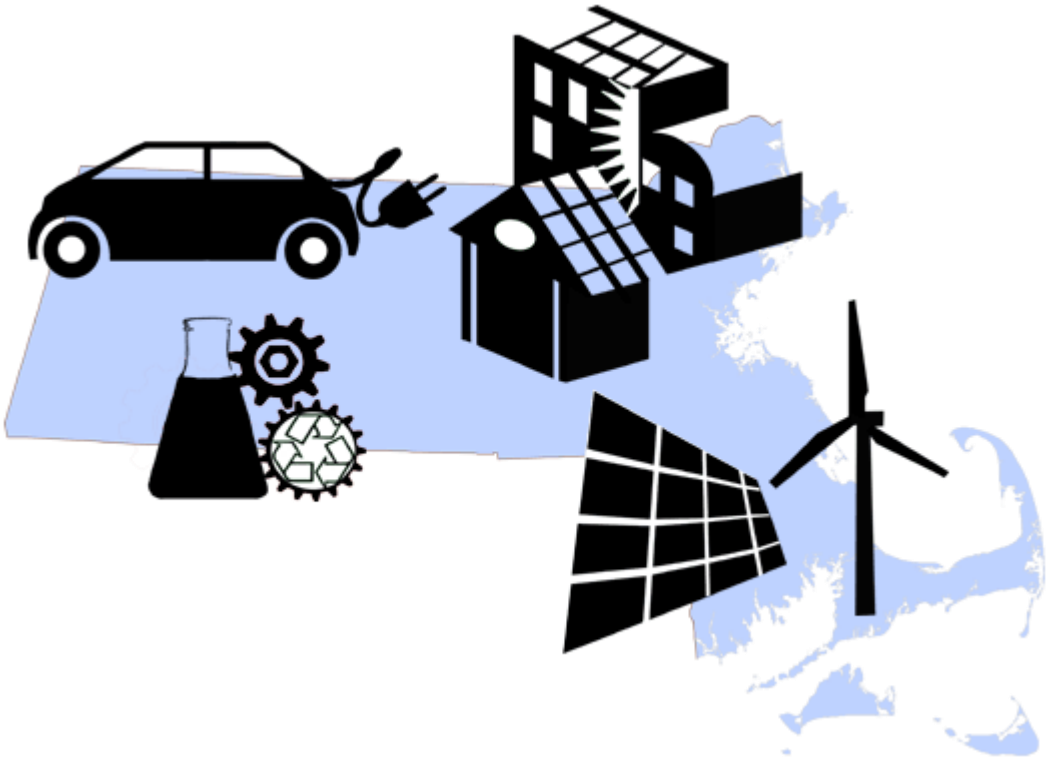
Massachusetts Clean Energy and Climate Plan for 2020



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

Secretary of Energy and Environmental Affairs

Ian A. Bowles

December 29, 2010

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Statutory Requirement

This report fulfills the requirements of Chapter 298 of the Acts of 2008, and as codified at M.G.L. c. 21N.

Section 4. (a) The secretary shall adopt the 2020 statewide greenhouse gas emissions limit pursuant to subsection (b) of section 3 which shall be between 10 per cent and 25 per cent below the 1990 emissions level and a plan for achieving said reduction.

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Executive Summary

A Clean Energy Revolution

Between 2007 and the end of 2010, solar photovoltaic (PV) systems installed and scheduled for installation in Massachusetts increased 20-fold — with jobs in solar manufacturing, installation, and services nearly tripling — while installed wind energy increased 10-fold. In that same time period, Massachusetts launched the most aggressive energy efficiency program in the country, with estimated savings of over $6 billion for residential, municipal, industrial and commercial customers and 4,500 jobs sustained or created.

This is not a vision of a possible future for Massachusetts. This is Massachusetts today.

It is in this context that the Executive Office of Energy and Environmental Affairs (EEA) presents the *Massachusetts Clean Energy and Climate Plan for 2020*. The Global Warming Solutions Act (GWSA, or the Act) of 2008 requires the Secretary of Energy and Environmental Affairs to establish a statewide limit on greenhouse gas (GHG) emissions of between 10 percent and 25 percent below 1990 levels for 2020 — on the way toward an 80 percent reduction in emissions by 2050 — along with a plan to achieve the 2020 target. Secretary Bowles has set that 2020 limit at 25 percent — and this Clean Energy and Climate Plan for 2020 contains the measures necessary to meet the limit.

Fulfilling that mandate will do much more than meet the requirements of the Act. It will allow the Commonwealth to address a number of challenges, only one of which is climate change. Most importantly, it will give powerful impetus to the clean energy revolution that has already begun.

Energy Independence: Massachusetts is at the end of the energy pipeline, figuratively and literally. All of our fossil-based energy sources — oil, natural gas, and coal — are derived from other regions of the country (e.g., the Gulf Coast or Western states) and other parts of the world, many of them unstable or hostile to the United States, (e.g., countries in the Middle East and Venezuela). Thus, all spending on fossil fuel energy — whether to fuel power plants, buildings, or vehicles — flows out of state and fails to provide income to in-state businesses or employees. This exported economic value is significant, totaling almost $22 billion in 2008.[1] In 2008, an average Massachusetts household spent about $5,200 for energy costs, of which about $1,700 was for heating (space and water), $1,300 for electricity, and $2,200 for gasoline. Almost all of these expenditures leave Massachusetts.

Energy Costs and Volatility: In addition to the economic drain represented by Massachusetts dollars flowing out of the state for energy resources, energy consumers have experienced wild price swings and long term energy price increases. The figures below show both steadily increasing and volatile prices for natural gas, electricity and gasoline.

[1] Energy Price and Expenditure Estimates by Source, Selected Years, 1970-2008, Massachusetts, U.S. Energy Information Administration (EIA). /www.eia.doe.gov/states/sep_prices/total/pdf/pr_ma.pdf

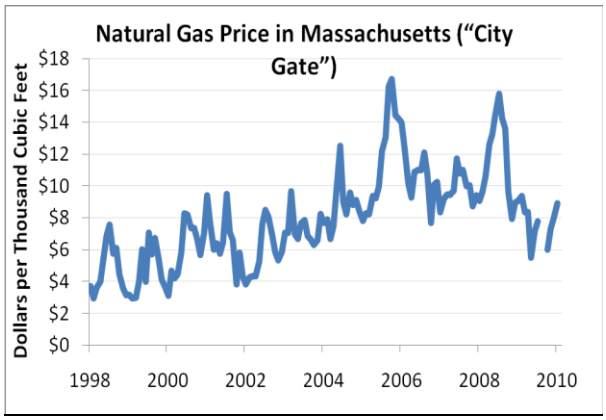


Figure ES-1. Increase and volatility in natural gas prices (source: DOER)

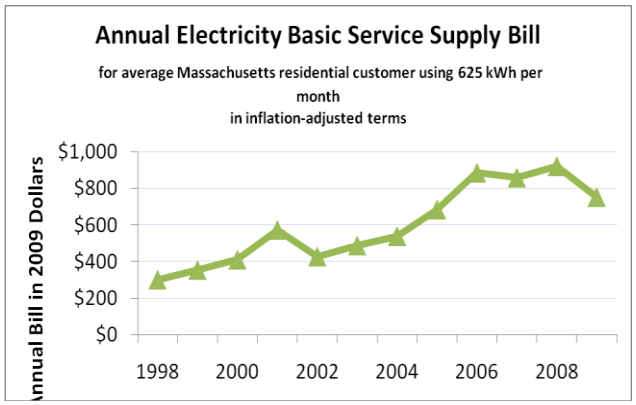


Figure ES-2. Increase and volatility in electricity prices (source: DOER)

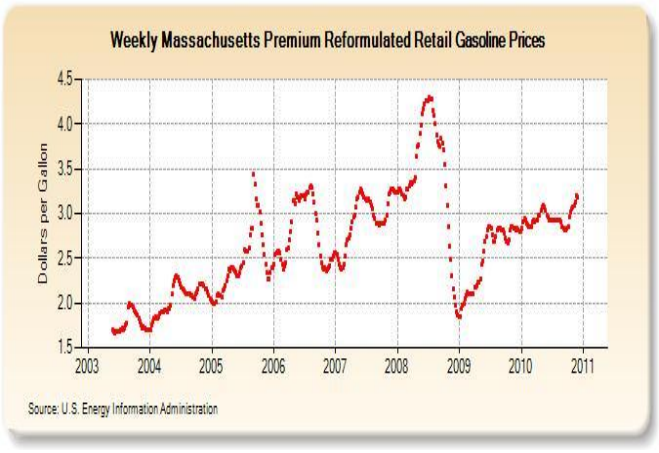


Figure ES-3. Increase and volatility in gasoline prices (source: U.S. Energy Information Administration (EIA))

Economic Opportunity: Along with the rest of the nation, Massachusetts is coming out of the most severe recession in half a century. In the transition to a clean energy economy, Massachusetts has many resources to bring to bear — and should be the disproportionate beneficiary as the economy becomes cleaner and greener. Clean Edge, Inc., has found that Massachusetts is the leading state on the East Coast for clean energy innovation, investment, deployment, and jobs.[2]

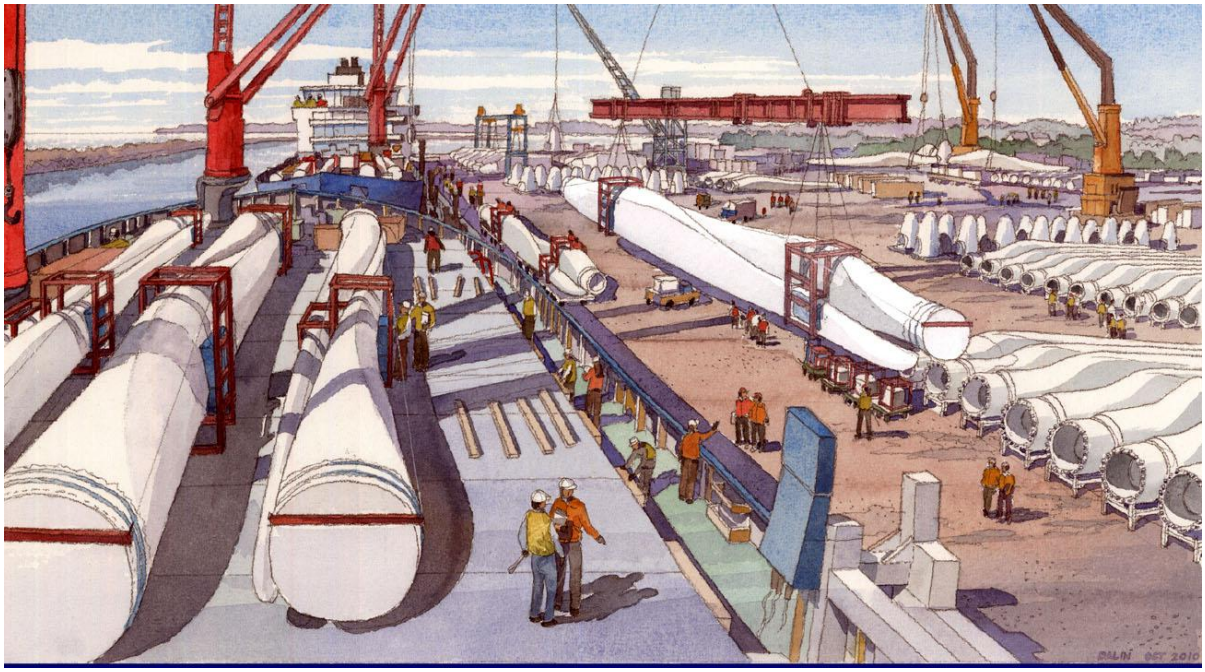
Massachusetts already has a core of companies and jobs in clean energy, and this industry has been growing even during challenging economic times. According to a Massachusetts Clean Energy Center (MassCEC) survey of 471 local companies, more than 11,000 people are employed in clean energy at the end of 2010, up 65 percent since 2007. Some 3,500 people are employed in manufacturing of energy efficiency products, with growth of 20 percent since 2007, and the fastest growth (67 percent) in energy storage, represented by such companies as A123 Systems, Inc., Beacon Power Corp., and Premium Power Corp.

