Massachusetts Offers Rebates for Electric Vehicles

MW – megawatt

MWh – megawatt hour

NHTSA – National Highway Traffic and Safety Administration

PAs – Program Administrators of energy efficiency programs

RGGI – Regional Greenhouse Gas Initiative

RPS – Renewable Portfolio Standard

SMART – Solar Massachusetts Renewable Target

TWh – terawatt hour

VMT – vehicle miles traveled

ZEV – zero emission vehicle

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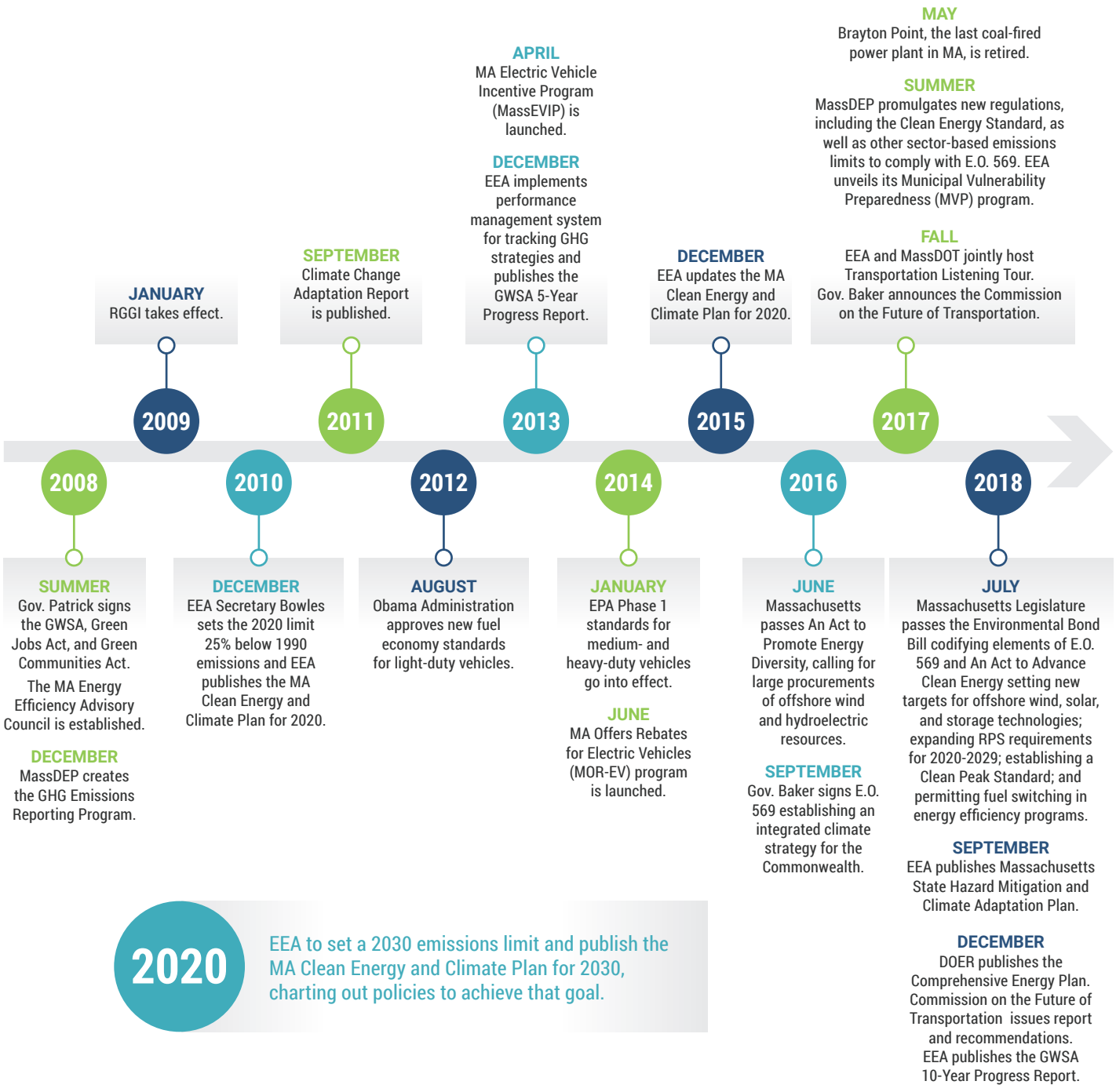
EXECUTIVE SUMMARY

1.1 SUMMARY OF GLOBAL WARMING SOLUTIONS ACT IMPLEMENTATION

The Global Warming Solutions Act (GWSA) was signed into law in 2008, making Massachusetts one of the few U.S. states with ambitious greenhouse gas (GHG) emissions reduction limits of 25% reduction below the 1990 baseline level by 2020 and at least 80% reduction by 2050. Since then, the Commonwealth has made great strides in implementing feasible and cost effective GHG emissions reduction strategies, coordinating state agencies, engaging stakeholders, evaluating progress towards the GWSA limits, and integrating GHG reduction strategies with climate change adaptation strategies. Through the combination of reducing and electrifying energy demand and decarbonizing energy sources, Massachusetts is on our way to meeting the emissions limits in the GWSA while continuing to support a vibrant economy, resilient communities, and a growing population.

Figure 1 shows that since the passage of the GWSA, Massachusetts has created a strong framework of state laws, regulations, and executive orders that guides the Commonwealth's actions to address climate change. The framework builds on the three overarching strategies through which the Commonwealth can effectively reduce GHG emissions: energy use reduction, electrification, and decarbonization. *The Massachusetts Clean Energy and Climate Plan for 2020 (CECP)* in 2010 and its update in 2015 (2015 CECP Update) featured a broad suite of policies that aim to reduce GHG emissions in the Commonwealth across all sectors through increased energy efficiency in buildings and vehicles, the electrification of vehicles and thermal conditioning in buildings, and the replacement of carbon intensive fuels with renewable energy sources.

FIGURE 1 | MAJOR MILESTONES SINCE PASSAGE OF THE GWSA.



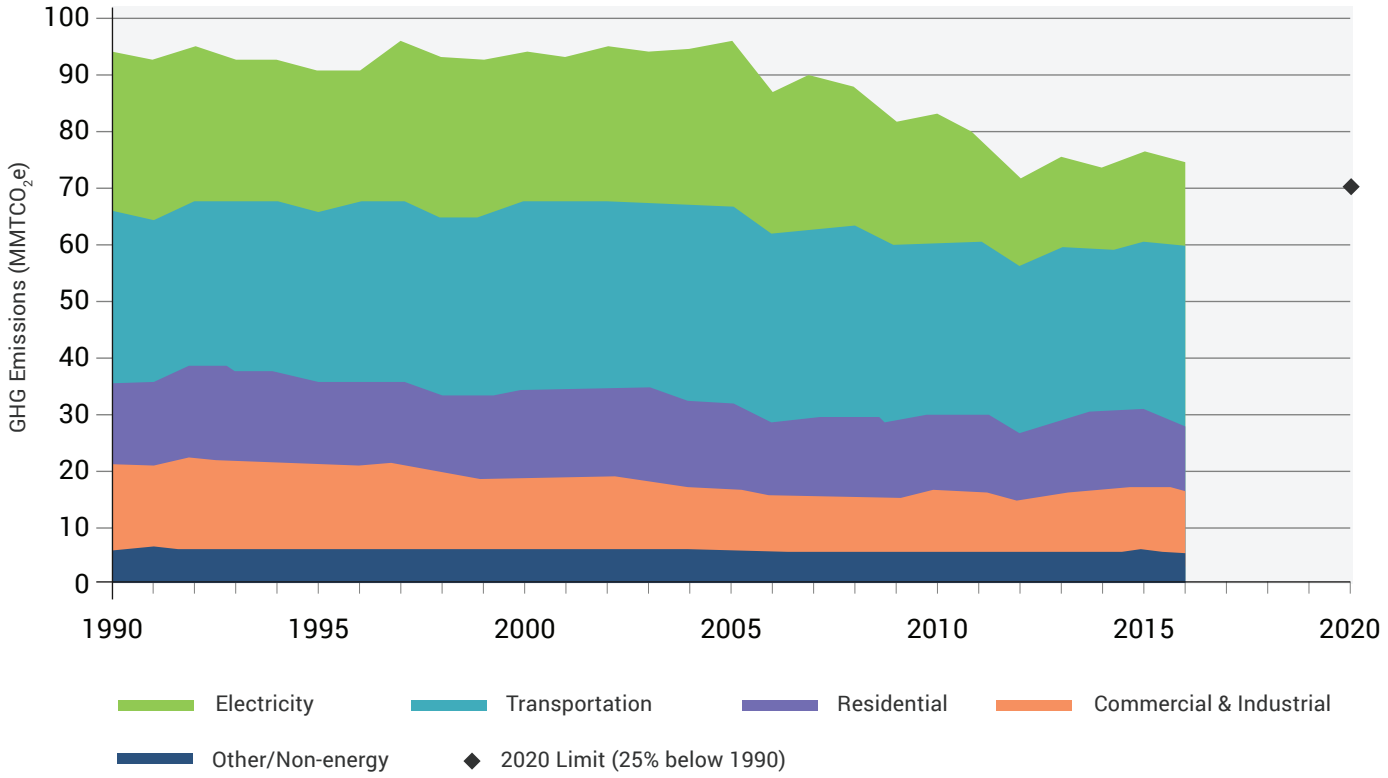
REDUCTION OF ENERGY USE ACROSS ALL SECTORS

- In 2018, the American Council for an Energy-Efficient Economy named Massachusetts the #1 state for energy efficiency in buildings for the 8th year in a row. The Massachusetts Energy Efficiency Advisory Council (EEAC) recently approved the latest three-year energy efficiency plan (2019-2021) that maintains nation-leading saving levels while transitioning to a more holistic approach to energy efficiency, demand management, and strategic electrification and ensuring continued growth of energy efficiency and economic benefits in the Commonwealth. Since 2010, the Mass Save® statewide efficiency programs have resulted, cumulatively, in over 6.8 million megawatt hours (MWh) of electricity savings, 93.4 million therms of natural gas savings, and 1.4 trillion British thermal units (Btu) in other heating fuel savings from existing residential and commercial buildings. For new construction, the Mass Save® statewide efficiency programs have resulted in over 1.4 million MWh of electricity savings and 23.9 million therms of natural gas savings since 2010.[1] Cumulatively, these savings combined have reduced emissions by more than 3.9 million metric tonnes of carbon dioxide equivalent ($MMTCO_2e$) and saved consumers more than a billion dollars on their energy bills.[2]
- In 2009, Massachusetts became the first state to adopt a local-option stretch energy code that extends beyond the base building energy code. The Stretch Code emphasizes energy performance instead of prescriptive requirements, and is an important strategy to reduce energy consumption in newly constructed homes and commercial buildings. As of November 2018, 250 municipalities had adopted the Stretch Code, which is mandatory for designation as a Green Community.
- Massachusetts law requires the Commonwealth to adopt and implement California's motor vehicle emissions standards as long as they are at least as protective as the federal standards. California has harmonized its standards with federal standards through 2025. Because of these standards, fuel efficiency in light-duty passenger vehicles sold in Massachusetts have increased 12% from 2009 to 2016, reducing GHG emissions from these vehicles by 2.6 $MMTCO_2e$ in 2016.
- The Greening the Gateway Cities program has planted over 19,000 trees in 14 Gateway Cities as of December 2018. The program is designed to reduce household heating and cooling energy use by increasing tree canopy cover in urban residential areas in the Commonwealth. It is estimated that every 1% increase in tree canopy above a minimum 10% canopy cover brings a 1.9% reduction in energy needs for cooling and up to a 1.1% reduction in energy for heating. The GHG reduction impact of these planted trees will increase significantly as they continue to grow in size.

ELECTRIFICATION OF TRANSPORTATION AND THERMAL CONDITIONING

- Massachusetts is a member of the Multi-state Zero Emission Vehicle (ZEV) Task Force and is committed to increasing the share of ZEVs in the Commonwealth. The Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) program by the Department of Energy Resources (DOER) and the Clean Cities Coalition has issued or reserved over $23 million in consumer rebates for over 11,000 ZEV purchases or leases since 2014. In December 2018, the MOR-EV program was extended through June 30, 2019 with additional funding to sustain this popular program. The Massachusetts Electric Vehicle Incentive Program (MassEVIP) through the Department of Environmental Protection (MassDEP) has given $2.66 million to Massachusetts municipalities, state agencies, and public colleges and universities to acquire 267 electric vehicles and 92 publicly accessible charging stations, and $1.35 million to employers to acquire 543 electric charging stations at 265 separate locations. The 15,111 electric vehicles registered in the Commonwealth as of September 2018 have resulted in net reductions of 33,150 metric tons of CO_2e in 2018.
- The Commonwealth is set to receive approximately $75 million from the Volkswagen Settlement Trust to spend on vehicle-related environmental mitigation projects, of which up to 15% can be spent on electric charging infrastructure. MassDEP has finalized the Beneficiary Mitigation Plan for cycle one investments and will spend up to $23.5 million in Year One to support the purchase of electric transit buses by the Pioneer Valley and Martha's Vineyard Transit Authorities, to supplement the existing network of electric vehicle supply equipment (EVSE) with additional EVSE, and to implement new projects selected from a public solicitation process that could include the replacement of a diesel engine, vehicle, or equipment with an all-electric engine, vehicle, or equipment.
- The Massachusetts Clean Energy Center's Clean Heating and Cooling programs have committed $48 million through 2020 to support the installation of highly efficient or renewable heating and hot water technologies at homes and businesses across the Commonwealth that often replace or supplement systems burning fossil fuel. Further electrification of thermal conditioning in buildings is expected to significantly increase following the amendment of the Green Communities Act of 2008 (GCA) in August 2018 to authorize energy efficiency investments in fuel switching and demand management strategies—such as cost effective strategic electrification, storage, and active demand management—by energy utilities for the Mass Save® program.