Policies in this Plan will result in large reductions in fossil fuel use in buildings, electricity generation, and transportation. These include energy efficiency programs, advanced building codes, requirements for increased renewable electricity generation, federal vehicle efficiency standards, state incentives for purchasing more efficient vehicles, incentives to reduce vehicle miles traveled, and "smart growth" policies. Through both direct and indirect impacts, these policies will create an estimated 42,000 to 48,000 jobs in Massachusetts in 2020.

[2] A Future of Innovation and Growth: Advancing Massachusetts' Clean Energy Leadership, Clean Edge, April 2010, Massachusetts Clean Energy Center.

Table ES-1. Approximate Massachusetts job increases, direct and indirect, in 2020 due to Implementation of the *Massachusetts Clean Energy and Climate Plan*	
Federal and California vehicle efficiency and GHG standards	6,000
Federal emissions and fuel efficiency standards for medium and heavy duty vehicles	1,000
Pay As You Drive auto insurance (PAYD)	3,000
Clean car consumer incentives	2,000
Smart growth policy package	1,000
subtotal — transportation	13,000
Electric efficiency programs	10,000
Natural gas, heating oil efficiency programs	9,000
Advanced building energy codes	3,000
Federal appliance & product standards	1,000
subtotal — buildings efficiency	23,000
Renewables (solar, wind, biomass, biofuels)	6,000 - 12,000[3]
Total	42,000 - 48,000

Note: see the methodological appendix for sources and description of how the employment gains were estimated.



Artist's rendering of proposed New Bedford Marine Commerce Terminal, staging area for offshore wind installation. (Courtesy of MassCEC)

[3] The figure for renewables is given as a range, because most of the value added for renewables is in manufacturing, and the degree to which renewable components will be manufactured in the Commonwealth is fluid at this time, as is the degree to which the state's 2020 renewable energy requirements will be met from in-state sources.

Climate Change: The international consensus on climate released in 2007 by the Intergovernmental Panel on Climate Change (IPCC) found that the "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."[4]

Massachusetts is vulnerable to severe impacts from climate change. Impacts are expected to include increased coastal flooding from intense storms and permanent inundation of low-lying coastal areas; infrastructure and development located along the coast affected by storm surges, sea level rise, and saltwater intrusion; degraded water quality and quantity, habitat loss, and increased sedimentation and pollution of waterways due to changes in precipitation; increased number of extreme heat days, impacting those with respiratory and cardiovascular conditions; habitat for commercially important fish and shellfish species, such as cod and lobster, shifted northward; and for recreation areas, decreased average ski and snowboard seasons and increased need for artificial snow making.

Local and Regional Air Pollution: In addition to causing climate change, emissions from the combustion of fossil fuels result in a range of negative human health and ecosystem impacts. The U.S. Environmental Protection Agency (EPA) has established health-based National Ambient Air Quality Standards (NAAQS) for six pervasive pollutants that have well-documented health and environmental impacts: ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter (PM), lead, and carbon monoxide (CO). Exposure to each of these pollutants has been linked to adverse health effects. Ozone can also irritate the respiratory system, causing coughing, throat irritation, chest pain and reduced lung function. Ozone can also aggravate asthma, leading to more asthma attacks and increased hospital admissions and emergency room visits for respiratory problems. Fine PM is associated with aggravation of respiratory and cardiovascular disease resulting in increased hospital admissions, emergency room visits and premature mortality.

These pollutants also damage ecosystems. Acid rain is created when SO_2 and NOx emissions mix with water in the atmosphere. Acid rain lowers the pH levels of lakes, rivers, and soils, harming fish and invertebrates. Exposure to ozone is associated with a range of adverse impacts to vegetation, including impairment of tree growth and loss of agricultural crop yield. Ozone can increase the rate of water loss by trees causing forests to drain streams and soils of water, thus stressing natural ecosystems beyond the trees themselves.

***Meeting Challenges, Seizing Opportunities*:** At roughly 2 percent of the U.S. economy and 1.3 percent of the nation's GHG emissions, Massachusetts could not, on its own, stop global climate change even if it reduced statewide emissions to zero instantly. However, Massachusetts is in a position to show the way to a clean energy economy — and reap direct benefits in economic growth — through the development of smart, targeted policies that reduce emissions by promoting greater energy efficiency, developing renewable energy, and encouraging other alternatives to the combustion of fossil fuels. In the process, Massachusetts will also start to get off the fossil fuel rollercoaster, become more energy independent, and jump start its economy with new technologies, new companies, and new jobs.

[4] *4th Assessment Report*, Intergovernmental Panel on Climate Change, 2007.

The *Massachusetts Clean Energy and Climate Plan for 2020* will put Massachusetts on a path to meeting its statutory obligation to reduce GHG emissions, and on the road to a vibrant clean energy economy.

Setting the 2020 Emissions Limit

The statewide GHG emissions limit set for 2020 was based on two years of analysis and public comment, and followed a process to determine the baseline Massachusetts 1990 emissions level and the predicted "Business as Usual" (BAU) emissions trajectory for 2020. The trend line of GHG emissions was found to be relatively stable since 1990 and projected as remaining relatively stable through 2020. Policies and programs implemented or initiated since the beginning of the Patrick-Murray Administration in 2007 — including the Green Communities Act and various state government executive actions, and federal government actions — are projected to result in GHG emissions reduction of roughly 18 percent — roughly the midpoint of the 10 percent to 25 percent range required by the GWSA.

Further analysis showed that it would be technically feasible to reduce emissions by up to 35 percent below 1990 levels by 2020 with additional policies that are cost-effective. In a series of eight public hearings held in June 2010, as required by the Act, nearly 200 individuals and organizations provided oral or written comment on the 2020 emissions reduction requirement and on policy measures to meet the requirement. The vast majority of commenters called for the Secretary to set the GHG limit at 25 percent below 1990 levels, the maximum allowed under the statute. The Secretary of EEA then directed state technical teams to conduct in-depth analyses of measures that satisfy criteria of cost-effectiveness and reducing GHG emissions.

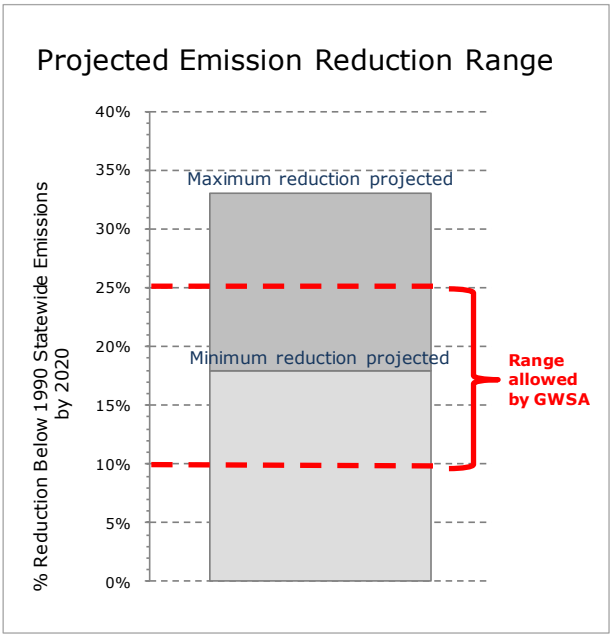


Figure ES-4. Projected emission reduction range below 1990 by 2020. The range results from uncertainties in Business as Usual (BAU) emissions, policy designs, and impacts of individual policies.

Table ES-2 (on page ES-6) displays the portfolio of policies incorporated in this *Clean Energy and Climate Plan for 2020*, and the associated potential contribution to GHG reduction below 1990 levels by 2020 for each policy. In aggregate, these policies, which include measures put in place since 2007 and new initiatives proposed in this Plan, are projected to achieve emissions reductions in the range of 18 percent to 33 percent by 2020 (see Figure ES-4). The lower end of this range represents a scenario in which Business as Usual (BAU) emissions are higher than projected and actual emissions reduction from the policies as implemented is at the low end of estimates. The higher end of the range represents a scenario in which BAU emissions are lower than projected and implementation success is relatively high. A mid-range estimate for the portfolio of policies results in GHG emissions approximately 27 percent below 1990 levels by 2020 (See Figure ES-5 on page ES-7).

Table ES-2. The Portfolio of Policies	**middle estimate % reduction below 1990**
Buildings	**9.8%**
All cost-effective energy efficiency/RGGI	7.1%
Advanced building energy codes	1.6%
Building energy rating and labeling	---
"Deep" energy efficiency improvements for buildings	0.2%
Expanding energy efficiency programs to C/I heating oil	0.1%
Developing a mature market for solar thermal water/space heating	0.1%
Tree retention and planting to reduce heating and cooling loads	0.1%
Federal appliance and product standards	0.6%
Electricity	**7.7%**
Expanded Renewable Portfolio Standard (RPS)	1.2%
More stringent EPA power plant rules	1.2%
Clean energy imports	5.4%
Clean energy performance standard (CPS)	---
Transportation	**7.6%**
Federal and California vehicle efficiency and GHG standards	2.6%
Federal emissions and fuel efficiency standards for medium and heavy duty vehicles	0.3%
Federal renewable fuel standard and regional low carbon fuel standard	1.6%
Clean car consumer incentives	0.5%
Pay As You Drive (PAYD) auto insurance (pilot program, possible expansion later)	1.1%
Sustainable Development Principles	0.1%
GreenDOT	1.2%
Smart growth policy package	0.4%
Non-Energy Emissions	**2.0%**
Reducing GHG emissions from motor vehicle air conditioning	0.3%
Stationary equipment refrigerant management	1.3%
Reducing SF_6 emissions from gas-insulated switchgear	0.2%
Reducing GHG emissions from plastics	0.3%
Cross-cutting Policies	---
MEPA GHG policy and protocol	---
Leading by Example	---
Green Communities Division	---
Consideration of GHG emissions in State permitting, licensing and administrative approvals	---
Overall reductions versus 1990 (adjusted for uncertainty in Business as Usual (BAU) emissions, policy designs, and impacts of individual policies)	
High BAU emissions and low policy impacts	**18%**
Middle BAU emissions and policy impacts	**27%**
Low BAU emissions and high policy impacts	**33%**

Note: the overall reduction is adjusted for overlap among policies, so is smaller than the sum of the individual policies. Individual lines may not sum to subtotals due to rounding.

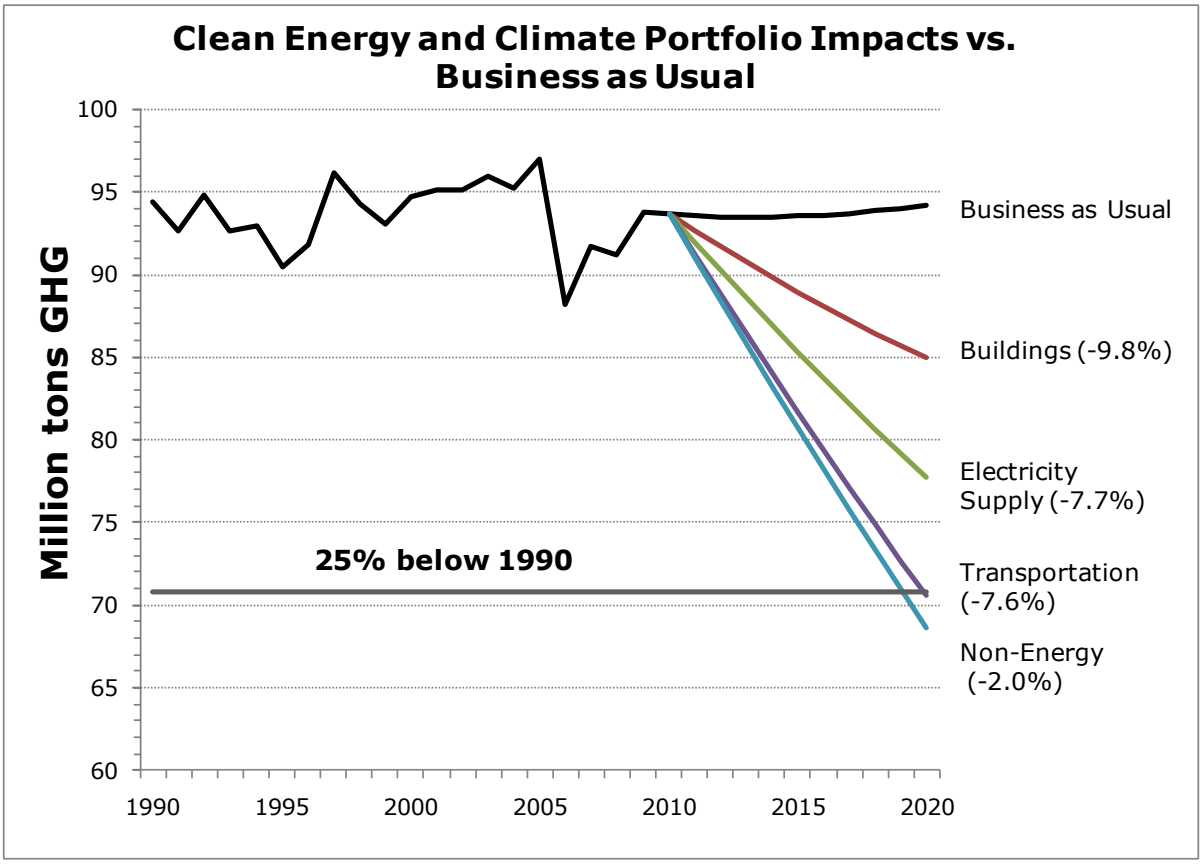


Figure ES–5. Emissions reductions by sector for the portfolio of policies, at the mid-range estimate of 27 percent below 1990 levels by 2020.

Based on these analyses, input from the Climate Protection and Green Economy Advisory Committee created by the GWSA, and full consideration of the public comments received, EEA determined that a responsible and achievable GHG emissions reduction limit for 2020 that maximizes opportunities to realize energy cost savings, increase energy independence, and promote growth in clean energy jobs in Massachusetts is 25 percent. The limit is at the high end of the range for 2020 authorized by GWSA, but the middle of the range of possible outcomes for the policies incorporated in this Plan.

An Integrated Portfolio of Policies

The GWSA provides broad authority to choose policy tools — from targeted and technology-specific policies to economy-wide and market-based mechanisms — to advance a clean energy economy while reducing GHG emissions. An integrated portfolio approach plays to Massachusetts strengths and, taken as a whole, has the greatest likelihood of reaching the goals of addressing energy costs, energy security and independence, and reducing GHG emissions.

In the last four years, Massachusetts has demonstrated the effectiveness of a portfolio approach. A combination of legislation, executive action and private sector entrepreneurship has aligned incentives and created opportunities for clean energy growth and GHG reductions.

The directive from the Secretary was to build on this portfolio — expanding existing programs where practical and developing

new complementary policies that could accelerate clean energy growth and lower GHG emissions. Each of the policies presented in this Plan — GHG reductions; cost-effectiveness; lowering energy costs for consumers and businesses; job growth; equity; implementability; and co-benefits — underwent rigorous analysis focusing on criteria established by the Act and input from the public hearings and Advisory Committee. Some policies can be put in place immediate-ly; others will be tested first through pilot programs. Not every one of these policies must be implemented to its fullest extent in order to achieve the 2020 mandate. But these represent the suite of policies that the Patrick-Murray Administra-tion is committed to pursuing over the next four years as we build on the foundation created in the past four years and work toward the 2020 emissions limit set by the Secretary.

This portfolio is divided into five categories: buildings, electricity supply, transportation, non-energy emissions, and cross-cutting policies.

BUILDINGS

9.8 PERCENT REDUCTION OF GHG EMISSIONS

Buildings consume over 50 percent of the energy used in Massachusetts and are therefore responsible for the greatest GHG emissions of any sector. Energy use in buildings comes from these two primary areas: 1) fuels for heating — primarily natural gas and heating oil, and 2) electricity for air conditioning, lighting, ventilation, appliances and equipment. The *Clean Energy and Climate Plan for 2020* takes into account Massachusetts nation-leading energy efficiency efforts mandated by the Green Communities Act (GCA) of 2008, which will produce substantial GHG reductions for 2020, and proposes additional measures that will contribute toward meeting the 2020 limit. This category is expected to yield GHG reductions of 9.8 percent.

- **All Cost-Effective Energy Efficiency**
  Existing Policy
  With the Governor's signing of the GCA of 2008, Massachusetts embarked on a path to greatly increase investments in—and return on investments from—building energy improvements. From 2010 to 2012—the first three year plan approved by the Department of Public Utilities (DPU) under the GCA mandate to capture all cost-effective energy efficiency opportunities — the state will invest over $2 billion, with an anticipated return of over $6 billion in savings for customers, and creation of thousands of clean energy jobs that cannot be outsourced overseas.

- **Advanced Building Energy Codes**
  Expanded Policy
  Massachusetts has adopted a pathway to greater energy efficiency in building codes through a commitment in the GCA to adopt the latest IECC, as well as by creating a local-option "stretch" code that has been adopted by over 60 municipalities. This policy would complete the transition to performance-based codes by 2020 that go beyond the IECC code in terms of efficiency while reducing their complexity, giving developers flex-ibility and clear performance targets and creating "green" jobs.

- **Building Energy Rating and Labeling**
  New Policy
  The real estate market currently operates without explicit consideration of energy efficiency. This policy would address this market failure by introducing an energy rating program designed to facilitate "apples-to-apples" comparisons between buildings. Initially in a pilot form, this would be the buildings equivalent of the EPA miles-per-gallon (MPG) rating on cars and light trucks.

- **"Deep" Energy Efficiency Improvements for Buildings** New Policy
  To reach our 2050 GHG reduction requirement, energy use in existing buildings must fall dramatically. To accomplish this, it is necessary to begin retrofitting buildings with much higher levels of insulation, less air leakage, and better windows than are typically installed in the retrofit energy efficiency programs. This policy, begun with pilots with utilities, would make rebates and appropriate training and technical support widely available for "deeper" energy improvements for residential buildings.

- **Expanding Efficiency Programs to Commercial/Industrial Heating Oil** New Policy
  Currently, electric utility programs provide funding for heating-related efficiency measures in homes that use oil heat but not for commercial and industrial buildings that use fuel oil for heating. Expanding the programs to such customers would yield significant cuts in energy use and GHG emissions.

- **Developing a Market for Solar Thermal Water and Space Heating** New Policy
  A policy framework will be established to develop a mature and self-sustaining market for solar thermal water and space heating in both residential and commercial buildings as part of a broader effort to support renewable heating technologies (such as clean biomass heating and efficient heat pumps) for low-grade heating needs and spur job and business growth in renewable thermal.

- **Tree Retention and Planting to Reduce Heating and Cooling Loads** New Policy
  Trees help to reduce heating and cooling loads in buildings. This policy would provide incentives to plant new trees around existing housing, and retain trees within new housing developments. This pilot program might be feasible within current utility efficiency programs, or might require new funding and/or regulatory authority.

- **Federal Appliance and Product Standards** Existing Policy
  The federal government sets energy efficiency standards for appliances, electronics, and other products. Under President Obama, the DOE has planned an accelerated schedule for setting new standards between 2009 and 2013. Nationwide these are expected to yield major savings in electricity (11.5 percent of total consumption in 2020), fuel, costs to homeowners and businesses, and carbon dioxide emissions, with Massachusetts getting its proportional share.

ELECTRICITY SUPPLY

7.7 PERCENT REDUCTION OF GHG EMISSIONS

The vast majority of existing power plants burn fossil fuels to generate electricity, producing millions of tons of pollution. Non-fossil fuel electricity generation technologies include nuclear, hydro, wind, solar, and eligible biomass and anaerobic digestion, which vary in their emissions profiles. The character of the electric power sector as a whole is determined by three key factors: the demand for electricity overall, existing generation capacity by technology type, and how much of each type of existing capacity is utilized to meet demand. The *Clean Energy and Climate Plan for 2020* relies on progress in each of these areas made since 2007, along with proposed new measures to move toward a cleaner electricity supply.

- **Renewable and Alternative Portfolio Standards (RPS, APS)** Existing Policy
  The RPS was created as part of electricity restructuring in Massachusetts in 1997 and then expanded in the GCA. The Portfolio Standards require retail electricity suppliers—both distribution companies and other retail suppliers—to buy a growing percentage of their electricity sales from eligible resources. The RPS classes I and II will require 22 percent of electricity supply to be from new and existing renewable sources by 2020, with an additional 5 percent from other eligible sources under the APS.