FIGURE 2 | MASSACHUSETTS GHG EMISSIONS, 1990 – 2016



DECARBONIZATION OF THE ELECTRIC GRID AND REMAINING FUEL

- In January 2007, Massachusetts joined the Regional Greenhouse Gas Initiative (RGGI), a cooperative effort by Northeast and Mid-Atlantic States to reduce CO_2 emissions from large fossil-fueled power plants. CO_2 emissions from the power sector in the RGGI states since 2007 have decreased by approximately 40%, and due to recent regulatory amendments, will fall an additional 30% between 2021 and 2030 relative to the 2020 level.
- Retirements of coal and oil-fired power plants have contributed a reduction in GHG emissions of 5.0 $MMTCO_2e$ to date.[3] MassDEP promulgated regulation 310 CMR 7.74 *Reducing CO_2 Emissions from Electricity Generating Facilities* in 2017 to set an annual declining limit on CO_2 emissions from large electric generating facilities in the Commonwealth. The limit further ensures that the generation of electricity in Massachusetts continues to decarbonize as required by the GWSA.
- The electric grid in Massachusetts has become significantly cleaner due to the Renewable Portfolio Standard (RPS). The expansion of the RPS requirement from a 0.5% per year increase to a 1% annual increase starting in 2009 translates to a reduction in GHG emissions of 0.5 $MMTCO_2e$ in 2015. With the passage of the *Advance Clean Energy Act of 2018*, the RPS requirement increases again to 2% annually between 2020 and 2030, reaching 35% in 2030 and increasing to 55% in 2050. The Clean Energy Standard (CES), promulgated in 2017, will reach a standard of 80% in 2050.[4] These requirements will be met in the near- and medium-term with renewable energy certificates from qualified resources as well as the clean energy procurements authorized by the *Energy Diversity Act of 2016*. The projects selected by Massachusetts's Electric Distribution Companies via these procurements are expected to provide 9.45 TWh of hydroelectric generation and 800 MW of offshore wind generation in the mid-2020s.

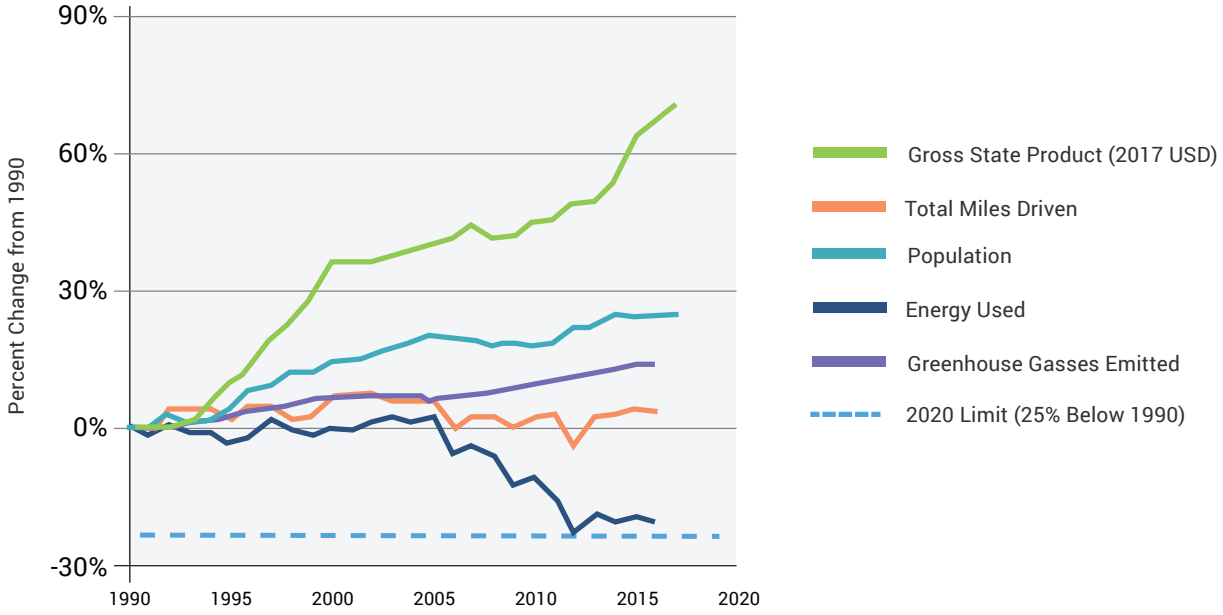
1.2 GHG EMISSIONS TRENDS AND SUCCESSES

The implementation of GHG emission reduction policies that were highlighted in the 2015 CECP Update, as well as additional policies and regulations implemented since then, are helping the Commonwealth effectively reduce GHG emissions and stay on track to meet the

[1] Reductions are estimated using an approach that isolates the impact of each policy on emissions each year. Because other factors affect emissions, they may not be correlated with trends over time. See Appendix A for summary of calculation methodology.
[2] Dollar estimate assumes 10-15 cents per KWh and $1 per therm.
[3] The closure of Pilgrim nuclear power plant in 2019 is estimated to result in an increase in emissions of 2.3 $MMTCO_2e$ from still operating power plants.
[4] RPS Class 1 credits are eligible for CES.

GWSA emissions limit in 2020. The latest statewide GHG inventory by MassDEP shows that GHG emissions in 2016 were 21.4% below the 1990 baseline level (Figure 2). The decrease in GHG emissions comes despite a 13% growth in population and 24% growth in vehicle miles traveled (VMT) (Figure 3). Significant GHG emissions reduction from the electric sector since 2005 has been a major contributor to the drop in gross GHG emissions, and vehicle standards have lowered the carbon intensity of each VMT while energy efficiency measures in buildings helped control energy demand despite increased economic growth and variable weather conditions.

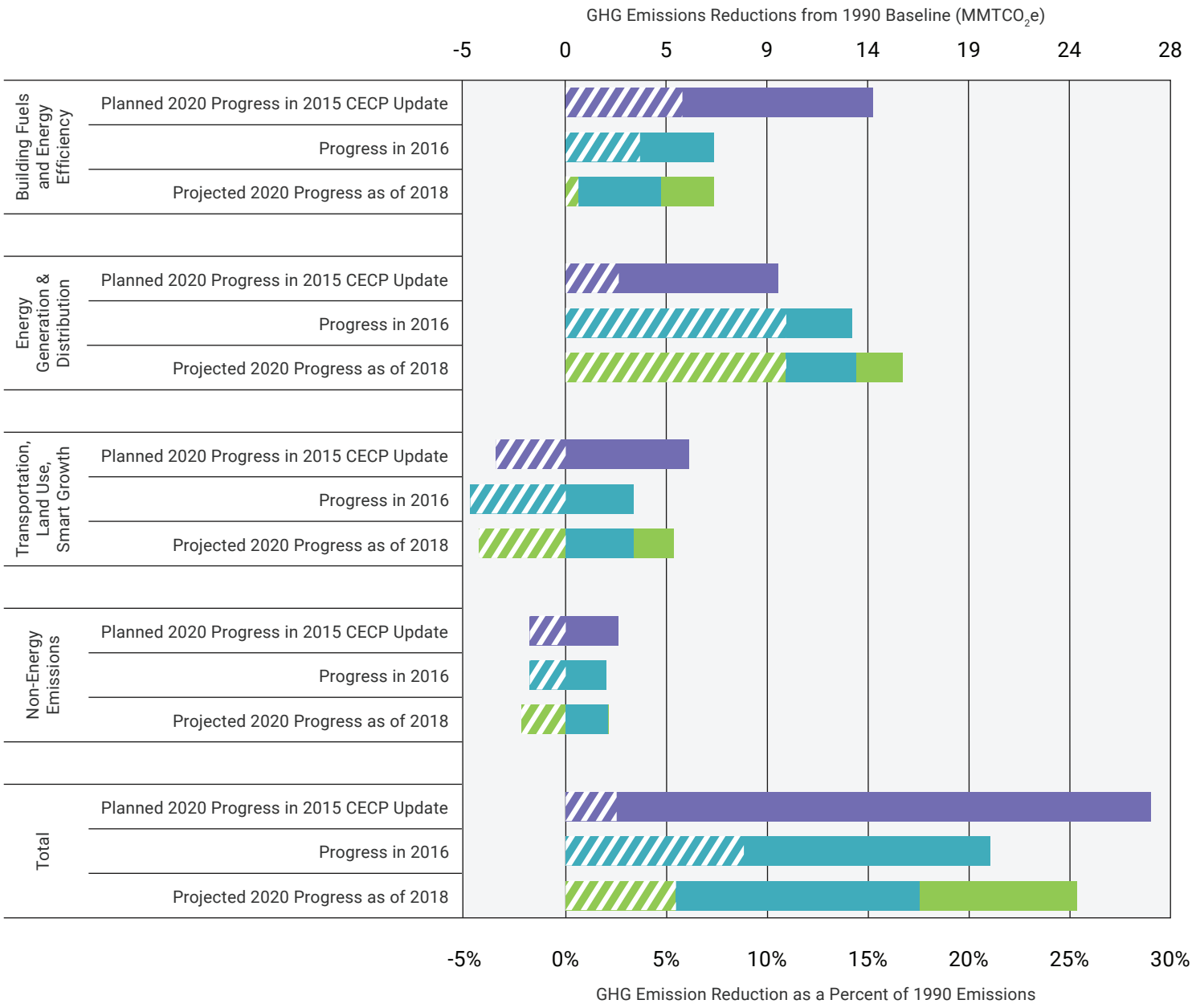
FIGURE 3 | TRENDS OF GROWTH IN GSP, VMT, AND POPULATION WHILE GHG EMISSIONS ARE DECREASING AND ENERGY USE HAS BEEN STABLE



The downward trend of statewide GHG emissions indicates that our climate change mitigation policies are working. Of the 20.2 $MMTCO_2e$ reduced in 2016 from the 1990 baseline level, approximately 11.6 $MMTCO_2e$ are attributed directly to the implementation of GHG mitigation policies from 2010 to 2016 (Figure 4)[5]. These reductions (represented by the solid colored bars) will grow larger over time as implementation of these policies continues. The remainder of the GHG emissions reductions observed in the GHG inventory (represented by the hashed colored bars) are not directly attributable to policies in the 2015 CECP Update, whether due to lack of available data, policies implemented before passage of the GWSA, or other factors, such as weather conditions, relative fuel prices, and changes in consumer preferences. The negative reductions in the transportation and non-energy emissions sectors indicate that emissions reduction from policies implemented before the GWSA or from non-policy impacts counteract the GHG reductions from GHG mitigation policies implemented after the GWSA. On the other hand, policies implemented before the GWSA and non-policy impacts in the building and energy sectors have assisted the overall GHG reductions seen in these two sectors. In 2020, post-GWSA policy implementation is projected to reduce approximately 19 $MMTCO_2e$ or 20% below the 1990 level while the impact of pre-GWSA policies and other factors are projected to reduce an additional 5 $MMTCO_2e$ or 6% below the 1990 level (Table 1). Combined, the overall expected GHG emissions reduction will put the Commonwealth on track to meet the 2020 emissions limit of the GWSA.

[5] Analyses behind the estimates of GHG savings from policy implementation are summarized in Appendix A.

FIGURE 4 | PLANNED, ACHIEVED, AND PROJECTED GHG EMISSIONS REDUCTIONS (NEGATIVE REDUCTIONS ARE EMISSIONS, WHICH COUNTERACT THE POSITIVE REDUCTIONS)



Net baseline changes including policy reductions from programs predating GWSA, policy-related reductions that can't be quantified or directly attributed to policies, and reductions from non-policy changes (such as weather & economic conditions)

Reductions attributable to post-GWSA policies in 2016

Additional post-GWSA policy reductions projected for 2020 as of 2018

Planned 2020 Progress in 2015 Update of CECP

TABLE 1 | SUMMARY OF ESTIMATED GHG REDUCTIONS FROM POLICY IMPLEMENTATION*

	PLANNED 2020 GHG EMISSIONS REDUCTION (ESTIMATED IN 2015)		2016 PROGRESS		PROJECTED 2020 GHG EMISSIONS REDUCTION (ESTIMATED IN 2018)	
	$MMTCO_2E$	% OF 1990 LEVEL	$MMTCO_2E$	% OF 1990 LEVEL	$MMTCO_2E$	% OF 1990 LEVEL
Building Fuels and Energy Efficiency	9.0	9.5%	4.0	4.2%	6.8	7.2%
All Cost-Effective Energy Efficiency	5.4	5.8%	3.2	3.4%	5.1	5.4%
Advanced Building Energy Codes	1.5	1.6%	0.7	0.7%	0.8	0.9%
Building Energy Rating and Labeling	–	–	Cross-cutting policy; savings reflected elsewhere.			
Expanding Energy Efficiency Programs to Commercial and Industrial Heating Oil	<<0.1	<<0.1%	Reductions to be included in All Cost-Effective Energy Efficiency.			
Appliance and Product Standards	1.0	1.1%	0.1	0.1%	0.8	0.8%
Renewable Thermal Technologies	1.0	1.1%	0.0	0.0%	0.1	0.1%
Tree Retention and Planting to Reduce Heating and Cooling Loads	<<0.1	<<0.1%	<<0.1	<<0.1%	<<0.1	<<0.1%
Transportation, Land Use, and Smart Growth	5.7	6.1%	3.2	3.4%	5.0	5.3%
Federal and California Vehicle Efficiency and GHG Standards (CAFE/Pavley)	3.7	3.9%	2.6	2.7%	3.7	4.0%
Federal Emissions and Fuel Efficiency Standards for Medium and Heavy Duty Vehicles	0.4	0.4%	0.0	0.0%	0.5	0.5%
Federal Renewable Fuel Standard (RFS) and Regional Clean Fuel Standard (CFS)	0.1	0.1%	0.0	0.0%	0.1	0.1%
Clean/Electric Vehicle Incentives	0.1	0.1%	Reductions included in CAFE/Pavley standards.			
State Transportation Regulations (includes policy formerly called GreenDOT)	1.0	1.1%	Transportation reductions included in CAFE/Pavley standards; Buildings reductions included in All Cost Effective Energy Efficiency.			
Smart Growth	0.4	0.4%	0.6**	0.6%**	0.7**	0.8%**
Electricity Generation and Distribution	7.8	8.2%	2.4	2.5%	4.7	5.0%
Coal-Fired Power Plant Retirements	2.7	2.9%	1.7	1.7%	2.7	2.9%
Regional Greenhouse Gas Initiative (RGGI)	–	–	Cross-cutting policy; reductions counted elsewhere.			
Renewable Portfolio Standard (RPS)	1.1	1.1%	0.7	0.8%	1.0	1.1%
Clean Energy Standard (CES)	–	–	0.0	0.0%	1.0	1.0%
Clean Energy Procurements	4.0	4.2%	Some reductions to be counted in RPS and CES after 2020.			
Electric Grid Modernization	–	–	Cross-cutting policy; reduction counted elsewhere.			