- **Regional Greenhouse Gas Initiative (RGGI)** Existing Policy
  Massachusetts is one of the 10 Northeast and Mid-Atlantic states participating in a regional effort to limit carbon dioxide emissions from electric generating units. The program, which began in January of 2009, establishes a region-wide cap on CO_2 emissions from fossil fuel-fired power plants that will remain at the initial level for six years then decrease 2.5 percent per year for the next four years, for a total reduction of 10 percent by 2018. Allowances are made available for purchase in quarterly auctions. Massachusetts is investing over 80 percent of its auction proceeds in energy efficiency, with smaller amounts for renewable energy and other consumer benefit programs.

- **More Stringent EPA Power Plant Rules** New Policy
  The EPA is in the midst of proposing and implementing a variety of regulations that will affect allowable water and air emissions of the nation's power plant fleet. The owners of some older, smaller power plants may find it is not economical to retrofit their plants to meet EPA's new regulations, and will instead choose to shut down the plants. In Massachusetts, The Somerset Power Station last ran in January 2010, and its permits will eventually expire if it is not restarted, and the owner of the Salem Harbor Station has indicated that it expects the plant to close within five years.

- **Clean Energy Imports** Expanded Policy
  Canada has substantial hydro-electric resources, which have very low emissions, and are available at relatively low cost and with no need for renewable energy subsidies (see RPS above). A new transmission line being developed by two Massachusetts utilities, NSTAR and Northeast Utilities Service Co., in partnership with Hydro Quebec (HQ) and with the support of the Patrick-Murray Administration would tap more of these resources. When this power line is completed, at HQ's expense, it will bring to New England enough clean power to serve up to 15 percent of Massachusetts present electricity demand. Additional transmission lines may also be possible.

- **Clean Energy Performance Standard (CPS)** New Policy
  A market-based framework is needed to provide a clear signal to the electricity market to improve upon the cleaner energy portfolios of the last few years. One approach to be considered is a CPS, which would require electricity suppliers to favor lower- and no-emissions sources in the mix of electricity delivered to their customers.

TRANSPORTATION

7.6 PERCENT GHG EMISSION REDUCTION

Transportation is second only to buildings in responsibility for GHG emissions in Massachusetts. The *Clean Energy and Climate Plan for 2020* takes into account state and federal measures to improve vehicle efficiency, reduce vehicle miles traveled (VMT), and increase use of lower-carbon fuels; and

proposes additional measures that will contribute toward meeting the 2020 limit.

- **Federal and California Light Vehicle Efficiency and GHG Standards** Existing Policy
  The EPA and the National Highway Traffic Safety Administration (NHTSA) have set harmonized standards for light-duty MPG and GHG emissions; raising the fuel efficiency standard from 27.5 MPG at present to 35.5 MPG for model year 2016. California is expected to propose stricter standards for model year 2017-2020 vehicles, and Massachusetts law requires the Commonwealth to adopt the California standards. In combination, the federal and California standards are forecasted to yield a 17 percent reduction in GHG emissions in 2020 (primarily from lower gasoline consumption, but also some reduced emissions from vehicle air conditioning systems).

- **Federal GHG Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Vehicles** Existing Policy
  The EPA and the U.S. Department of Transportation (DOT) have announced complementary programs to reduce GHG emissions and improve fuel efficiency, for medium- and heavy-duty vehicles, such as the largest pickup trucks and vans, combination tractors (semis), and all types and sizes of work trucks and buses for model years 2014-2018.

- **Federal Renewable Fuel Standard and Regional Low Carbon Fuel Standard (LCFS)** Existing Policy
  Title II of the federal Energy Independence and Security Act of 2007 creates a "renewable fuel standard," which requires an increase in the volume of renewable fuels used in the U.S. Massachusetts biofuels law, passed in 2008, instructs the state to pursue development of a LCFS on a regional basis throughout the Northeast. The LCFS (first developed by California) would require that the average carbon intensity of vehicle fuels falls by a specific percentage compared to petroleum fuels.

- **Clean Car Consumer Incentives** New Policy
  There are various means by which the Commonwealth could provide incentives for consumers to shift their vehicle purchases to more fuel-efficient (or lower GHG) models. This includes varying the rates on new car sales taxes, annual auto excise (property) taxes, and registration fees, with rates raised on low-MPG vehicles and reduced on high-MPG ones. The change could be designed to be revenue-neutral to consumers as a whole and to the state. EEA and MassDOT will conduct a study to examine critical implementation challenges and possible regulatory or legislative paths for this policy.

- **Pay As You Drive (PAYD) Auto Insurance Pilot** New Policy
  PAYD would convert a large fixed annual premium into a variable cost based on miles traveled, creating a major incentive to reduce discretionary driving, while cutting the overall cost of insurance due to fewer accidents. Miles driven would fall substantially, along with CO_2 emissions and costs for gasoline, accidents, and congestion. The Commonwealth plans to conduct a PAYD pilot program initially, and, depending on results, work with the insurance industry to make this payment method more widely available.

- **Massachusetts Sustainable Development Principles** Existing Policy
  In 2007, the Patrick-Murray Administration updated the Massachusetts *Sustainable Development Principles*. Making state investments consistent with the *Principles* increases the amount of

growth that takes place in locations and densities that reduce VMT and GHG emissions and have other clean energy benefits.

- **GreenDOT** New Policy
  GreenDOT is MassDOT's sustainability initiative, announced through a Policy Directive by the Secretary of Transportation in June 2010. GreenDOT is focused on three related goals: reducing GHG emissions; promoting the healthy transportation modes of walking, bicycling, and public transit; and supporting smart growth development.

- **Smart Growth Policy Package** Expanded Policy
  Additional "smart growth" would make it easier for households and businesses to decrease the number and distance of vehicle trips, reducing VMT and related emissions. Massachusetts already has several policies promoting smart growth, but new, complementary policies are necessary to achieve our smart growth targets. Such policies would focus on influencing infrastructure investments by state agencies and planning decisions made by local governments.

NON-ENERGY EMISSIONS

2.0 PERCENT GHG EMISSIONS REDUCTION

Greenhouse gas emissions not related to energy use represent a small but important part of statewide GHG emissions. Although these sources currently represent only 7 percent of total emissions, many of the gases emitted by these processes have high global warming potential (GWP) — thousands of times greater than CO_2. The *Massachusetts Clean Energy and Climate Plan for 2020* addresses a number of non-energy sources of GHG emissions.

- **Reducing GHG Emissions from Motor Vehicle Air Conditioning** New Policy
  Massachusetts law requires adoption of California's emissions standards for new motor vehicles, and the California Air Resources Board (CARB) is developing regulations to reduce emissions associated with motor vehicle air conditioning (MVAC). CARB's standard aims to minimize emissions by reducing direct GHG emissions from MVAC systems, by using low GWP refrigerants and reducing leaks, as well as improvement in the efficiency of the AC system (e.g., more efficient compressors, fans and motors; systems that avoid over-chilling and reheating; and technologies to reduce heat gain in the passenger cabin).

- **Stationary Equipment Refrigerant Management** New Policy
  This policy aims to minimize emissions of high GWP refrigerants used in non-residential refrigerating equipment through: facility registration, leak detection and monitoring, leak repair, system retrofit and retirement, required service practices, recordkeeping and reporting, and eventual replacement with equipment using no-GWP or lower GWP substances, where such alternatives are available and practical. The policy would affect facilities with refrigeration units containing at least 50 pounds of refrigerant, beginning with a voluntary pilot program focused on leak detection and repair.

- **Reducing SF_6 Emissions from Gas-Insulated Switchgear** New Policy
  Through a pilot program, followed by possible regulatory action, this policy aims to minimize emissions of sulfur hexafluoride (SF_6), a high GWP substance, from leakage of gas insulated switchgear (GIS) used in electricity transmission and

distribution systems by setting limits on leakage rates and implementing best management practices for the recovery and handling of SF_6.

- **Reducing GHG Emissions from Plastics** Expanded Policy
  Diverting plastics from the waste stream under this Plan will result in materials with a lower carbon content being combusted at Massachusetts' municipal waste–to-energy facilities, reducing emissions of CO_2.

CROSS-CUTTING POLICIES

Several policies pursued under the *Massachusetts Clean Energy and Climate Plan for 2020* do not neatly fit in the categories of buildings, electricity supply, transportation or non-energy emissions, but involve state actions that drive clean energy adoption across all of these domains.

- **MEPA GHG Policy and Protocol** Expanded Policy
  MEPA requires that all major projects proposed in the Commonwealth that have state involvement (in the form of state permits, land transfers or financial assistance, for example) undertake an assessment of project impacts and alternatives in an effort to avoid, minimize and mitigate damage to the environment to the maximum extent feasible. Building on this general requirement, the MEPA GHG Policy requires that certain projects undergoing review by the MEPA office quantify their GHG emissions and identify measures to avoid, minimize, and mitigate such emissions.

- **Leading by Example** Expanded Policy
  The Leading by Example (LBE) Program, established in April 2007 by Governor Patrick's Executive Order No. 484, works to lower costs and reduce environmental impacts at all Executive Branch agencies, public colleges and universities and quasi-public authorities. The program oversees efforts to reduce energy use by the state's buildings and vehicles, expand recycling programs, cut water consumption, promote green procurement, facilitate the construction of high performance state buildings, and reduce carbon emissions across state government. In addition, the Administration has proposed creation of a Commonwealth Energy Solutions program charged with managing and purchasing low-cost, clean energy across all public agencies, authorities, and facilities — providing an integrated strategy for energy procurement that capitalizes on economies of scale.

- **Green Communities Division** Existing Policy
  Created by the GCA, the Green Communities Division of the Department of Energy Resources (DOER) helps municipalities become more sustainable, control rising energy costs, and incubate the clean energy technologies and practices. Envisioned as a way to encourage municipalities to make greener energy decisions, the Division offer assistance to municipalities in order to be designated as "Green Communities" and qualify for grant funding.

- **Consideration of GHG Emissions in State Permitting, Licensing and Administrative Approvals** New Policy
  The Global Warming Solutions Act requires all state agencies, departments, boards, commissions and authorities to consider climate change impacts, such as GHG emissions, when they issue permits, licenses and other administrative approvals in the context of environmental review. EEA, in collaboration with other state and quasi-public agencies, will develop a plan to implement this requirement in selected agency actions.

The Road to 80 Percent Lower Emissions in 2050

The clean energy economy of 2050 will be very different than the fossil-fuel dominated economy of today. With many of the policies embodied in this Plan in place, 2050 would find a Massachusetts where energy costs are less volatile and comprise a smaller part of budgets. Businesses, households, municipalities and institutions are better able to manage their energy needs. Renewable and alternative sources of energy have largely displaced fossil-based sources, and a smart grid and advanced storage technologies release to the grid as needed electricity generated during the night by massive wind farms off the coast of the Northeast. Both small and large-scale solar installations are ubiquitous across the state. National security has been strengthened by an economy driven by homegrown sources of energy that no longer depend on fossil fuel from unstable regions or countries that do not share the interests of the U.S.

By 2050, the clean energy cluster in Massachusetts has matured, much as the biotechnology and health care sectors matured in the early part of the 21st century. Massachusetts plays a major role in the global market for technologies in offshore wind, solar PV and thermal, electricity storage and energy management. Massachusetts architects and engineers are leaders internationally in green building design and building energy management. Massachusetts companies that pioneered battery technology have robust partnerships with American, European, Indian and Chinese car and truck manufacturers.

And by law, in 2050, GHG emissions are 80 percent lower than in 1990 and the air cleaner.

Getting to this clean energy future will require significant innovation in policy, technology and business practices over the next 40 years. Unlike the 2020 limit, which can be met with actions that we take here in Massachusetts, reaching 80 percent reductions below 1990 emission levels, as required by the Global Warming Solutions Act, will mean broad changes that are beyond the reach of Massachusetts alone. Between 2010 and 2050, much will change — in the economy, in federal regulation, and in technology — that will make possible GHG emission reductions that would be unthinkable today. But in imagining — and planning for — a path to the mandated GHG emissions reduction of 80 percent in 2050, it is important to ask now: How do we get there?

The *Clean Energy and Climate Plan for 2020* describes two scenarios — one based on maximum energy conservation, the other on widespread switching from fossil fuels to electricity for transportation, buildings, and industry, powered by an extremely clean electricity supply. While there are differences between the two scenarios — the former allows marginally greater use of conventional fuels for meeting the remaining energy needs after fundamental efficiency improvements, while the latter allows for marginally greater energy utilization, as long as the source is clean — but there is more that they have in common. Both require dramatic reductions in energy use to meet heating, cooling, lighting, transportation, and production needs, and both require dramatic shifts in where the energy we use comes from.

Although it could not, by itself, get Massachusetts to the mandated 2050 emissions levels, the Plan contains a number of policies that produce modest emissions reductions for 2020 but, if put in place under the Plan for 2020, will make substantial contributions to meeting the 2050 requirement. These include advanced

building codes and building energy rating and labeling, since building stock turns over slowly. The same is true for smart growth, which will take many years to reap emissions dividends in changed transportation patterns. Also vital will be reducing the carbon content of vehicle fuels through a low carbon fuel standard, which will require the development and widespread commercialization of advanced, truly low-carbon biofuels that are not yet in the marketplace, and/or the near universal installation of fueling infrastructure for electric vehicles, which will take time.

Conclusion

Developed under the authority of the GWSA of 2008, the Commonwealth's *Clean Energy and Climate Plan for 2020* provides the means for meeting the Secretary's GHG emissions reduction requirement of 25 percent in 2020, putting the Commonwealth on track toward the GWSA's mandate of 80 percent reduction in 2050 — and accelerating the development of a clean energy economy for Massachusetts.

As this Plan is implemented, homeowners and businesses will discover new ways to save money on energy costs, make living and work spaces more comfortable, and make production processes cleaner and more efficient. The air we breathe will be cleaner, and we will be less dependent on energy from unstable parts of the world. Above all, we will be putting Massachusetts in a leadership position in the clean energy economy of the future.

Capitalizing on the state's advantages in academic resources, venture capital, and skilled resources, the measures advanced in this Plan will give rise to technological innovation and commercialization, company formation, and job creation up and down the skill ladder. There will be clean energy jobs for scientists and engineers, construction workers and insulation installers, as Massachusetts develops the products and services not only needed here, but across the country and around the world. There will be opportunities for those displaced by economic change to retool for a new industry, and for those long disadvantaged in the mainstream economy to find a new point of entry.

Clean energy is an industry of the future, but for Massachusetts, the future is now.

Deep retrofit with super-insulation. (source: DOER)

I. A Clean Energy Revolution

Between 2007 and the end of 2010, solar photovoltaic (PV) systems installed and scheduled for installation in Massachusetts increased 20-fold — with jobs in solar manufacturing, installation, and services nearly tripling — while installed wind energy increased 10-fold. In that same time period, Massachusetts launched the most aggressive energy efficiency program in the country, with estimated savings of over $6 billion for residential, municipal, industrial and commercial customers and 4,500 jobs projected. Companies that are saving on energy costs can devote those dollars to business development and job expansion. School districts that cut energy costs can devote more resources to students. Homeowners who reduce their energy bills can spend more on other needs and desires. By the end of 2010, thousands of new jobs will have been added in clean energy services, manufacturing and research and development (R&D) — this at a time when the country is undergoing the most severe economic recession in a generation. Vibrant high-tech clusters in biofuels, wind energy, solar power, energy storage, and energy efficiency services have taken root and are leading clean energy technology development globally.

This is not a vision of a *possible* future for Massachusetts. This is Massachusetts *today*.

Solar array at Chelmsford Drinking Water Plant
Photo Credit: MassDEP

Here in the Commonwealth, the transition to a clean energy economy has begun — and has already shown itself to be an engine of economic growth. Driven by an entrepreneurial private sector, and an integrated state framework of legislation, regulation and executive branch programs, Massachusetts has launched the clean energy revolution. Unparalleled academic and technical resources, local sources of investment capital, and a highly skilled workforce are all ingredients of this revolution — lowering costs to consumers, increasing our energy independence, growing clean energy jobs, and reducing our contribution to climate change and other environmental impacts. Massachusetts is poised to lead the transition to a clean energy economy nationally and to disproportionately benefit from the economic development and jobs resulting from that transition.

It is in this context that the Executive Office of Energy and Environmental Affairs offers the *Massachusetts Clean Energy and Climate Plan for 2020*. The Global Warming Solutions Act (GWSA) of 2008 requires the Secretary of Energy and Environmental Affairs to establish a statewide limit on GHG emissions of between 10 percent and 25 percent below 1990 levels for 2020, on the way toward 80 percent reduction in emissions by 2050, along with a plan to achieve the 2020 target. Secretary Bowles has set that 2020 limit at 25 percent — and the *Massachusetts Clean Energy and Climate Plan for 2020* contains the measures necessary to meet that limit. But fulfilling that mandate will do much more than meet the requirements of the Act. It will allow the Commonwealth to address a number of challenges, only one of which is climate change. Importantly, it will give

powerful impetus to the clean energy revolution that has already begun. Rather than putting a burden on our economy, a statewide mandate to reduce GHG emissions, achieved through measures that are carefully chosen, designed, and implemented to reduce costs or maximize job growth, will accelerate the transition to a clean energy economy that has already taken hold across the state.

Energy Independence

Massachusetts is at the end of the energy pipeline, figuratively and literally. *All* of our fossil-based energy sources — oil, natural gas, and coal — are derived from other regions of the country (e.g., the Gulf Coast or Western states) and other parts of the world, many of them unstable or hostile to the United States, (e.g., countries in the Middle East and Venezuela). Thus, all spending on fossil fuel energy — whether to fuel power plants, buildings, or vehicles — flows out of state and fails to provide income to in-state businesses or employees. This exported economic value is significant, totaling almost $22 billion in 2008.[5] To put this is at a smaller scale, in 2008, an average Massachusetts household spent about $5,200 for energy costs, of which about $1,700 was for heating (space and water), $1,300 for electricity, and $2,200 for gasoline. Almost all of these expenditures leave Massachusetts.

Energy Costs and Volatility

In addition to the economic drain represented by Massachusetts dollars flowing out of the state for energy resources, energy consumers have experienced wild price swings and long term energy price increases. Figures 1-3 show both steadily increasing and volatile prices for the cost of natural gas, electricity and gasoline.

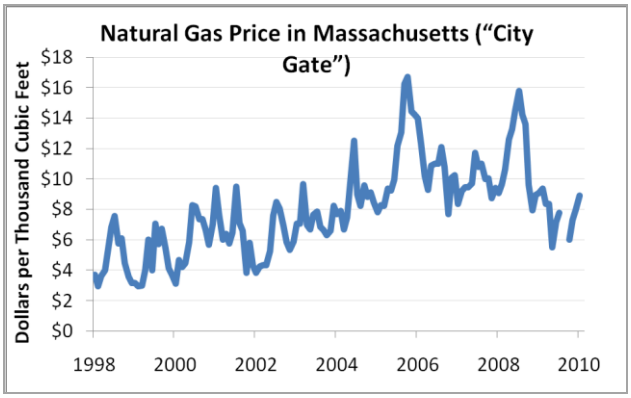


Figure 1. Increase and volatility in natural gas prices (source: DOER)

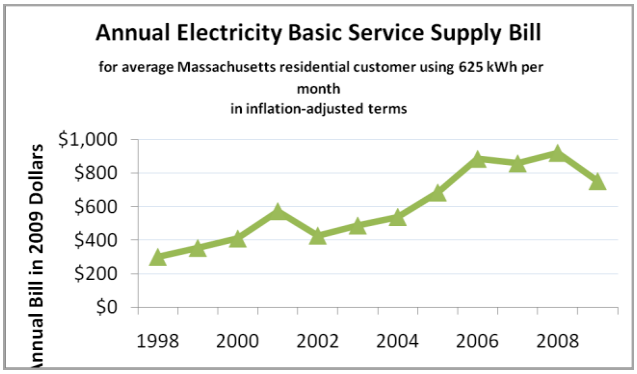


Figure 2. Increase and volatility in electricity prices (source: DOER)

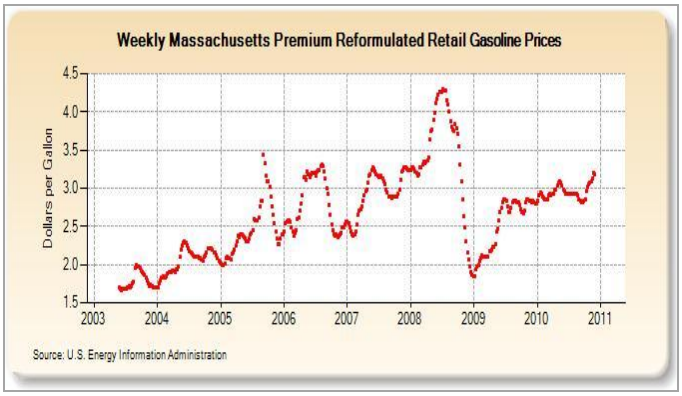


Figure 3. Increase and volatility in gasoline prices (source: U.S. Energy Information Administration (EIA))

As has been experienced numerous times in the past decades, events in other regions and countries drive global energy markets and prices, often to the detriment of Massachusetts consumers and businesses.

[5] Energy Price and Expenditure Estimates by Source, Selected Years, 1970-2008, Massachusetts, EIA. www.eia.doe.gov/states/sep_prices/total/pdf/pr_ma.pdf

Between 2005 and 2008, the combination of Hurricane Katrina's impact on refining and pipeline capacity and exploding demand in China and India for petroleum products resulted in some of the most rapid increases in energy prices that Massachusetts has experienced. Basic service electricity prices quadrupled between 1998 and 2008, before dropping at the onset of the global recession. The price of home heating oil peaked at $4.71 per gallon in 2008 and regular gasoline topped $4 a gallon. Over the past decade, price shocks have forced Massachusetts consumers, businesses and governments to struggle with an increasing burden of costs and uncertainty.