Non-Energy Emissions	2.5	2.6%	2.1	2.2%	2.2	2.3%
Reducing GHG Emissions from Plastics Combustion	0.3	0.3%	0.1	0.1%	0.1	0.1%
Reducing SF6 Emissions from Gas-Insulated Switchgear	0.4	0.4%	0.4	0.4%	0.4	0.4%
Reducing Emissions from the Natural Gas Distribution Network	1.7	1.8%	1.7	1.8%	1.7	1.8%
Stationary Equipment Refrigerant Management	0.1	0.1%	Policy not yet pursued.			
Total Reductions Attributable to Policies post-GWSA	25.0	26.4%	11.6	12.3%	18.7	19.8%
Other Changes Not Attributable to Policies post-GWSA	2.5	2.6%	8.6	9.1%	5.3	5.6%
Total Emissions Reductions	27.5	29.0%	20.2	21.4%	24.0	25.4%

* See Appendix A for summary of methodology
** Rough estimate using proxy data.

Massachusetts's experience implementing the GWSA shows that environmental programs can support economic development. Since the passage of the GWSA, Gross State Product (GSP) has increased by more than $91 billion (21%), from $436 billion in 2008 to $527 billion in 2017 after adjusting for inflation (Figure 3).[6] The clean energy industry employs more than 110,000 people in Massachusetts (Figure 5), and contributes $13.2 billion to the Commonwealth's economy, or about 2.5% of the annual GSP.[7] As the clean energy industry continues to grow, so will the overall economy of Massachusetts.

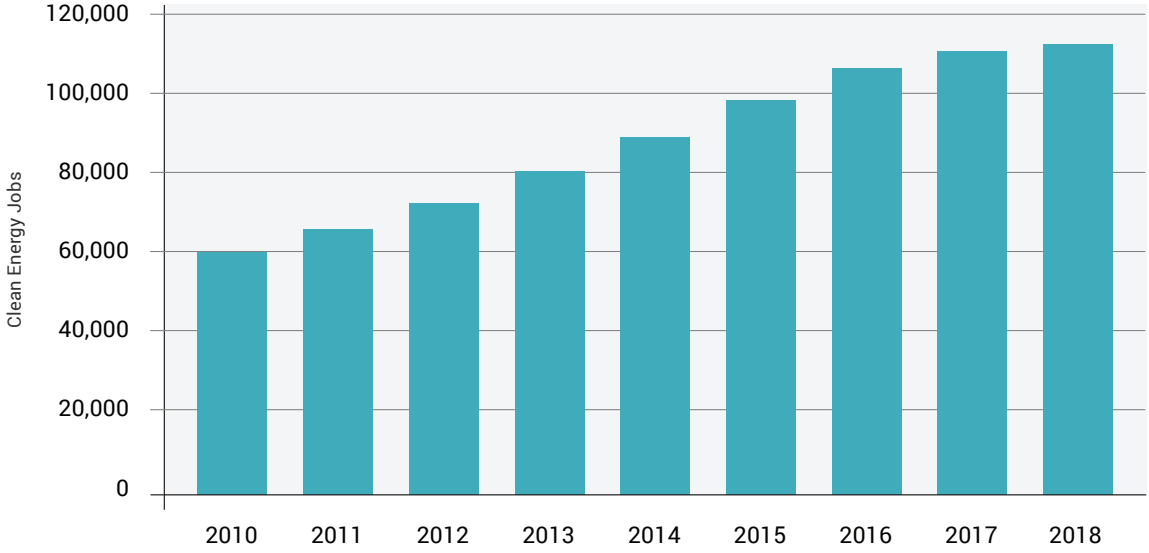
Clean energy innovation has played, and will continue to play, a powerful role in accelerating our progress toward the Commonwealth's GHG reduction goals. Clean energy innovation has reduced the cost of clean energy technologies, thereby facilitating more rapid adoption, and improved the performance of clean energy technologies. Meanwhile, clean energy business and financing model innovation has helped promote broader adoption of climate solutions, helping to impact difficult to reach customer segments.

In addition to stimulating economic growth, investing in renewable energy and energy efficiency keeps more of Massachusetts residents' dollars in their wallets. Mass Save® energy efficiency measures saved, cumulatively, 6.8 million MWh hours of electricity and 93 million therms of natural gas in 2017. Net economic benefits from ratepayer and state investment in the Mass Save® programs, since their expansion beginning in 2010 through 2020, are projected to exceed $18 billion through a combination of direct bill savings, avoided supply and infrastructure costs as well as non-energy benefits such as reduced costs for operation and maintenance, longer equipment replacement cycles, increased comfort and productivity improvements, and reductions in costs associated with reduced customer arrearages, service terminations, and reconnections.

Climate change mitigation policies also have the benefits of improving public health from co-reduction of other pollutants such as sulfur oxides (SO_x), nitrogen oxides (NO_x), and particulate matter (PM_{10} and $PM_{2.5}$). Sulfur and nitrogen oxides in the atmosphere can cause acid rain, act as respiratory irritants, and combine with other compounds to produce ozone and particulate matter, both of which can also cause or exacerbate respiratory conditions. Policies covering SO_x, NO_x, and mercury (Hg) (including pre-existing state clean air regulations) are estimated to result in $340 million to $18 billion in health benefits for Massachusetts, including 300-500 fewer premature deaths and 860 fewer hospitalizations.[8] Since

[6] All values are in constant 2017 dollars; nominal value of GSP in 2008 was $385 billion.
[7] MassCEC's 2018 Clean Energy Industry Report
[8] https://archive.epa.gov/clearskies/web/html/ma.html

FIGURE 5 | CLEAN ENERGY JOB GROWTH IN MASSACHUSETTS



2008, implementation of motor vehicle standards has led to a 50% decline in NO_x emissions and a 78% reduction in $PM_{2.5}$ emissions. The retirement of coal-fired power plants in Massachusetts since 2008 has contributed to a 95% decline in sulfur dioxide emissions.[9]

Additionally, some GHG mitigation policies provide significant co-benefits in terms of ecosystem services, or the many and varied benefits provided by the natural environment. For example, the Greening the Gateway Cities urban tree planting program alleviates the urban heat island effect and lowers the cooling needs of adjacent buildings, which reduces the energy bills of residents. Urban forestry also reduces storm-water runoff and absorbs air pollutants.

1.3 CONTINUED COLLABORATION, COORDINATION, AND COMMITMENT

The Commonwealth remains committed to meeting the requirements of the GWSA. In the first five years of GWSA implementation, EEA focused on building substantial institutional capacity, both within EEA and across state agencies, to enable smoother and more rapid implementation of climate and clean energy programs. This included close collaboration of EEA state agencies and coordination with other Secretariats that continues to date, as well as valuable external stakeholder engagement (such as the GWSA Implementation Advisory Committee) and important regional coordination both within and outside the Commonwealth.

Capacity building also included development of systems to track, evaluate, and report on climate change and clean energy programs, and the staff and software investments in GHG measurement, reporting, and policy implementation progress evaluation. In the first five years of GWSA implementation, EEA state agencies developed the Massachusetts GHG Registry and Inventory and various systems that document progress made toward GHG mitigation program goals, identify program impacts, inform program planning and management decisions, and provide transparent information to the public. In the last five years, EEA has increased staff capacity to analyze the GHG reductions from policy implementation, and developed the Massachusetts Clean Energy and Climate Performance Management System (CCPMS) for tracking and reporting policy implementation progress. These investments help EEA and state agencies estimate how much of the emissions reduction in the GHG inventory is due to policy implementation thus far and how much GHG emissions reduction can be expected in 2020. Information on progress is communicated regularly to external stakeholders and the general public on the GWSA implementation online portal.[10]

For GWSA commitments beyond 2020, EEA and state agencies have begun preparing for the development of the *Massachusetts Clean Energy and Climate Plan for 2030*—due by the end of 2020—and a roadmap of how the Commonwealth can reach the GWSA emissions limit for 2050 in a strategic, equitable, and cost-effective manner. Analyses of what statewide GHG emissions would be in 2050 with only existing GHG mitigation policies implemented (i.e., no new policies) have been conducted by EEA staff in the Long-Range Energy Alternatives Planning (LEAP) modeling tool. Additionally, DOER recently completed a Comprehensive Energy Plan (CEP) that provides guidance to policy makers by examining the impacts of policies to reduce GHG emissions on cost and reliability. The Commission on the Future of Transportation in the Commonwealth, established by Governor Baker in January 2018 as part of Executive Order 579, also recently released a report summarizing the results of their fact finding, scenario development, and recommendations on transportation sector trends, needs, and GWSA compliance between 2020 and 2040.

In early 2019, building upon recent analyses in the LEAP modeling tool, the analyses and subsequent recommendations from the CEP, and recommendations of the Commission on the Future of Transportation, EEA is commissioning a multi-year comprehensive "80x50 Study" to analyze and integrate the development of GHG emissions reduction pathways with a suite of recommended policies for the Commonwealth to set appropriate emissions limits for 2030 and to ultimately best meet the emissions limit of at least 80% below the 1990 baseline level by 2050. The recommended policies and implementation timeline could inform what policies are to be included in the *Massachusetts Clean Energy and Climate Plan for 2030*.

1.4 INTEGRATING CLIMATE CHANGE MITIGATION AND ADAPTATION EFFORTS

Massachusetts has a population of 6.9 million people, about 70% of whom live in coastal shoreline communities that are and will continue to be significantly impacted by a changing climate. Inland communities across the state will also be affected by extreme weather, flooding, and increased heat. Recognizing the importance of addressing global climate change to protect vulnerable populations and ecosystems, Massachusetts has taken important steps to integrate the reduction in GHG emissions with improvement in the adaptive capacity of our built and natural environments. While mitigation is our first line of defense to reduce risks from climate change, adaptation efforts are needed to manage ongoing impacts from climate change. Adaptation and mitigation strategies can work synergistically toward the goals of the GWSA.

In 2016, Governor Baker issued Executive Order 569 Establishing an Integrated Climate Change Strategy for the Commonwealth (E.O. 569). It requires the setting of emissions limits for 2030 and 2040 in 2020 and 2030 respectively, development of a comprehensive energy plan, development of a statewide climate adaptation plan, and assistance to municipalities in the Commonwealth to assess their vulnerability to climate change and build resiliency. EEA launched the Municipal Vulnerability Preparedness (MVP) grant program in the summer of 2017, and published the State Hazard Mitigation and Climate Adaptation Plan (SHMCAP) and the Climate Change Clearinghouse website[11] on the second anniversary of E.O. 569 in 2018. The MVP program, the SHMCAP, and other elements of E.O. 569 pertaining to climate adaptation vulnerability assessment and implementation were codified into law by Governor Baker in August 2018 after the Massachusetts Legislature passed *An Act Promoting Climate Change Adaptation, Environmental and Natural Resource Protection and Investment in Recreational Assets and Opportunity* (also known as the Environmental Bond Bill). The bill authorizes over $500 million to climate change resiliency efforts and stipulates that investments made by EEA and its agencies must be consistent with the state climate adaptation plan.

[9] Massachusetts 2011 Periodic Emissions Inventory, https://www.mass.gov/lists/massdep-emissions-inventories
[10] https://www.mass.gov/progress-towards-reducing-greenhouse-gas-emissions
[11] http://resilientma.org/

As EEA and state agencies integrate climate change mitigation and adaptation, one of the priorities is to better understand the carbon flux in natural and working lands in the Commonwealth over time and to better track how human activities are impacting the carbon flux. Carbon sequestration and avoided loss or degradation of natural and working lands have benefits for both climate change mitigation and adaptation. To support these efforts, acquisition of better land use and land cover tracking data is underway. Combining data on the changes between land use and land cover types with carbon stock profiles developed by Abt Associates and Applied GeoSciences in 2015 can provide valuable information on changes to the Commonwealth's carbon stock as a result of human activities or acts of nature.

1.5 CONCLUSIONS AND RECOMMENDATIONS

Recent analyses of GHG emission trends and policy impacts on GHG emissions indicate that the Commonwealth is on the way to meeting the GWSA emissions limit for 2020. Most of the emissions reductions observed in the GHG inventory since passage of the GWSA are directly attributable to the policies listed in the 2015 CECP Update and additional GHG mitigation policies implemented since then. However, there are also reductions in GHG emissions that are from policies implemented before the GWSA, reductions that cannot be directly attributable to policies due to lack of data, or reductions from other factors such as mild weather, relative fuel prices, and changes in consumer preferences. Nevertheless, overall GHG emissions in 2020 are projected to be 25% below the 1990 baseline level.

While analyses indicate a strong likelihood of GWSA compliance in 2020, the Baker-Polito Administration recognizes the importance of sustaining aggressive efforts to reduce GHG emissions in the Commonwealth in order to meet the GWSA emissions limits for 2020 and ultimately for 2050. Below are recommendations for how to focus GWSA implementation efforts over the next five years.

CONTINUE IMPLEMENTATION OF POLICIES IN THE 2015 CECP UPDATE AND ADDITIONAL GHG MITIGATION POLICIES.