Economic Opportunity

…more than 11,000 people are employed in clean energy at the end of 2010, up 65 percent since 2007.

Along with the rest of the nation, Massachusetts is coming out of the most severe recession in half a century. Massachusetts has fared better than most other states during this difficult period, but still faces a steep climb to regain the prosperity its citizens expect and deserve. Routinely recognized as one of the nation's centers of economic innovation,[6] Massachusetts has many strengths to draw on, but local fossil-based energy sources are not among them. With no oil, coal, or natural gas of its own, Massachusetts has paid dearly for energy, sending precious economic resources out of state and out of the country in order to fuel its economy. But in the transition to a clean energy economy, Massachusetts has many resources to bring to bear — and should be the disproportionate beneficiary as the economy becomes cleaner and greener.

Jobs in solar manufacturing, installation, and services have nearly tripled in the same period, from 1,200 to 3,000

This is, in fact, already happening, as clean energy innovations developed at academic centers such as the Massachusetts Institute of Technology (MIT) and the University of Massachusetts translate into products and companies, and as laws, regulations, and incentive programs developed under Governor Patrick have created or expanded markets in Massachusetts for clean energy products and services. A study earlier this year by Clean Edge, Inc. found that Massachusetts has become the leading state on the East Coast for clean energy innovation, investment, deployment, and jobs.[7]

Massachusetts already has a core of companies and jobs in clean energy, and this industry has been growing even during challenging economic times. According to a Massachusetts Clean Energy Center (MassCEC) survey of 471 local companies, more than 11,000 people are employed in clean energy at the end of 2010, up 65 percent since 2007. Some 3,500 people are employed in manufacturing of energy efficiency products, with growth of 20 percent since 2007, and the fastest growth (67 percent) in energy storage, represented by such companies as A123 Systems, Inc., Beacon Power, and Premium Power.

Jobs in solar manufacturing, installation, and services have nearly tripled in the same period, from 1,200 to 3,000; solar manufacturing jobs alone have jumped from 750 in 2007 to 2,000 in 2010. Despite fierce competition from overseas, Marlborough-

[6] 2008 Index of the Massachusetts Innovation Economy, Massachusetts Technology Collaborative/John Adams Innovation Institute.

[7] *A Future of Innovation and Growth: Advancing Massachusetts' Clean Energy Leadership*, April 2010, Clean Edge, for Massachusetts Clean Energy Center.

based Evergreen Solar, Inc. has more than maintained its commitment to manufacturing jobs in Massachusetts in exchange for state support, with a payroll of more than 900 employees at the end of 2010. Meanwhile, 1366 Technologies, a Lexington-based start-up that received a prestigious "transformational energy technologies" grant from the U.S. Department of Energy (DOE), has developed production technology that promises to slash the cost of solar power, and plans to break ground on a Massachusetts manufacturing facility within a year.

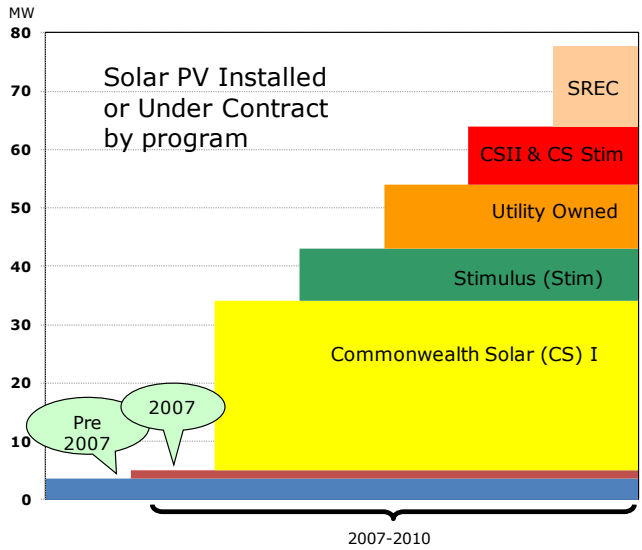


Figure 4. Expansion from 3.5 MW to over 75 MW installed and in the pipeline from 2007 to 2010. (source: DOER)

With nation-leading firms such as Conservation Services Group, Ameresco and Noresco based in Massachusetts, employment in energy efficiency services has nearly doubled, from 1,000 in 2007 to 1,972 in 2010 in just the 69 firms that responded to the MassCEC survey — representing just one fifth of energy efficiency services companies in the state. Anecdotal information indicates similar growth is taking place across the Commonwealth's energy efficiency sector.

This growth should accelerate in the coming years, thanks in part to state initiatives, including those contained in this report. From 2010 to 2012 the state's electric and gas utilities will invest close to $2 billion in energy efficiency incentives, as a result of the Green Communities Act, producing $6 billion in savings for consumers — and 4,500 direct jobs. The Advanced Biofuels Task Force estimated that development of non-food-crop-based alternatives to petroleum fuels could yield 2,500 permanent Massachusetts jobs within the industry by the year 2025, with another 3,700 jobs through indirect spending effects.[8] Massachusetts has the only tax incentive in the nation for cellulosic biofuel — exemption from the state gasoline tax, and nation-leading companies like Qteros, Inc. in partnership with research at UMass, are leading the way to a non-fossil future.

In addition to solar power, which has boomed from 3.5 megawatts (MW) at the start of 2007 to over 75 MW installed or slated for installation at the end of 2010 (see Figure 4), wind power is another local energy resource — and opportunity for economic growth. Governor Patrick has set a goal of 2,000 MW of wind — enough to power 800,000 homes — by 2020 (see Figure 5 on page 5). Much of that will come from offshore wind — the greatest renewable energy resource available to Massachusetts. At 468 MW, Cape Wind will be the first offshore wind project in the United States, and installation — which will be based in a new port facility in New Bedford — will create 600 to 1,000 jobs. Siemens AG, one of the world's largest manufacturers of wind turbines, has located its U.S. offshore wind headquarters in Boston, because of its contract to supply Cape Wind with 130 turbines, and EEW Group of Germany, a leading maker of foundations for offshore

[8] "Advanced Biofuels Task Force Report," Commonwealth of Massachusetts, Spring 2008, page 20.

wind, has partnered with Middleboro-based Mass Tank Corp. to supply monopile foundations and other structural components for Cape Wind at a new manufacturing facility in Massachusetts.

The Wind Technology Testing Center (WTTC), now under construction in Charlestown, will also bolster Massachusetts' emerging role as a center for wind energy advancement and jobs. Backed by a $25 million grant from the DOE, the WTTC will be the first facility in the United States capable of testing the large-scale (up to 90 meters long) wind turbine blades that represent the next generation of wind energy technology, specifically applicable to offshore installations. The WTTC has already attracted TPI Composites, Inc. a leading manufacturer of turbine blades, to establish an R&D facility in Fall River. Devens-based American Superconductor Corp. is engaged in development of technology for ever-larger wind turbines (a 10 MW turbine is now under development), and Massachusetts-based ePower LLC was acquired by Vestas Technology R&D Americas, Inc., one of the world's largest wind turbine companies, for its direct drive technology. With support from the MassCEC, FloDesign Wind Turbine Corporation — another "transformational energy technology" grant winner — has established a new facility in Waltham, with a promise of creating 150 new jobs as it brings its innovative "shrouded" wind turbine design to market.

In addition to companies that are providing the new technologies of the clean energy future, Massachusetts also has thousands of individuals and small companies who are taking risks and making investments to power their businesses with smaller scale energy installations to provide energy stability, diversification, and in some cases powering back to the grid. In the last four years, these entrepreneurs have invested in small-scale anaerobic digestion, solar thermal, low head hydro and geothermal.

Employment Projections for 2020

Reducing energy use through efficiency and conservation — for both buildings and vehicles — cuts living costs for households and expenses for business, improving prosperity and creating jobs. Efficiency relies more heavily on local labor and companies than do fossil-fuel based industries. Efficiency programs not only create employment directly, but households and companies will spend their energy cost savings at other businesses within the state, creating "indirect" and "induced" jobs and economic growth. Renewable energy facilities tend to be more capital-intensive, but also provide many local jobs in construction.

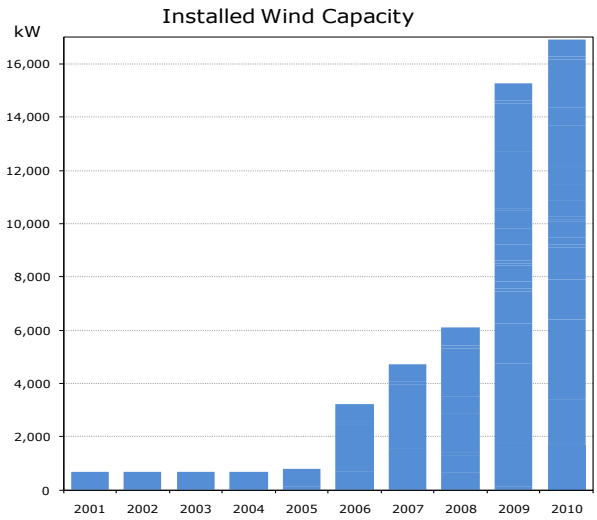


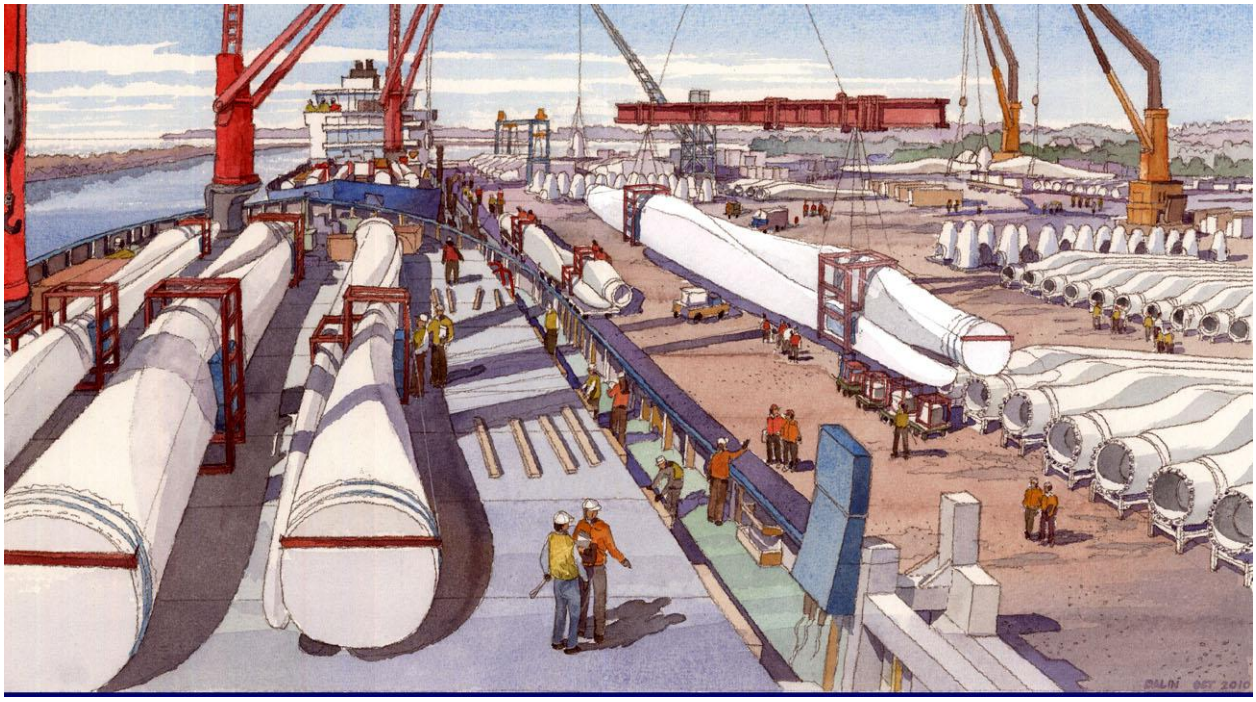
Figure 5. Expansion from about 3MW to over 16 MW installed from 2007 to 2010, with more in the pipeline. (source: DOER)

A number of the most important policies in this Plan will cause large reductions in fossil fuel use in buildings, electricity generation, and transportation. These include energy efficiency programs, building codes, requirements for increased renewable electricity generation, federal vehicle efficiency standards, state incentives for purchasing more efficient vehicles, incentives to reduce vehicle miles traveled, and "smart

growth" policies. Through both direct and indirect impacts, we estimate that these policies will create 36,000 jobs in Massachusetts in 2020, including about 13,000 via transportation policies and 23,000 via policies to improve efficiency of energy use in buildings.

The estimate for employment from in-state demand for renewable energy in Massachusetts in 2020 is 6,000 to 12,000 full-time jobs.

The figures for transportation, efficiency and renewables are based on employment needed to cover in-state demand for these clean energy sectors. They do not include the ability of Massachusetts companies to export both services and products to other states and countries in greater amounts than we import. To the degree that the Commonwealth can continue and expand its leadership in clean energy R&D, manufacturing, and service provision (such as Massachusetts companies that operate energy efficiency programs across the nation), the employment gains could be significantly larger than shown in the table on page 7. However, projecting such changes in industry growth is difficult, and beyond the scope of the modeling conducted for this Plan.



Artist's rendering of proposed New Bedford Marine Commerce Terminal, staging area for offshore wind installation. (Courtesy of MassCEC)

Table 1. Approximate Massachusetts job increases, direct and indirect, in 2020 due to implementation of the *Massachusetts Clean Energy and Climate Plan*	
Federal and California vehicle efficiency and GHG standards	6,000
Federal emissions and fuel efficiency standards for medium and heavy duty vehicles	1,000
Pay As You Drive auto insurance (PAYD)	3,000
Clean car consumer incentives	2,000
Smart growth policy package	1,000
Subtotal — transportation	13,000
Electric efficiency programs	10,000
Natural gas, heating oil efficiency programs	9,000
Advanced building energy codes	3,000
Federal appliance & product standards	1,000
Subtotal — buildings efficiency	23,000
Renewables (solar, wind, biomass, biofuels)	6,000 - 12,000[9]
Total	42,000 - 48,000
Note: See the methodological appendix for a description of how the employment gains were estimated and for the data sources and studies utilized.	

Retrofitting a house with new windows and energy efficient insulation. (source: DOER)

[9] The figure for renewables is given as a range, because most of the value-added for renewables is in manufacturing, and the degree to which renewable components will be manufactured in the Commonwealth is fluid at this time, as is the degree to which the state's 2020 renewable energy requirements will be met from in-state sources.

Transportation and buildings efficiency policies that reduce consumption of fossil fuels aid employment not only in Massachusetts, but in other states and nationally. One study, conducted at the UMass Amherst, estimated that $100 billion of national spending directed toward the green economy would create approximately 2 million jobs through both direct and indirect effects, compared to only 540,000 jobs if the same amount of money continued to be spent on oil, natural gas, and electricity. The differences are due to how much of the spending stays within the U.S. economy and to how much pays for labor expenses versus capital costs.[10]

Another recent study, "Green Jobs/Green Homes New York," estimated the economic impacts of conducting energy efficiency retrofits of one million housing units over the course of five years. It found that the program would cut home energy consumption by 30 percent to 40 percent, save New York households $1 billion annually in energy bills, and create about 120,000 "job years" (one year's worth of employment, reflecting that many of these would be temporary construction jobs). Half of these jobs would be direct results of the retrofit activity and half would come from the re-spending of increased incomes throughout the New York economy.[11]

In short, the private sector has already grasped the potential huge revenue growth by capitalizing on the Commonwealth's emerging clean energy policies and programs. The Bay State has a long and impressive entrepreneurial history, and it is that spirit — fueled by the intellect and innovation of world-class academic centers such as Harvard, MIT, and UMass, and catalyzed by the state's nation-leading clean energy policies — that will continue to propel the Commonwealth forward.

Climate Change

The international consensus on climate released in 2007 by the Intergovernmental Panel on Climate Change (IPCC) found that the "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."[12] There is broad agreement and high confidence that the documented increase in GHG concentrations is changing the earth's climate — not only raising average global temperatures but altering regional and local climatic and weather patterns. Observed effects of climate change include: increased atmospheric and ocean temperatures, heat waves, increased evaporation and changes in precipitation patterns, and a greater intensity of storms, floods, and droughts. Thermal expansion of a warmer ocean and the melting of glaciers are contributing to a rise in sea level. These trends are expected to continue for a minimum of several decades even if GHG emissions are reduced.

Global atmospheric concentrations of carbon dioxide (CO_2), methane, and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values (see Figure 6 on page 9).

The global increases in CO_2 concentration are primarily due to increased fossil fuel use and

[10] "Green Recovery: A Program to Create Good Jobs and Start Building a Low-Carbon Economy," Robert Pollin et al, Political Economy Research Institute and Center for American Progress, Sept. 2008, page 10.

[11] "Green Jobs/Green Homes New York: Expanding home energy efficiency and creating good jobs in a clean energy economy," Center for Working Families, Green Jobs New York and Center for American Progress, May 2009, page 5.

[12] Fourth Assessment Report, Intergovernmental Panel on Climate Change, (IPCC, 2007.)

land use change, while increases in methane and nitrous oxide are primarily due to agriculture. Carbon dioxide is the most important anthropogenic (human induced) GHG. Globally, CO_2 concentrations have reached 385 parts per million (ppm) — about 105 ppm greater than during pre-industrial times. The increasing atmospheric CO_2 and other heat trapping greenhouse gases are causing an increase in the earth's air temperatures. Eleven of the 12 warmest years on record have occurred in the period between 1995 and 2006.[13] A recent study by the National Oceanic and Atmospheric Administration (NOAA) indicated that the summer of 2010 tied with 1998 as the warmest global temperature on record.

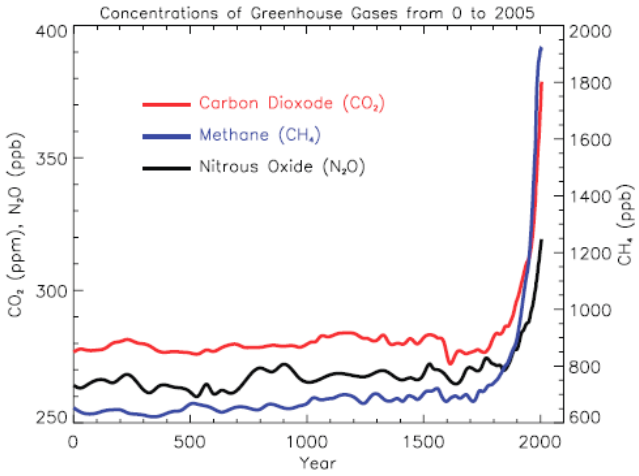


Figure 6. Increasing concentrations of atmospheric GHGs: carbon dioxide; methane and nitrous oxide. (source: IPCC)

For the period between January and September in 2010, the global combined land and ocean surface temperature was 0.65°C (1.17°F) above the 20th century average of 14.1°C (57.5°F).[14]

In order to understand the potential impacts of climate change in Massachusetts, EEA undertook a year-long study driven by the Climate Adaptation Advisory Committee, a body created by the GWSA to advise the Secretary on adaptation strategies.[15] The Adaptation Advisory Committee found that Massachusetts' climate is already changing and will continue to change over the course of this century. Under the IPCC's high emissions scenario, by the end of the century Massachusetts is set to experience a 3° to 5°C (5° to 10°F) increase in average ambient temperature[16]; summer temperatures would feel like the current summer climate of the Carolinas. Days with temperatures greater than 32°C (90°F) are predicted to increase from the five to 20 days a year that Massachusetts presently experiences to between 30 and 60 days each year (IPCC, 2007). Sea surface temperatures are predicted to increase by 4°C (8°F) (IPCC, 2007); precipitation is expected to increase in winter months by 12 percent to 30 percent, but will fall mostly in the form of rain[5]; and the number of snow days is predicted to decrease from five each month to one to three each month. Finally, while no single event can be entirely attributed to global warming, a warming climate is increasing the likelihood of more extreme weather. The Northeast has recently experienced major storms, with notable

[13] Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.)], IPCC (Intergovernmental Panel on Climate Change), 2007. Cambridge University Press, Cambridge, UK, and New York, 996 pp.

[14] State of the Climate Global Analysis. National Oceanic and Atmospheric Administration, September 2010. www.ncdc.noaa.gov/sotc/?report=global

[15] Massachusetts Climate Change Adaptation Report, forthcoming.

[16] *Past and Future Changes in Climate and Hydrological Indicators in the U.S. Northeast*, K. Hayhoe et al., 2006, *Climate Dynamics* 28:381-407, DOI 10.1007. www.northeastclimateimpacts.org/pdf/tech/hayhoe_et_al_climate_dynamics_2006.pdf

rainfall and flooding events occurring in May 2006, April 2007, and March 2010.

Massachusetts is vulnerable to severe impacts from climate change. Impacts to natural resources include:

Coastal

- Substantial increases in the extent and frequency of coastal flooding and increased risk of severe storm-related damage.
- Permanent inundation of low-lying coastal areas and increased shoreline erosion and wetland loss due to projected sea-level rise and increased wave action.

Rivers and wetlands

- Alteration of stream flow timing and volumes due to precipitation changes, punctuated by increased winter flooding events and longer low-flow periods.
- Degraded water quality and quantity, habitat loss, and increased sedimentation and pollution of waterways due to precipitation changes, higher temperatures, and more frequent droughts.
- Changes in temperature will lead to shifts in wetlands species and types and/or composition, changes to wetland soils that could result in increased erosion, decreased species diversity, and reduced groundwater recharge capabilities.

Forests

- Certain species may succumb to climate stress, increased competition, and other pressures, resulting in trickle-down impacts to dependent bird and animal species, increasing vulnerability to invasives and pests.
- A shift northward of suitable habitat by 350 to 500 miles is expected for most of the Northeast region's tree species.