Regarding building fuels and energy efficiency:

- Continue aggressive implementation of energy efficiency as proposed in the latest 3-Year Energy Efficiency Plan for 2019-2021 filed with the Department of Public Utilities (DPU):
  - Achieve more aggressive gas savings goals. Increase weatherization measures to improve existing building shell efficiencies and targeted winter gas savings.
  - Achieve electric energy efficiency goals and peak demand reductions. Expand programs to include new cost-effective active demand management programs such as energy storage, residential direct load control, and commercial and industrial (C&I) load curtailment programs.
  - Expand electric efficiency programs to holistically serve customers and promote fuel switching to more efficient and lower GHG emitting heating and hot water systems.
  - Serve more customers through additional efforts to serve moderate income, non-English speaking residents, renters, and small business customers.
  - Drive market/consumer demand for energy efficiency measures and fuel switching by educating consumers about the benefits of energy efficiency and creating a market incentive for consumers to invest in energy efficiency improvements through a "Home Energy Scorecard".
  - Further reduce energy demand in new buildings through promoting high efficiency building construction (such as meeting Passive House or Zero Net Energy standards).
- Explore possible ways to drive additional efficiency in new construction and better support renewable energy, electrification, energy storage, and resiliency policy goals.

Regarding transportation, land use, and smart growth:

- Continue electrification of passenger vehicles, and promote electrification/decarbonization of freight and other vehicles.
- Continue to provide incentives for in transit-oriented development areas and other locations with low car travel.
- Continue regional collaboration through the Transportation and Climate Initiative to develop a framework for a regional program that addresses GHG emissions from the transportation sector.

Regarding energy generation and distribution:

- Continue to increase cost-effective clean electricity supply to meet RPS and CES compliance obligations.
- Continue policies that support distributed resources, including considering policies that will support solar development in the Commonwealth after the SMART program concludes, especially projects that pair renewables with energy storage to align supply and demand and provide grid flexibility.
- Implement policies and programs, including the Clean Peak Standard, that incentivize energy conservation and renewable energy utilization during peak periods.

Regarding non-energy emissions:

- Explore potential strategies to limit use and emissions of HFCs.

Regarding cross-cutting policies:

- Leverage and enhance data collection and analyses to help a diverse portfolio of government offices, public university campuses, and other state buildings track energy use and GHG emissions, as well as prioritize opportunities and strategies for future emissions reductions.
- Assist Green Communities to reduce their energy use by 20% within 5 years of their official designation despite growth in demand for municipal services.
- Identify opportunities to engage more municipalities to participate in the Green Community Designation and Grant Program.
- Revise the Massachusetts Environmental Policy Act (MEPA) GHG Emissions Policy and Protocol including incorporation of climate change adaptation and resiliency and land use.
- Look for opportunities to deploy strategies that achieve adaptation and mitigation goals, such as sustainable forestry practices and urban tree planting.

ANALYZE AND DEVELOP A ROADMAP FOR MEETING THE GWSA EMISSIONS LIMIT FOR 2050, INFORMED BY EXISTING ANALYSES.

- Continue addressing socio-economic and environmental justice equity in policy design and implementation.
- Continue to integrate climate change mitigation and adaptation strategies and policies.
- Explore additional land use strategies and policies and promote nature-based solutions to increase carbon sequestration and avoid GHG emissions from natural and working lands.

INTRODUCTION

2.1 BACKGROUND

The Global Warming Solutions Act (GWSA) was signed into law in 2008, making Massachusetts one of the few U.S. states with ambitious GHG emissions reduction limits of 25% reduction below the 1990 baseline level by 2020 and at least 80% reduction by 2050. Since then, the Commonwealth of Massachusetts has made great strides in implementing feasible and cost-effective GHG emissions reduction strategies, coordinating state agencies, engaging stakeholders, evaluating progress towards the GWSA limits, and integrating GHG reduction strategies with climate change adaptation strategies. Through the combination of reducing and electrifying energy demand and decarbonizing energy sources, Massachusetts is on our way to meeting the emissions limits in the GWSA while continuing to support a vibrant economy, resilient communities, and a growing population.

Since passage of the GWSA in 2008, Massachusetts has created a strong framework of state laws, regulations, and executive orders that guides the Commonwealth's actions to address climate change, notably:

- **Energy Diversity Act of 2016** calling for large procurement of offshore wind and hydroelectric resources;
- **Executive Order 569** establishing an integrated climate strategy for the Commonwealth;
- **Clean Energy Standard** requiring retail electricity sellers to annually demonstrate the use of clean energy to generate an increasing percentage of their electricity sales;
- **State regulations** to set annual declining caps on sources of GHG emissions in the electric, transportation, and non-energy sectors;
- **Environmental Bond Bill** codifying aspects of E.O. 569 such as the development of a statewide climate adaptation plan and a grant program to assist municipalities to assess and address vulnerabilities to climate change and extreme weather;
- **Advance Clean Energy Act of 2018** setting new targets for offshore wind, solar, and storage technologies; expanding RPS requirements for 2020-2029; establishing a Clean Peak Standard; and permitting fuel switching in energy efficiency programs.

The framework provided by these laws, regulations, and executive orders builds on three overarching strategies through which the Commonwealth can effectively reduce GHG emissions: energy use reduction, electrification, and decarbonization. They also enable the Commonwealth to better prepare for climate change and extreme weather events through better coordination and assessment of vulnerabilities both within state government and at each municipality.

In fulfilling with the GWSA requirement to develop an implementation plan to achieve the 2020 emissions limit, EEA published the *Massachusetts Clean Energy and Climate Plan for 2020* (CECP) in 2010 featuring a broad suite of policies that aim to reduce GHG emissions in the Commonwealth across all sectors through increased energy efficiency in buildings and vehicles, the electrification of vehicles and thermal conditioning in buildings, and the replacement of carbon intensive fuels with renewable energy sources. The CECP included estimates of GHG reductions expected in 2020 from the full implementation of each policy. In 2015, as required by the GWSA, the EEA published a 5-year update to the CECP (2015 CECP Update), which included some new policies and their expected GHG reductions in 2020 as well as updates to the existing policies and revisions to their expected GHG reduction estimates.

2.2 PURPOSE AND SCOPE OF 10-YEAR PROGRESS REPORT

The purpose of this GWSA 10-Year Progress Report (Progress Report) is to meet several objectives. First, it is designed to comply with Section 5 of Massachusetts General Law (MGL) Chapter 21N and section 18 of the GWSA. These sections of the GWSA require that: 1) the Secretary of EEA monitor implementation of regulations relative to climate change and publish a report every five years on measures undertaken including recommendations regarding implementation; and 2) publish the first report of progress by January 1, 2014. In addition, Section 5 of MGL c. 21N requires EEA to consider how measures and strategies taken to reduce GHG emissions will affect other criteria and public policy considerations which are important to the Commonwealth, including:

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

The GWSA 5-Year Progress Report was published at the end of 2013. It provided qualitative discussion of possible effects of the CECP's implementation on these criteria and policy considerations whenever feasible. This Progress Report follows the same spirit as the 5-Year Progress Report, though estimates of GHG reduction from policy impacts can now be provided for each non-cross cutting policy in the 2015 CECP Update. The remainder of this Progress Report is organized as follows:

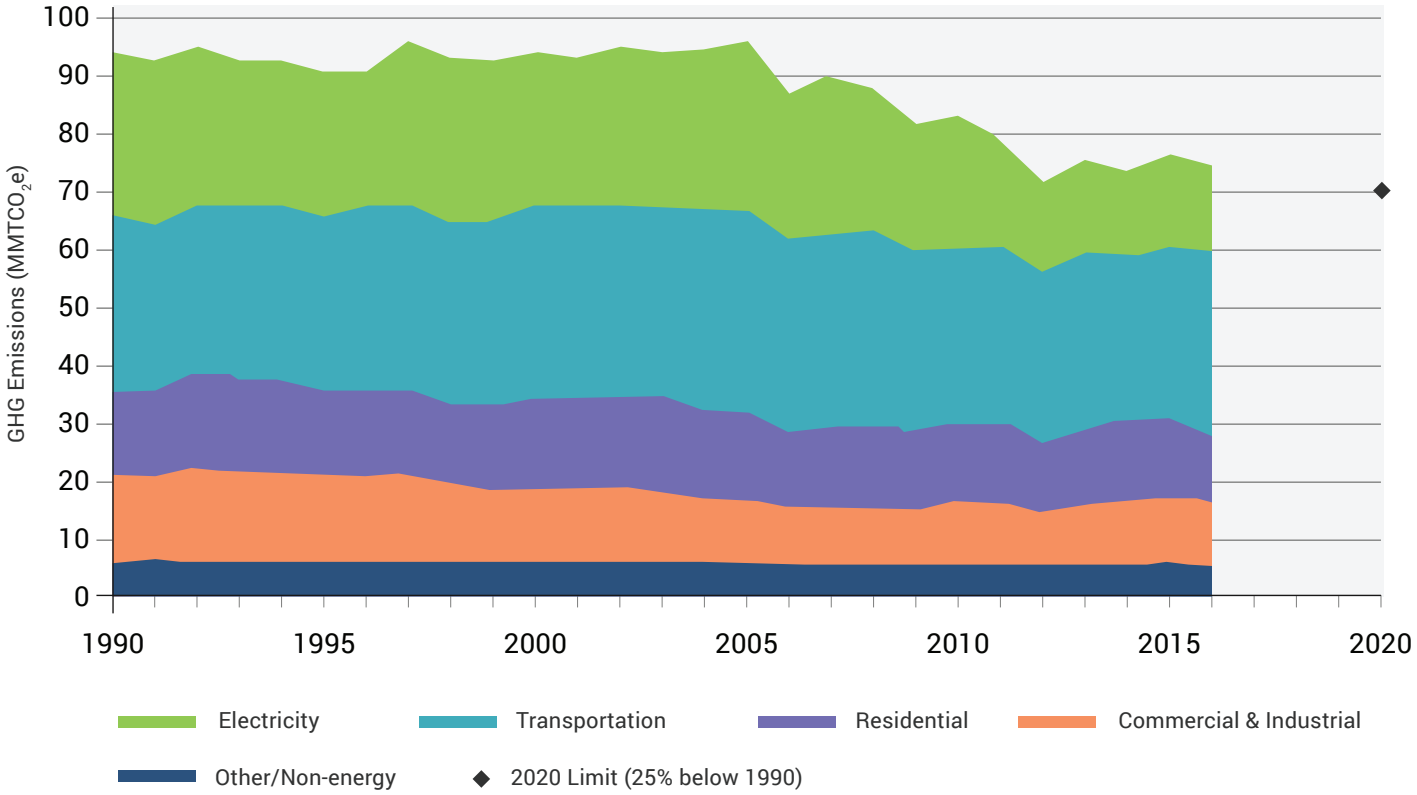
- Section 3: GWSA Implementation
- Section 4: GHG Mitigation Progress
- Section 5: Integrating Climate Change Mitigation and Adaptation
- Appendix A: GHG Reduction Methodologies

GWSA IMPLEMENTATION

3.1 GHG EMISSIONS TRENDS

The implementation of GHG emission reduction policies that were highlighted in the 2015 CECP Update, as well as additional policies and regulations implemented since then, are helping the Commonwealth effectively reduce GHG emissions and stay on track to meet the GWSA GHG emissions limit in 2020. The latest statewide GHG inventory[12] shows that GHG emissions in 2016 were 21.4% below the 1990 baseline level (Figure 2).

FIGURE 2 | MASSACHUSETTS GHG EMISSIONS, 1990 – 2016



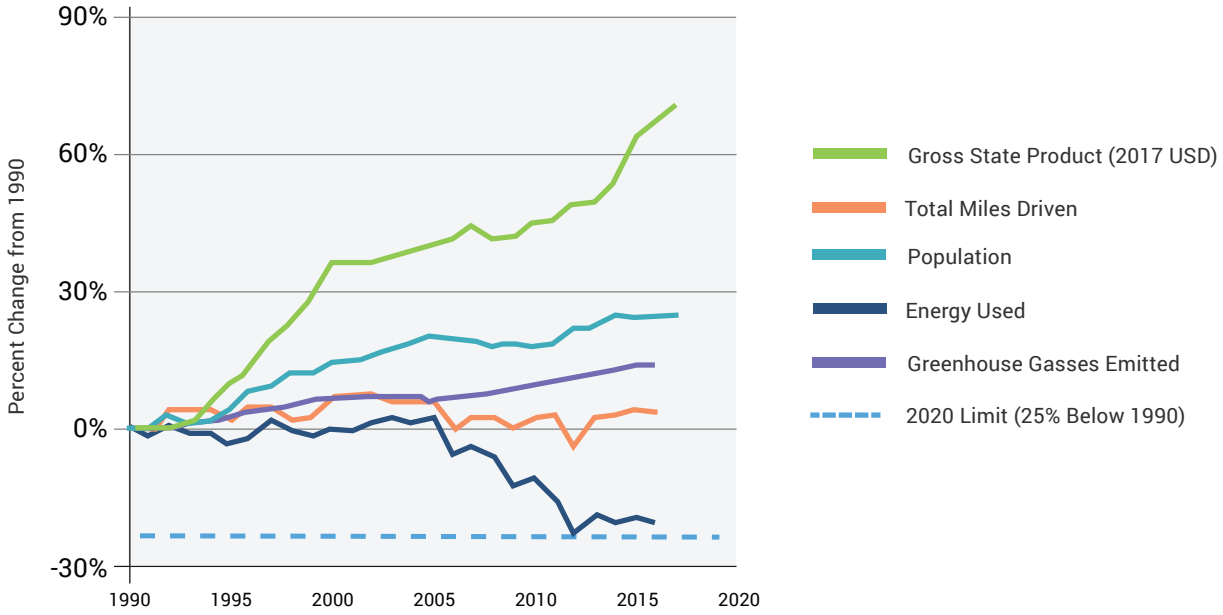
The long-term trend of GHG emissions reduction comes despite a 13% growth in population and 24% growth in vehicle miles traveled (Figure 3). Significant GHG emissions reduction from the electric sector since 2005 has been a major contributor to the drop in gross GHG emissions. Additionally, vehicle standards have lowered the carbon intensity of each vehicle mile traveled while energy efficiency measures in buildings helped control energy demand despite increased economic growth and variable weather conditions.

The trend of decreasing statewide GHG emissions indicates that our GHG mitigation policies are working. Recent analyses of GHG emissions trends to 2020 by EEA and state agencies in the LEAP modeling tool[13] indicate that GHG emissions in 2020 will be 25% below the 1990 baseline. Additional analyses of policy impacts indicate that, of the 20.2 $MMTCO_2e$ reduced in 2016 from the 1990 baseline level, approximately 11.6 $MMTCO_2e$ are attributed directly to the implementation of GHG mitigation policies from 2010 to 2016 (Figure 4). These reductions (represented by the solid colored bars) will grow larger over time as implementation of these policies continues. The remainder of the GHG emissions reductions observed in the GHG inventory (represented by the hashed colored bars) are not directly attributable to policies in the 2015 CECP Update, whether due to lack of available data, policies implemented prior to passage of the GWSA, or other factors such as weather conditions, relative fuel prices, and changes in consumer preferences. The negative reductions in the transportation and non-energy emissions sectors indicate that emissions reduction from policies implemented before the GWSA or from non-policy impacts counteract the GHG reductions from GHG mitigation policies implemented after the GWSA. On the other hand, policies implemented before the GWSA and non-policy impacts in the building and energy sectors have assisted the overall GHG reductions seen in these two sectors.

[12] The MassDEP develops and regularly updates an inventory of statewide GHG emissions, based on a combination of reputable federal data and data reported by regulated entities in Massachusetts. At the time of this Progress Report, the last year with full annual emissions data in the GHG emissions inventory is 2016.

[13] See Appendix A for discussion of analysis and modeling approach.

FIGURE 3 | TRENDS OF GROWTH IN GSP, VMT, AND POPULATION WHILE GHG EMISSIONS ARE DECREASING AND ENERGY USE HAS BEEN STABLE



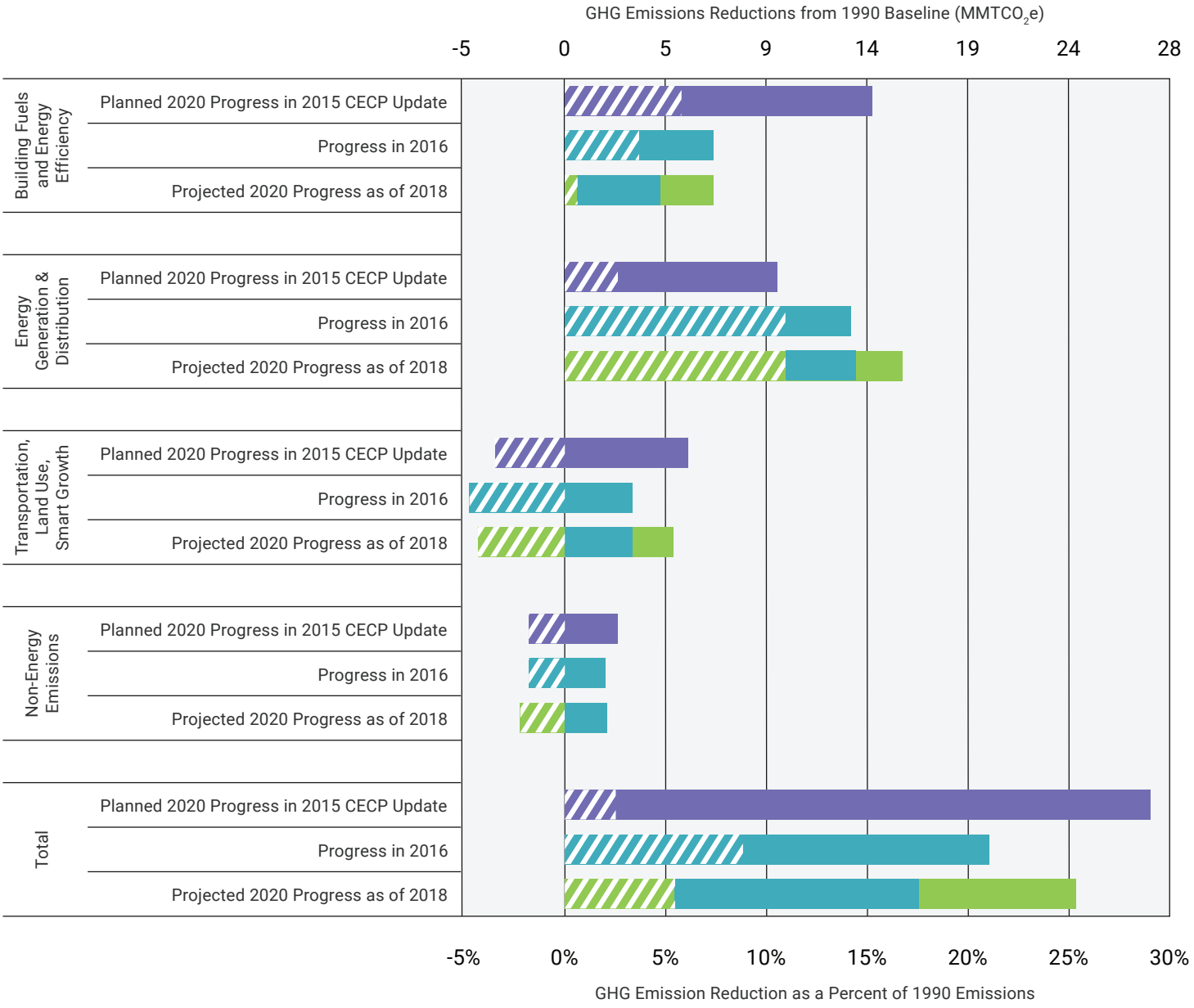
In 2020, post-GWSA policy implementation is estimated to reduce approximately 19 $MMTCO_2e$ or 20% below the 1990 level while the impact of pre-GWSA policies and other factors are estimated to reduce an additional 5 $MMTCO_2e$ or 6% below the 1990 level. These reductions add up to the 25% reductions from the 1990 baseline. Section 4 of this Progress Report discusses the estimates of GHG reductions from each policy and the implementation progress to date.

3.2 CONTINUED COLLABORATION, COORDINATION, AND STAKEHOLDER ENGAGEMENTS

The Commonwealth remains committed to meeting the requirements of the GWSA. In the first five years of GWSA implementation, EEA focused on building substantial institutional capacity, both within EEA and across state agencies, to enable smoother and more rapid implementation of climate and clean energy programs. This includes close collaboration of EEA state agencies and with other Secretariats that continues to date, as well as including valuable external stakeholder engagement and important regional coordination both within and outside the Commonwealth:

- **Interagency GWSA Team Leaders group:** Since 2012, staff representatives from MassDEP, DOER, DPU, the Department of Transportation (MassDOT), the Massachusetts Clean Energy Center (MassCEC), and other staff guests have met two to four times per month to discuss implementation and evaluation of GHG mitigation policies and to plan for the development of the Clean Energy and Climate Plans and the 5-year update, and GWSA Progress Reports.
- **GWSA Implementation Advisory Committee (IAC):** Established by the GWSA, the IAC has met four to six times per year since 2012 to discuss and provide advice on all aspects related to the implementation of the GWSA. Members are representatives from the following sectors: commercial, industrial, and manufacturing; transportation; low-income consumers; energy generation and distribution; environmental protection; and energy efficiency and renewable energy as well as from local government and academic institutions.
- **Zero Emission Vehicle (ZEV) Commission:** The ZEV Commission was established by the FY2015 Budget to recommend policies to expand access to electric and fuel cell vehicle infrastructure and to encourage the purchase and lease of these vehicles. Members of the Commission worked with the Massachusetts legislature to pass *An Act Promoting Zero Emission Vehicle Adoption* in 2016.
- **Commission on the Future of Transportation in the Commonwealth:** Established by Executive Order 579 in January 2018, the Commission was tasked with assessing key transportation trends between 2020 and 2040, developing plausible scenarios for the transportation

FIGURE 4 | PLANNED, ACHIEVED, AND PROJECTED GHG EMISSIONS REDUCTIONS (NEGATIVE REDUCTIONS ARE EMISSIONS, WHICH COUNTERACT THE POSITIVE REDUCTIONS)



Net baseline changes including policy reductions from programs predating GWSA, policy-related reductions that can't be quantified or directly attributed to policies, and reductions from non-policy changes (such as weather & economic conditions)

Reductions attributable to post-GWSA policies in 2016

Additional post-GWSA policy reductions projected for 2020 as of 2018

Planned 2020 Progress in 2015 Update of CECP

sector in 2040, and providing recommendations for the transportation sector based on their analyses. The report by the Commission was published in December 2018.

- **Regional collaboration and coordination:** EEA and its state agencies participate in regional multi-state collaboration such as RGGI, the Georgetown Climate Center's Transportation and Climate Initiative, the Multi-state ZEV Task Force, and the Coalition of Northeastern Governors and Eastern Canadian Premiers. In addition, Massachusetts joined the U.S. Climate Alliance when it was formed in June 2017. State agency staff joins regularly scheduled working group phone calls on policy discussions and coordination.
- **Municipal collaboration and coordination:** EEA and its state agencies coordinate with municipalities on climate mitigation planning and analyses, such as state staff participation in the City of Boston's Carbon Free Boston initiative and state staff leadership of the Data Focus Group on data and assumptions behind GHG emissions pathways modeling and analyses.
- **External stakeholder engagement:** In addition to the GWSA IAC and the ZEV Commission, EEA and its state agencies regularly seek stakeholder input on numerous policy matters, including GHG emissions inventory development and updates, the Volkswagen Settlement Beneficiary Mitigation Plan, and transportation sector policies as part of the Transportation Listening Sessions in the Fall of 2017.

3.3 COMMITMENT TO MEETING GHG EMISSIONS LIMITS FOR 2020 AND BEYOND

The other components of capacity building were 1) the development of systems to track, evaluate, and report on climate change and clean energy programs and 2) the staff and software investments in GHG measurement, reporting, and policy implementation progress evaluation. In the first five years of GWSA implementation, EEA state agencies developed the Massachusetts GHG Registry and Inventory, the EEAC and the Evaluation, Measurement, and Verification (EM&V) framework, the RGGI CO_2 Allowance Tracking System (COATS), and other systems that document progress made toward program goals, identify program impacts, inform program planning and management decisions, and provide transparent information to the public. In the last five years, EEA has increased staff capacity to analyze the GHG reductions from policy implementation, and developed the CCPMS for tracking and reporting policy implementation progress. These investments help EEA and the state agencies estimate how much of the emissions reductions in GHG inventory is due to policy implementation thus far and how much GHG emissions reduction can be expected for 2020. Such progress information is included in this Progress Report, and communicated regularly to external stakeholders and the general public alike on the GWSA implementation online portal.[14]

For GWSA commitments beyond 2020, EEA and state agencies have begun preparing for the development of the *Massachusetts Clean Energy and Climate Plan for 2030*–due at the end of 2020–and a roadmap of how the Commonwealth can reach the GWSA emissions limit for 2050 in a strategic, equitable, and cost effective manner. Staff at EEA recently analyzed a scenario in the LEAP modeling tool projecting what statewide GHG emissions could be in 2050 with only existing GHG mitigation policies implemented (i.e., no new policies). Results were presented to the GWSA IAC throughout 2018 and posted on the GWSA implementation online portal[15] as part of the IAC meeting materials. Additionally, DOER recently completed the CEP that provides guidance to policy makers by examining the impacts of policies to reduce GHG emissions on cost and reliability. The Commission on the Future of Transportation in the Commonwealth also recently released a report summarizing the results of their fact finding, scenario development, and recommendations on transportation sector trends, needs, and GWSA compliance between 2020 and 2040.

In early 2019, building upon the recent analyses in the LEAP modeling tool, the analyses and subsequent recommendations from the CEP, and recommendations of the Commission on the Future of Transportation, EEA is commissioning a multi-year comprehensive "80x50 Study" to analyze and integrate the development of GHG emissions reduction pathways with a suite of recommended policies for the Commonwealth to set appropriate emissions limits for 2030 and to ultimately best meet the emissions limit of at least 80% below the 1990 baseline level by 2050. The recommended policies and implementation timeline could inform what policies are to be included in the CECP for 2030.

TABLE 2 | HOUSEHOLD INCOME AND ENERGY USE

Household Income Level	No. Households	Avg. Energy Use Per Household (kBTU/year)	Avg. Cost of Energy (USD/year)	Approximate Percent of Income
Less than $20,000	1,259,360	72,656	$1,873	9.40%
$20,000 - $39,999	1,323,719	94,072	$2,320	7.90%
$40,000 - $59,999	721,569	97,508	$2,565	5.20%
$60,000 to $79,999	752,101	96,761	$2,735	3.90%
$80,000 to $99,999	418,333	80,311	$2,232	2.50%
$100,000 to $119,999	424,537	128,897	$3,236	3.00%
$120,000 to $139,999	291,612	131,712	$3,440	2.70%
$140,000 or more	437,614	140,687	$3,850	2.70%

Source: EEA analysis, RECS 2015 Microdata, values represent all of New England

3.4 EQUITY

A key component of the GWSA is ensuring equitable impacts on and outcomes for all residents in Massachusetts. Low-income, non-English-speaking, and other vulnerable communities may not have the resources to adapt to climate change. Moreover, the cost of energy represents a larger portion of low-income households' annual income (Table 2), so even small increases in energy prices can be burdensome.

Not only are low-income households more vulnerable to changes in the energy market, they also contribute less to global warming, consuming on average less energy per household than wealthier households. Across New England, the lowest income bracket consumed only half as much energy per household as the highest income bracket (Table 2).

The 2015 CECP Update policies are sensitive to these needs and issues, and the Commonwealth has undertaken several initiatives to bring energy savings to those who need them the most. In 2017, Mass Save's low-income initiatives resulted in more than $220 million in total benefits, from investments of $110 million.[16] Expanding on that success, Governor Baker directed DOER and the Department of Housing and Community Development (DHCD) to collaborate with MassCEC to launch the Affordable Access to Clean and Efficient Energy (AACEE) Initiative with $15 million in committed funding. As an initial step in implementing the Initiative, MassCEC developed a new income-based rebate, among other programs, which sought to improve and expand access to the best and most efficient technologies.

In 2017, the AACEE working group published a report identifying significant barriers and opportunities for improving delivery of energy efficiency programs to low- and moderate-income households. The report identifies three major recommendations:

1. Aligning housing and clean energy processes, especially budget cycles and capital needs assessments.
2. Improving technical assistance and communication of benefits at the community level.
3. Targeting funding initiatives at specific barriers in very low-income communities and households.

The DOER and DHCD are taking steps in implementing the working group's recommendations, such as the Whole Building Incentive Program which is seeking competitive proposals to produce the maximum energy efficiency benefits at subsidized and public housing. Looking further into the future, the Initiative has also looked to expand DOER's Path to Zero grant program with the Zero-Energy Modular Affordable Housing Initiative, a pilot program that will build new homes or replace existing mobile or manufactured units with new affordable zero energy modular homes and provide lessons learned for future programming.

[14] https://www.mass.gov/progress-towards-reducing-greenhouse-gas-emissions
[15] https://www.mass.gov/service-details/the-global-warming-solutions-act-gwsa-public-meetings
[16] Mass Save® data

Additionally, EEA's Greening the Gateway Cities program provides both energy savings and health benefits to low-income urban communities. By buffering houses and neighborhoods against the wind in the winter and shading them from the sun in the summer, tree-planting can help to reduce heating and cooling demands, resulting in lower energy bills. These urban forestry projects also target public health benefits in some of the Commonwealth's most vulnerable communities by reducing the urban heat island effect and absorbing harmful air pollution.

3.5 ADDITIONAL BENEFITS OF GWSA IMPLEMENTATION

3.5.1 ECONOMIC BENEFITS

Massachusetts's experience implementing the GWSA shows that environmental programs can support economic development. According to MassCEC's 2018 Clean Energy Industry Report, the clean energy industry employs more than 109,000 people in Massachusetts (Figure 5), most of whom earn more than $50,000 per year. This sector contributes $13.2 billion to the Commonwealth's economy, or about 2.5% of its annual GSP.[17] Moreover, electric generation companies spent more than $700 million on fuel to run their power plants in Massachusetts in 2017,[18] almost all of which was imported from another state or country. Continuing to build Massachusetts's clean energy portfolio will mean that costs that would have gone to generate electricity via traditional fossil fuels will instead benefit Massachusetts's economy. As the clean energy industry continues to grow, this will benefit the economy of Massachusetts as a whole.

Clean energy innovation has played, and will continue to play, a powerful role in accelerating our progress toward the Commonwealth's GHG reduction goals. Clean energy innovation has reduced the cost of clean energy technologies, thereby facilitating more rapid adoption, and improved the performance of clean energy technologies. Meanwhile, clean energy business and financing model innovation has helped promote broader adoption of climate solutions, helping to impact difficult to reach customer segments. The MassCEC has invested nearly $40 million over the past 5 years in Massachusetts clean energy technology innovation and companies, leveraging nearly $134 million in private investment. These strategic investments in clean energy innovation create jobs, provide more GHG reduction strategy options for the state, attract private investment, and complement our existing portfolio of efficiency, electrification, and decarbonization.

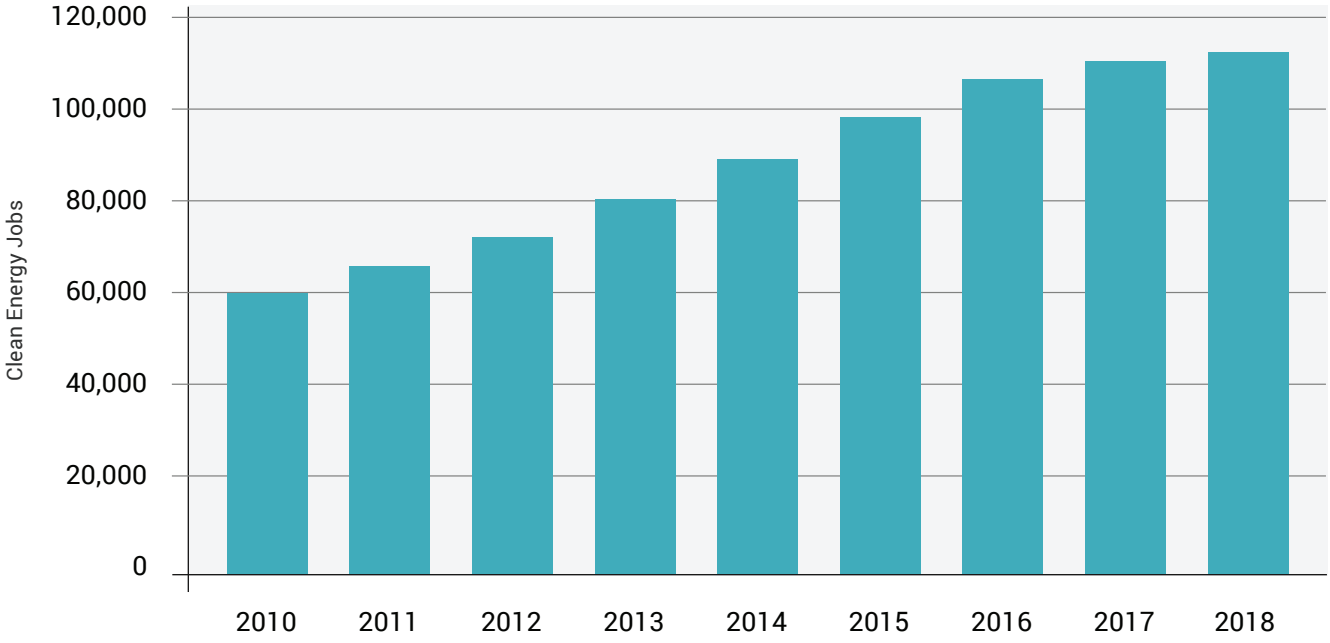
In addition to stimulating economic growth, investing in renewable energy and energy efficiency keeps more of Massachusetts residents' dollars in their wallets. Mass Save® energy efficiency measures investments in 2017 alone will save over 14.4 million megawatt hours of electricity and 371 million therms of natural gas over their lifetime.[19] Net economic benefits from ratepayer and state investment in the Mass Save® programs, since their expansion beginning in 2010 through 2020, are projected to exceed $18 billion through a combination of direct bill savings, avoided supply and infrastructure costs, as well as non-energy benefits such as improvements to building real estate values and health outcomes for low-income populations.

3.5.2 PUBLIC HEALTH BENEFITS

In addition to carbon dioxide, burning fossil fuels can release other pollutants, such as SO_x, NO_x, PM_{10}, $PM_{2.5}$, and Hg. Exposure to Hg, even in trace amounts, can result in severe medical issues, including neurological problems and kidney failure. Once emitted, SO_x and NO_x can cause acid rain, act as respiratory irritants, and combine with other compounds to produce ozone and particulate matter, both of which can also cause or exacerbate respiratory conditions. In 2016, asthma affected over a million Massachusetts residents, including more than 200,000 children, limiting physical activity and causing them to miss work or school, respectively.[20] In 2002, the U.S. EPA's Clear Skies Program estimated that, by 2020, a suite of policies covering SO_x, NO_x, and Hg (including pre-existing state clean air regulations) would result in $340 million to $1.8 billion in health benefits for Massachusetts, including 300-500 fewer premature deaths and 860 fewer hospitalizations.[21]

Since 1990, Massachusetts has followed through on many policies addressing criteria pollutants, and pollutant emissions have dropped precipitously (Figure 6). The Low-Emission Vehicle (LEV) program and Inspection & Maintenance (I&M) Programs administered by MassDEP have led to a 60% decline in NO_x emissions since 1990,

FIGURE 5 | CLEAN JOB GROWTH IN MASSACHUSETTS



even as Massachusetts residents have driven more vehicle miles each year.[22] $PM_{2.5}$ emissions from all highway vehicles fell from 4,934 tons in 2008[23] to 1,101 tons in 2016[24] — a 78% decline. Although any fossil fuel combustion will emit some of these pollutants, coal in particular emits SO_x and Hg in significant quantities.[25] Power plants, a major consumer of coal in Massachusetts, burnt more than 4.2 million tons of coal in 1990.[26] The last coal-fired power plant in the Commonwealth, Brayton Point, retired its final boiler in May 2017. Echoing that decline, sulfur dioxide emissions have fallen from about 1,000 tons per day in 1990 to almost none today.[27]

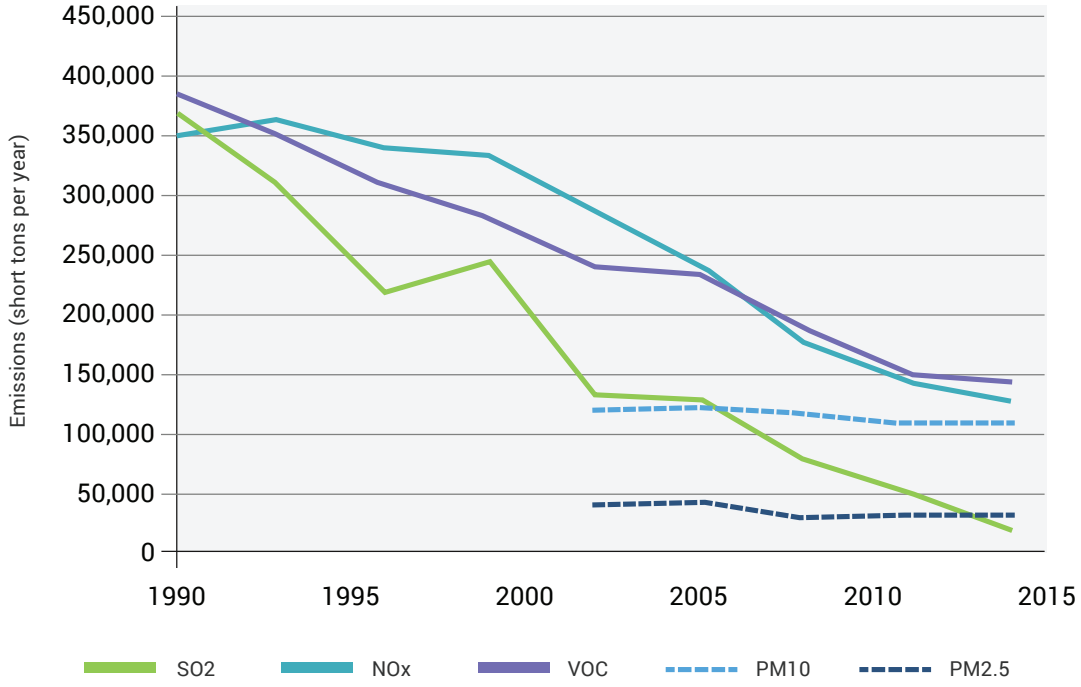
The Complete Streets Program, a major component of the Smart Growth policies and implemented by MassDOT, looks to improve pedestrian and bicycle infrastructure across the Commonwealth, which could help reduce personal vehicle travel and emissions. Two out of three adults in Massachusetts are obese, resulting in $3.5 billion annually in excess health care costs.[28] Developing walkable and bikeable communities can alleviate these health care costs by allowing or promoting active commuting, as well as simply encouraging physical exercise and recreation. Emphasizing dense communities with walkable town centers and easy access to public transit, these programs can reduce carbon emissions as well as foster a greater sense of community and civic pride throughout the Commonwealth.

3.5.3 ECOSYSTEM SERVICES

Several of EEA's GHG mitigation policies also serve to protect natural resources and the built infrastructure. The Greening the Gateway Cities urban tree planting program alleviates the urban heat island effect, and can reduce the energy bills of the residents of these communities. Urban forestry also reduces storm-water runoff and absorbs air pollutants. According to an analysis by the Metropolitan Area Planning Council (MAPC), urban forests in the 15 communities of Metro Boston (i.e., the Metro Mayors Coalition) store 962,000 tons of carbon, worth $125 million,[29] and capture an additional 23,000 tons of carbon per year, worth nearly $3 million. Added benefits include

[17] MassCEC's 2018 Clean Energy Industry Report
[18] U.S. Energy Information Administration, State Energy Data System, https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_sum/html/sum_ex_eu.html&sid=MA
[19] Mass Save® data
[20] Massachusetts 2016 Diesel Particulate Matter Inventory, https://www.mass.gov/lists/massdep-emissions-inventories
[21] https://archive.epa.gov/clearskies/web/html/ma.html
[22] Massachusetts 2011 Periodic Emissions Inventory, https://www.mass.gov/lists/massdep-emissions-inventories
[23] Massachusetts 2008 Periodic Emissions Inventory, https://www.mass.gov/files/documents/2016/08/ou/08pei-data.pdf
[24] Massachusetts 2016 Diesel Particulate Matter Inventory, https://www.mass.gov/lists/massdep-emissions-inventories
[25] EPA FIRECHIEF database
[26] U.S. Energy Information Administration, State Energy Data System
[27] Massachusetts 2011 Periodic Emissions Inventory, https://www.mass.gov/lists/massdep-emissions-inventories
[28] Mass in Motion, https://www.mass.gov/files/documents/2016/07/vm/mim-community-overview.pdf

FIGURE 6 | EMISSIONS OF CRITERIA POLLUTANTS IN MASSACHUSETTS



527 million gallons of avoided stormwater runoff, worth $4.7 million,[30] and 1.75 million pounds per year of air pollutants removed, worth $11 million.[31,32]

The suite of policies collectively referred to as Smart Growth seeks to reduce suburban sprawl and make communities physically denser and more interconnected. By reducing total land lost to development, the policy preserves the intrinsic benefits of natural landscapes and ecosystem services, including the land's actual resources and secondary impacts such as storm-water and water quality management. Preserving the remaining agricultural lands in Massachusetts also yields cultural benefits, as well as some ecosystem benefits from low impact, small-scale farming.

[29] Economic value = $143 /metric ton value of carbon storage or capture * social cost of carbon, an economic value quantifying in dollars the long-term damage due to a ton of carbon in a given year (EPA).
[30] iTree Landscape. Economic value of avoided runoff = (The difference between runoff with existing vegetative cover by Land Use Data minus the runoff where impervious surface replaces vegetative cover) * value of runoff (Hirabayashim 2015)
[31] iTree Landscape. Pollution Removal Economic Benefit = pollution removal (g/m_ from tree cover)* value of pollution mitigation ($/$m^2$ of tree cover where values determined by EPA BenMAP)
[32] iTree Landscape, 2018. Model run on June 19, 2018.


150A

GHG MITIGATION PROGRESS

Concord Highlands, Cambridge, MA 98 Units of Affordable Housing Seeking Passive House Certification and 105 KW Solar PV Array. First floor designed to be resilient to flooding. Owner: Homeowner's Rehab Inc. Architect: ICON Architecture

4.1 BUILDING FUELS AND ENERGY EFFICIENCY

4.1.1 OVERVIEW

Electricity and fossil fuel consumption in residential, commercial, and industrial buildings accounts for more than half of Massachusetts's energy use and half of GHG emissions in the Commonwealth. The 2015 CECP Update outlined a variety of strategies to reduce energy use and GHG emissions from the buildings sector. The primary strategy for reducing building energy use is implementation of 'all cost-effective energy efficiency and demand reduction' as laid out in the Green Communities Act (GCA) of 2008, and subsequently modified by energy legislation in 2012 and 2018.

Aligned with the policy of pursuing all cost-effective energy efficiency and demand reduction are a number of complementary and overlapping policies for managing energy demand in buildings. These include improving building energy codes, adopting updated appliance standards, and accelerating the adoption of renewable thermal heating technologies. The buildings sector has also seen a continuing trend of downward carbon emissions due to residential and commercial conversions from heating oil to natural gas. These fuel conversions have been driven largely by economics, due to the price differential between heating oil and natural gas.

The 2015 CECP Update set an emissions reduction goal for the buildings sector of 9.0 percent below 1990 emission levels. Progress to date on these policies is summarized in Tables 3 & 4, and described in more detail in the next section. In addition to implementing these policies, the Commonwealth is also pursuing supplemental strategies to further boost consumer awareness and market drivers for energy and carbon savings in the buildings sector.

TABLE 3 | SUMMARY OF ESTIMATED GHG REDUCTIONS FROM POLICY IMPLEMENTATION*

	PLANNED 2020 GHG EMISSIONS REDUCTION (ESTIMATED IN 2015)		2016 PROGRESS		PROJECTED 2020 GHG EMISSIONS REDUCTION (ESTIMATED IN 2015)	
	$MMTCO_2E$	% OF 1990 LEVEL	$MMTCO_2E$	% OF 1990 LEVEL	$MMTCO_2E$	% OF 1990 LEVEL
Building Fuels and Energy Efficiency	9.0	9.5%	4.0	4.2%	6.8	7.2%
All Cost-Effective Energy Efficiency	5.4	5.8%	3.2	3.4%	5.1	5.4%
Advanced Building Energy Codes	1.5	1.6%	0.7	0.7%	0.8	0.9%
Building Energy Rating and Labeling	–	–	Cross-cutting policy; savings reflected elsewhere.			
Expanding Energy Efficiency Programs to Commercial and Industrial Heating Oil	<<0.1	<<0.1%	Reductions to be included in All Cost-Effective Energy Efficiency.			
Appliance and Product Standards	1.0	1.1%	0.1	0.1%	0.8	0.8%
Renewable Thermal Technologies	1.0	1.1%	0.0	0.0%	0.1	0.1%
Tree Retention and Planting to Reduce Heating and Cooling Loads	<<0.1	<<0.1%	<<0.1	t<<0.1%	<<0.1	<<0.1%

* See Appendix A for summary of methodology.

4.1.2 BUILDINGS SECTOR POLICIES

ALL COST-EFFECTIVE ENERGY EFFICIENCY

The Baker-Polito Administration has consistently prioritized energy efficiency as a central component of the Commonwealth's energy policy. In large part, this is due to the recognition that cost-effective delivery of energy efficiency is a win-win strategy which provides substantial economic benefits to consumers and businesses, retains more capital in the local economy, and results in other environmental benefits (e.g., improvements to air quality) in addition to significant and sustained GHG reductions. The policy to implement all cost-effective energy efficiency, primarily through the statewide Mass Save® programs, has the highest projected GHG reduction of all policies in the 2015 CECP Update, at 5.4 percent of the 1990 level. This estimate only includes the additional GHG reductions since 2009 from the expansion of the state's energy efficiency programs under the GCA, recognizing that Massachusetts has established energy efficiency programs dating back to 1990.

Under the requirements of the GCA, investor-owned natural gas and electric utilities in Massachusetts are required to acquire all cost-effective energy efficiency, i.e., energy efficiency which is less costly than securing additional energy supply. The Program Administrators (PAs)[33] begin the implementation process for natural gas and electricity efficiency programs by submitting a Three-Year Plan for approval by the DPU, the first of which covered 2010-2012. In these plans, the PAs outline their intentions for the types of energy efficiency programs (e.g., high-efficiency lighting) and customer classes (i.e., residential, commercial and industrial, and low-income) they expect to reach, the expected costs and benefits of implementing the programs, and the target energy and demand savings.

These plans have matured to the point where they have been delivering sustained GHG savings for the past 5 years after growing dramatically over the first two 3-year plan periods. In the period since 2014, the Mass Save®

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

TABLE 4 | IMPLEMENTATION PROGRESS ON BUILDING FUELS AND ENERGY EFFICIENCY POLICIES FROM THE 2015 CECP UPDATE

BUILDING FUELS AND ENERGY EFFICIENCY		
Policies	Key Accomplishments and Highlights	Recommendations and Next Steps
All Cost-Effective Energy Efficiency	• The Mass Save® 3-year plans have saved on average over 800,000 metric tons/year since 2014. The program is on track to deliver over $18 billion in net benefits by 2020. • Electricity savings grew from under 1% of annual sales in 2009 to over 3% in 2017; natural gas savings grew from 0.5% to 1.2%.	• Continue Commonwealth's investment in all cost-effective energy efficiency and demand reduction thru Mass Save®, including new opportunities to increase gas energy efficiency. • Expand programs to promote fuel conversions from oil and propane heating to renewables and efficient electrification. • Focus on peak demand reduction in the summer and winter through new active demand management programs.
Advanced Building Energy Codes	• Widespread adoption of the Stretch energy code by 250 towns and cities as of November 2018 helped offset modest improvements in IECC model energy codes in recent years. • Sharp decline in residential construction during housing-led recession has now returned to historical levels with more multi-family housing units.	• The Baker-Polito Administration has set a goal of 135,000 new housing units by 2025 as part of the Housing Choice Initiative. Explore how best to encourage high efficiency building construction of these units in a cost-effective manner. • Explore possible ways to drive additional efficiency in new construction and better support renewable energy, electrification, energy storage, and resiliency policy goals.
Building Energy Rating and Labeling	• DOER's 'HomeMPG' and 'Home MVP' energy scorecard pilots led to commitment to residential scorecard integration in Mass Save® programs. The Baker-Polito Administration filed proposed legislation in 2018 to require home energy scorecard disclosure during real estate transactions. • Commercial building operational performance is tracked by Cities of Boston and Cambridge, but DOER's commercial asset rating pilot demonstrated challenges in asset rating of diverse range of commercial buildings.	• Create a market incentive for consumers to invest in energy efficiency improvements through a "Home Energy Scorecard".
Expanding Energy Efficiency Programs to Commercial/ Industrial Heating Oil	• The Advance Clean Energy Act of 2018 enables fuel switching to clean energy sources in all sectors, including heating oil in the Commercial & Industrial (C&I) sector.	• Continue to promote fuel switching in the C&I sector.
Appliance and Product Standards	• Federal standards for various household appliances and device chargers are estimated to save Massachusetts residents more than $20 million in energy costs by 2020.	• Consider state-level and regional next-generation appliance and product standards with other US Climate Alliance states.
Renewable Thermal Technologies	• The Alternative Energy Portfolio Standard was modified in 2017 to provide financial incentives for renewable thermal technologies. • The Baker-Polito Administration committed $3 million for the Renewable Thermal Infrastructure Grant Program. • MassCEC launched the HeatSmart Mass program in 2017 in select communities and the Reheat Mass program in 2018 to encourage adoption of renewable thermal technologies.	• Expand utility programs to offer consumer rebate for renewable thermal technologies, especially for air source heat pumps. • Promote fuel switching through expanded public outreach efforts.
Tree Retention and Planting To Reduce Heating and Cooling Loads	• Over 19,000 trees have been planted in 14 Gateway Cities. • The Baker-Polito Administration has committed $1 million annually in planning grants, with tree retention bylaws or incentives encouraged as one of the eligible activities.	• Pursue necessary information and establish systems to track the effectiveness of VMT reductions and changes in land use and land cover change associated with smart growth.

programs have saved on average over 800,000 metric tons/year – a roughly 4-fold increase in annual GHG savings from the baseline year of 2009. During this same time period, the American Council for an Energy-Efficient Economy *(*ACEEE) has ranked Massachusetts as the number 1 state for energy efficiency policy for 8 straight years from 2011-2018.

The recently filed statewide plan covering 2019-2021 projects the Mass Save® programs to maintain this nation-leading rate of GHG reductions through 2020 even as programs begin to undergo a significant shift away from residential lighting savings. Beyond 2020, residential and commercial lighting savings will be accounted for in the Appliance and Product Standards policy. The filed 2019-2021 plan, currently under review at the DPU, proposes the following improvements and shifts from previous plans to ensure a balanced portfolio of programs and continued GHG impacts:

- Additional savings goal on electric energy efficiency to quantify overall MMBtu reductions including electric, oil, and propane savings;
- Emphasis on fuel switching from delivered fuels to the efficient electrification of heating;
- New active demand management programs to educe peak electric consumption in both the summer and winter;
- Among the highest natural gas reduction targets ever seen in the U.S.; and
- New residential sector program design improvements to continue to invest in cost-effective electricity savings as residential lighting savings transition into appliance standards.

The impact of fuel interactions

Table 5 shows the anticipated GHG reductions, fuel savings, and economic benefits to consumers and businesses from all cost-effective energy efficiency.

As Table 5 illustrates, progress on electric energy efficiency has slightly exceeded the forecast for 2020 made in 2015, whereas natural gas and fuel oil savings are significantly lower than originally forecasted. The primary driver of these low gas and oil savings are the unanticipated interactive effects on heating fuels of two dominant electric energy efficiency measures over the past decade: the market shift from incandescent and fluorescent lighting to light emitting diode (LED) lighting across all sectors, and the adoption of combined heat and power in the commercial and industrial sector.

1. LED lighting - indirectly increases heating fuel usage

Improvements in the efficiency of lighting since 2010 have been dramatic. In recent years, the market has rapidly migrated to LED lighting in all sectors. The superior conversion of electricity into useful light enabled by LEDs relative to incandescent, halogen, and fluorescent lighting significantly reduces the heat generated as a by-product of lighting in buildings. Where incandescent lights would previously provide a small percentage of heating in a typical home or business, that heat is now typically provided by a few additional Btu of oil, propane, or natural gas each winter. This interactive effect has led to net increases in oil and propane usage from the electric Mass Save® programs in recent years as lighting retrofits across all buildings counteracted the significant heating fuel savings from the insulation and air sealing of homes, and limited envelope improvements in commercial spaces.

2. Combined Heat and Power – electric savings that increase natural gas usage

Combined Heat and Power (CHP), also known as co-generation, increases system energy efficiency in buildings by generating electricity on-site typically from natural gas as a source fuel, and utilizing much of the waste-heat from the electric generation process to provide building heating and process loads. The net impact of the addition of a CHP system is to significantly reduce electric MWh while increasing natural gas usage. Since 2008, Massachusetts has been recognized as a leading state in the promotion of CHP with the Mass Save® programs, complemented by significant Alternative Energy Certificates (AECs) through the Alternative Energy Portfolio Standard, all while natural gas prices have been at historically low levels. CHP is an important strategy for generating power and heat more efficiently, but does result in significant increases in building natural gas usage, which impacts the GHG savings attributable to natural gas energy efficiency in Table 5.

TABLE 5 | PROJECTED SAVINGS FROM ALL COST-EFFECTIVE ENERGY EFFICIENCY

CUMULATIVE IMPACT OF EE	FORECAST IN 2015 FOR 2020	UPDATED PROJECTION IN 2018 FOR 2020	% OF 2015 FORECAST
GHG Reductions in 2020	5.4 $MMTCO_2e$ (5.8% of 1990 level)	5.1 $MMTCO_2e$ (5.4% of 1990 Levels)	94%
Electricity Savings in 2020 (MWh)	9,000,000	9,700,000	108%
Natural Gas Savings in 2020 (MMBTU)	19,700,000	12,200,000	62%
Heating Oil Savings in 2020 (MMBTU)	3,200,000	1,500,000	47%
Propane Savings in 2020 (MMBTU)	0	130,000	
Cumulative Net Benefits, 2010 to 2020	**$14.4 billion**	**$18.0 billion**	**125%**

Source: DOER 2018

3. Low Natural Gas prices

Low natural gas prices also pose a challenge to gas efficiency programs because low prices dampen the magnitude of energy savings from efficiency, thereby resulting in longer "pay-back" periods on a given investment. Natural gas efficiency program savings goals have grown from 0.5 percent of annual sales in 2009 to over 1.2 percent of annual sales by 2017, but this is a slower rate of growth than experienced in the electric programs that have achieved 3 percent annual sales at the peak of lighting and CHP claimable savings. There continues to be a focused effort on natural gas efficiency, with the 2019-2021 filed targets at the highest levels yet, at 1.25% of annual sales.

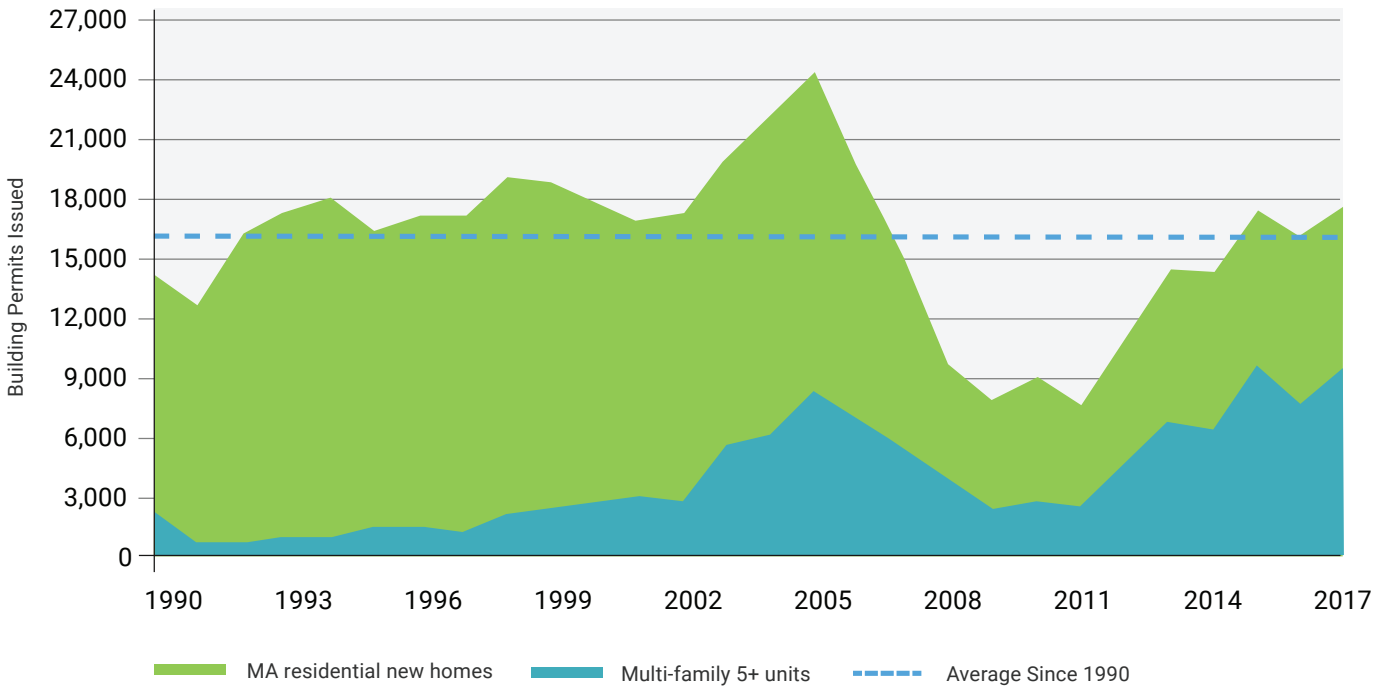
ADVANCED BUILDING ENERGY CODES

The 2015 CECP Update makes clear that a strategy requiring advanced building energy codes is one of the lowest-cost options for reducing GHG emissions. In the GCA, Massachusetts adopted a requirement that building energy codes meet or exceed the International Energy Conservation Code (IECC) and stay current with the IECC's three-year update cycle. An update to the base energy code is currently underway based on the 2018 International Energy Conservation Code (IECC2018). Nonetheless, this update from IECC2015 to IECC2018 only represents a 1% improvement on average for residential homes, as compared to the 15% average improvement made when the Commonwealth moved from the IECC2009 to the IECC2012. The slowing progress of the IECC national model energy codes has been partially mitigated by Massachusetts' nation-leading adoption of a "stretch" energy code at the city and town level. The Stretch Code in Massachusetts has also accelerated the transition from a prescriptive code, which dictates specific energy measures, to a performance code pathway that encourages building designers to focus on a building's overall energy performance. As noted in the discussion of Green Communities later in this Progress Report, 250 communities in Massachusetts, representing more than 2/3rd of the state population, have voluntarily adopted the Massachusetts stretch energy code as of November 2018.

Greenhouse gas reductions from advanced building energy codes were impacted not just by the slow improvements in the IECC model code, but also notably by the national housing sector economic recession. As Figure 7 illustrates, construction of new homes fell precipitously from 2005 to 2009, and remained below historic averages through 2014. Home construction has largely recovered to historic average levels in recent years. Equally significant, the housing recovery has come with an increased percentage of multi-family homes in urban and semi-urban areas, relative to single-family homes. This shift reflects the urban-led 'smart growth' experienced in Massachusetts as in many other states, which has also resulted in a commercial construction boom in metro-Boston.

Despite the recovery of the construction sector, the lean intervening years since 2008 contributed to a reduction in the expected GHG policy impact for this

FIGURE 7 | CONSTRUCTION OF NEW RESIDENTIAL UNITS IN MASSACHUSETTS, 1990 TO 2017



Source data: https://www.census.gov/construction/bps/stateannual.html

strategy to 0.9% of the 1990 baseline by 2020. Going forward, the Comprehensive Energy Plan identified increasing emissions savings from new construction through building envelope efficiency improvements and increased electrification as increasingly critical components of policies for meeting the 2050 emissions limit.

BUILDING ENERGY RATING AND LABELING

Rating and labeling buildings according to their expected energy use provides prospective building owners and tenants with information on the comparative energy costs of potential homes and work spaces. Currently, this information is largely absent from decision-making in real estate markets, even though Massachusetts's residents and businesses use more energy in their buildings than any other sector. In the same way that the familiar "miles per gallon" rating of vehicle fuel efficiency communicates to buyers how much they can expect to spend to operate their vehicle, building energy scorecards seek to address the "market failure" which exists due to the lack of energy information. This in turn would enable better informed decisions and create incentives for the real estate market to invest in more efficient buildings.

As noted in the 2015 CECP Update, the potential GHG reductions associated with this policy are indirect, and GHG reductions will likely be captured through the All Cost-Effective Energy Efficiency policy. It is appropriate then that residential scorecards are being integrated into the Mass Save® residential home assessment program in the recently filed 2019-2021 plans.

In developing the Commonwealth's Building Energy Rating and Labeling policy, DOER implemented two residential pilot programs; the first was a collaboration with Mass Save® partners in the Springfield area in 2013-2014 and the more recent was through the contractor focused Home MVP program[34] available statewide.

For the commercial buildings sector, DOER implemented a Building Asset Rating (BAR) pilot over two phases from 2013-2016 with support from the cities of Boston and Cambridge and the Mass Save® PAs The BAR pilot demonstrated that streamlined asset rating tools are available which can provide energy efficiency investment recommendations at a much lower cost than traditional audit protocols for commercial buildings.

[34] https://www.mass.gov/guides/home-mvp

Commercial and multi-family buildings can be effectively benchmarked using operational tools, most notably using EPA's Portfolio Manager tool. The Cities of Boston and Cambridge have leveraged the U.S. EPA tool to implement energy disclosure ordinances (which apply to commercial buildings greater than 25,000 square feet) to inform and motivate energy performance improvements. However, the diversity of the commercial building stock in the Commonwealth makes it more challenging to create a standardized asset score in the commercial sector than can be done in the residential market.

EXPANDING ENERGY EFFICIENCY TO COMMERCIAL AND INDUSTRIAL HEATING OIL

When the 2015 CECP Update was published in 2015, measures to improve heating oil energy efficiency in Massachusetts were limited to residential customers in 1-4 family homes. The 2015 CECP Update estimated that expanding heating oil programs to commercial and industrial customers would result in GHG reductions of less than 0.1 MMTCO2e (or less than 0.1 percent of the 1990 level). A significant step toward this goal was made in 2018 with new legislation allowing the Mass Save® PAs to expand the scope of heating oil energy efficiency funding to commercial and industrial customers as well as residential customers. The PAs have committed to promoting fuel switching in both the residential and the commercial and industrial sectors in the filed 2019-2021 Mass Save® plan, with a focus on shifting customers away from delivered fuels (heating oil and propane) to efficiency, and in particular cold-climate air source heat pumps (ASHPs). Therefore, moving forward, this policy is being merged with the All-Cost Effective Energy Efficiency policy.

FEDERAL APPLIANCE AND PRODUCT STANDARDS

Federal standards for various household appliances and device chargers are estimated to save Massachusetts residents and businesses hundreds of millions in energy costs each year.[35] Efficiency standards for most products, appliances, and electronics are set by the U.S. Department of Energy (DOE) with a pre-emption on state standards for products covered at the federal level. However, Massachusetts did request a waiver to set its own higher standard for furnaces. While the Massachusetts waiver was denied, it did lead to a new regional efficiency standard for furnaces being proposed under the Obama Administration. Nonetheless, progress at the federal level has been slower than anticipated in the 2015 CECP Update, and has led to renewed interest in state legislation to set appliance and product standards where federal pre-emption does not apply. State standards would provide modest incremental savings, which would accrue steadily after 2020 and could contribute to GHG emissions reduction significantly by 2030. The updated forecast for statewide energy savings by 2020 from updated federal appliance standards is 0.8 $MMTCO_2e$, (0.8 percent reduction from the 1990 level).

RENEWABLE THERMAL TECHNOLOGIES

Thermal energy use for process heat and space conditioning of buildings accounts for over 30% of the GHG emissions in Massachusetts. The trend for this sector has largely remained unchanged, presenting a significant opportunity to reduce GHG emissions by converting existing heating systems to a renewable thermal technology. In Massachusetts, renewable thermal technologies have been supported through the MassCEC incentive programs. These programs have particularly been effective at increasing the use of ASHPs for heating and cooling conditioned spaces. Additionally, the APS supports incentives for renewable thermal technologies. Similar to the RPS, the APS requires a certain percentage of the Commonwealth's electric load to be met by eligible technologies, which for APS includes renewable thermal technologies among others. The annual percentage requirement increases by 0.25 percent per year indefinitely. System owners create AEC when their system generates heat, and these AECs are subsequently sold into the market, producing revenue for the system owner.

In 2017, MassCEC began the HeatSmart Mass program. The program seeks to increase the number of renewable thermal installations by supporting local grassroot awareness campaigns in select communities across the state. Building off of this effort, MassCEC began the Reheat Mass program in 2018 to expand the public awareness campaign across the entire state through

[35] https://appliance-standards.org/sites/default/files/fedappl_ma.pdf

online advertisements focused on specific consumers based on geographic location and socio-demographic profiles. Analysis will be undertaken to refine the advertisement messaging in future years.

The DOER has also undertaken a second round of Renewable Thermal Infrastructure Grants in 2018. The purpose of the funding is to build the supply chain services for renewable thermal technologies, allowing for more businesses to offer systems, and to increase supply of fuels (such as biomass) to ensure demand for the systems can grow.

Going forward, the Mass Save® program will increase its role to incentivize renewable thermal technologies, notably for air source heat pumps.

TREE PLANTING & RETENTION

The Greening the Gateway Cities Program continues to aggressively plant trees. The primary purpose of the Greening the Gateway Cities Program is to reduce building energy consumption, but trees also sequester carbon, reduce stormwater runoff, improve air quality, and enhance property values. As of the Fall of 2018 there are eight active Department of Conservation and Recreation (DCR)planting crews, and the Program is also funding planting being completed by the Cities of New Bedford and Springfield and by the non-profit Groundwork Lawrence on behalf of the City of Lawrence. The Program's current planting rate is about 8,000 trees per year. As of December 2018, more than 19,000 trees have been planted in the 14 Gateway Cities in which the Program is currently active:

- Brockton: 1,378
- Chelsea: 1,880
- Chicopee: 1,531
- Fall River: 2,463
- Haverhill: 1,577
- Holyoke: 1,588
- Lawrence: 1,061
- Leominster: 1,907
- Lynn: 1,213
- New Bedford: 232
- Pittsfield: 1,949
- Quincy: 819
- Revere: 1,302
- Springfield: 286

The intent is to plant in the other 12 Gateway Cities (Attleboro, Barnstable, Everett, Fitchburg, Lowell, Malden, Methuen, Peabody, Salem, Taunton, Westfield & Worcester) by shifting planting crews as soon as the target of at least five trees per acre – set in order to reach sufficient tree canopy density to reduce energy use – is reached in each of the currently active communities. While the target zones in each city vary in size, the Program is generally looking to plant about 2,400 trees in each Gateway City. In several cities, such as Chelsea & Fall River, the Program has started to plant in nearby cities (Revere & New Bedford) as the limit is approached. The Program has recently hired a marketing firm in order to reach additional willing property owners – necessary to attain the minimum trees/acre target.

In regard to tree retention, starting in 2017, the Baker-Polito Administration has committed $1 million annually in planning grants. These planning grants are offered to communities interested in adopting an incentive or regulatory requirement, such as zoning, to encourage or require that trees be retained as a site is developed.

4.1.3 CONCLUSIONS AND RECOMMENDATIONS

With the impetus and authority provided by the GWSA and the GCA, EEA and supporting agencies focused a tremendous amount of energy and attention on the buildings sector and specifically, the All Cost-Effective Energy Efficiency policy. This commitment produced impressive results, establishing Massachusetts as the national leader in state-based efficiency programs. As the implementation of this policy transitions into the fourth Three-Year Plan submitted by the Mass Save® PAs, state agencies led by EEA, DPU, and DOER are identifying ways to enhance the effectiveness of programs in reducing GHG emissions, including a focus on improving thermal sector reductions associated with natural gas, oil, and propane heat.

The EEA and DOER continue to explore new opportunities to reduce GHG emissions from the buildings sector, through the significant changes proposed in the 2019-2021 Mass Save® energy efficiency plans and exploring other additional opportunities:

- Achieve more aggressive gas savings goals. Increase weatherization measures to improve existing building shell efficiencies and targeted winter gas savings.
- Achieve electric energy efficiency goals and peak demand reductions. Expand programs to include new cost-effective