Climate change will also impact a number of business sectors in Massachusetts that depend on overall ecosystem health, including fisheries, agriculture, and recreation. These impacts include:

Fisheries

- As ocean temperatures continue to rise, the range of suitable habitat in the Northeast for many commercially important fish and shellfish species, such as cod and lobster, is projected to shift northward. Certain fisheries will decline in productivity, impacting the economic viability of fishing-related industries.
- Temperature, precipitation, nutrient, and salinity changes will result in a loss of habitat for marine species, altering the location or productivity of commercial and recreational fishing.

Agriculture

- Changes to growing seasons, frequency and duration of droughts, increased frequency of extreme precipitation events, and heat stress will make some areas unsuitable for growing popular varieties of produce (e.g., apples, cranberries), depress milk production from dairy cows, and increase irrigation needs to maintain viable crop production.
- A longer growing season may allow farmers to experiment with new crops, but many traditional farm operations in the region will become unsustainable without adaptation strategies that could be costly, impacting already narrow profit margins.

Recreation

- Global warming is projected to profoundly affect winter recreation and tourism in the Northeast as winter temperatures continue to rise and snow cover declines.
- With warmer winters, the average ski and snowboard season will decrease and operation costs will increase with greater requirements for artificial snow making.

Infrastructure/developed land

Climate change will also profoundly impact the built environment such as energy infrastructure, transportation, water supply, wastewater and stormwater, dam safety and flood control, solid and hazardous waste, and telecommunications.

- Key infrastructure and development that is located along the coast will particularly be affected by storm surges, sea level rise, and salt water intrusion. The 100-year coastal storm floodplain can get shifted further inland.
- Inland, the predicted changes in precipitation patterns and more frequent and intensive precipitation events will inundate development that is located in the floodplains.
- Increased temperature can affect the structural integrity of many elements of the built environment.

Human Health

Higher temperatures and intensive and increased precipitation events impact human health (especially the most vulnerable populations) both directly and indirectly.

- Higher temperatures including extreme heat days will increase heat stress, impact those with respiratory and cardiovascular conditions, increase ozone and particulate matter production resulting in poor air quality, and increase pollen production.
- Increased runoff from precipitation events can degrade surface water quality, increase outbreaks of water-borne diseases, and result in more algal blooms.

There is compelling evidence that the Northeast's climate has already begun to change, with additional changes predicted to unfold over the next century. All of these will require the implementation of adaptation measures to help decrease the state's vulnerability and increase resilience.

Impacts of Local and Regional Air Pollution

In addition to causing climate change, emissions from the combustion of fossil fuels result in a range of negative human health and ecosystem impacts.

The U.S. Environmental Protection Agency (EPA) has established health-based National Ambient Air Quality Standards (NAAQS) for six pervasive pollutants that have well-documented health and environmental impacts: ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter (PM), lead, and carbon monoxide (CO). The federally regulated pollutant of greatest concern in Massachusetts is ozone.

Ozone concentrations in Massachusetts exceed the health-based NAAQS due to a combination of locally generated emissions (particularly from vehicles), and the transport of pollutants from states to the south and west of Massachusetts. Massachusetts' overall air quality has improved significantly over the last 25 years. Nonetheless, ozone concentrations in the Commonwealth regularly exceed the national standards, despite the adoption of a wide range of control programs that have reduced emissions of the pollutants that contribute to ozone.

Exposures to each of the criteria pollutants have been linked to adverse health effects. For example, ozone can irritate the respiratory system, causing coughing, throat irritation, chest pain and reduced lung function. Ozone also can aggravate asthma, leading to more asthma attacks and increased hospital admissions and emergency room visits for respiratory problems. Fine PM is associated with a number of serious health effects including aggravation of respiratory and cardiovascular disease reflected in increased hospital

admissions, emergency room visits and premature mortality.

In its 2010 proposed Transport Rule,[17] EPA proposes to reduce emissions from power plants in 32 eastern states. In the proposal, EPA concludes that reducing the emissions from power plants that contribute to ozone and fine PM pollution will lead to significant health benefits. EPA estimates that the national benefits, which include the value of avoiding approximately 14,000 to 36,000 premature deaths, 22,000 nonfatal heart attacks, 11,000 hospitalizations for respiratory and cardiovascular diseases, 1.8 million lost work days, 100,000 school absences, and 10 million days when adults restrict normal activities because of respiratory symptoms exacerbated by fine PM and ozone pollution, significantly outweigh the costs of the emission reductions.[18]

Since air pollution levels are highly sensitive to weather, climate change may significantly affect our overall air quality. For example, ozone is formed in warm weather, so higher summer temperatures may result in increased ozone concentrations in Massachusetts. Climate-driven increases in global and regional wild fires and dust-storms and changes in precipitation may impact PM concentrations in Massachusetts.

Criteria pollutants also damage ecosystems. Acid rain is created when SO_2 and NO_x emissions mix with water in the atmosphere. Acid rain lowers the pH levels of lakes, rivers, and soils, harming fish and invertebrates. It damages forest ecosystem health by making plant roots more likely to dry out and by washing away calcium and other minerals essential for plant growth. Exposure to ozone is associated with a range of adverse impacts to vegetation, including impairment of tree growth and loss of agricultural crop yield. Ozone can increase the rate of water loss by trees causing forests to drain streams and soils of water, thus stressing natural ecosystems beyond the trees themselves. Ozone interferes with photosynthesis, thus reducing carbon capture by trees, affecting the efficiency of large forested areas to act as carbon sinks.

Meeting Challenges, Seizing Opportunities

At roughly 2 percent of the U.S. economy and 1.3 percent of the nation's GHG emissions, Massachusetts could not, on its own, stop global climate change even if it reduced statewide emissions to zero instantly. But the severity of the climate change challenge requires leadership at every level, and Massachusetts is in a position to show the way toward a clean energy economy through the development of smart, targeted policies that reduce emissions by promoting greater energy efficiency, developing renewable energy, and encouraging other alternatives to the combustion of fossil fuels. There are opportunities to reduce emissions this way across the economy, and Massachusetts should continue to be a leader in identifying and capitalizing on those opportunities.

But, more importantly, Massachusetts can make use of the climate change imperative to get off the fossil fuel rollercoaster, become more energy independent, and jump start its economy with new technologies, new companies, and new jobs. The *Massachusetts Clean Energy and Climate Plan for 2020* will put Massachusetts on a path to meeting its statutory obligation to reduce GHG emissions, and on the road to a vibrant clean energy economy.

[17] Federal Implementation Plans to Reduce Interstate Transport of Fine Particulate Matter and Ozone. (August 2, 2010, 75 FR 45210-45465).

[18] EPA estimates that the benefits from the reductions outweigh the costs by 60 to145 to one or 55 to 130 to one depending on the discount rate used in the economic analysis. *Regulatory Impact Analysis for the Proposed Federal Transport Rule,* EPA, June 2010, page 1. http://www.epa.gov/ttn/ecas/regdata/RIAs/proposaltrria_final.pdf

II. An Integrated Portfolio of Policies

The GWSA gives broad authority to the state to choose policy tools — from targeted technology-specific policies to economy-wide market-based policies — to advance a clean energy economy while reducing GHG emissions. Since the passage of the Act in 2008, the interagency technical team, the Climate Protection and Green Economy Advisory Committee, and an outside group of consulting experts in energy, transportation, buildings, and industrial emissions have analyzed a wide range of policies and explored other states' and other countries' efforts to make concrete steps toward a clean energy economy. Public comments collected during hearings held through the summer of 2010 focused on policy choices, design and outcomes.

In weighing the different paths forward, it became clear that an integrated portfolio approach plays best to Massachusetts' strengths and, taken as a whole, has the greatest likelihood of reaching the goals of addressing energy costs, energy security and independence, and reducing GHG emissions in the absence of broad federal action on climate and clean energy. In the last four years Massachusetts has demonstrated the effectiveness of a portfolio approach: a combination of legislation, executive actions and private sector entrepreneurship has aligned incentives and created opportunities for clean energy growth and GHG reductions. Successful energy efficiency programs, solar incentives, building codes, transportation planning, ocean planning and green jobs training are tailored to the Masaschusetts economic and workforce landscape. The portfolio that the state has built in the last four years is greater than the sum of its parts, working synergistically to launch the Commonwealth on a path to GHG reductions of 18 percent below 1990 levels by 2020.

The directive from the EEA Secretary was to build on this portfolio — expand existing programs where practical and develop new complementary policies that could accelerate clean energy growth and lower GHG emissions. Each of the policies presented in this section underwent rigorous analysis that focused on criteria established by the Act and input from the public hearings and Advisory Committee: GHG reductions, cost-effectiveness, energy cost mitigation, job growth, equity, implementability, and co-benefits.

The portfolio of policies that follow are those deemed most likely to reach our clean energy and climate goals. Some can be put in place immediately; others will be tested through pilot programs, with those that show the best results ultimately implemented statewide through regulation or legislation, as needed. Depending on actual (as opposed to projected) results, not every one of these policies must be implemented to its fullest extent in order to achieve the 2020 mandate. But these represent the suite of policies that the Patrick-Murray Administration is committed to pursuing over the next four years as we build on the foundation created in the past four years and work toward the 2020 emissions limit set by the Secretary.

This portfolio is divided into five categories: buildings, energy supply, transportation, non-energy emissions, and cross-cutting policies. Each policy is labeled as either "Existing", "Expanded" or "New". Existing policies are those that were put in place prior to our Draft Implementation Plan in June of 2010. An example is the energy efficiency programs that started with the passage of the Green Communities Act of 2008. Expanded policies are those that build on already existing policies and exand their scope. An example is Smart Growth policies. New policies are those that have not yet been initiated or were begun since June of 2010. The GreenDot policy is an example of a new policy.

Buildings

Buildings consume more than 50 percent of the energy used in Massachusetts and are therefore responsible for the greatest GHG emissions of any sector; 49 percent of GHGs, including over 21 percent from direct fuel use excluding electricity. Energy use in buildings comes from these two primary areas: 1) fuels for heating, primarily natural gas and heating oil, and 2) electricity for air conditioning, lighting, ventilation, appliances and equipment. The character of energy use in the buildings sector overall is determined by three factors: the amount and location of existing and new building space in use, the energy performance of these buildings, and the choice of energy sources. There are several effective approaches for enabling changes, primarily related to the latter two factors.[19] The issue of location is covered in the transportation chapter.

Global, national and regional studies have consistently pointed to energy efficiency and improved energy performance of residential and commercial buildings as the largest and most cost-effective clean energy opportunities. This is particularly true in the Northeast, where the combination of a cold climate and heavy reliance on heating oil results in both high heating energy use[20] and high average fuel costs. For existing buildings, energy improvements can be encouraged through financial incentives, access to financing, and rating of building energy performance. For new buildings, energy performance can be moved to higher standards through advanced building energy codes.

In addition to eliminating energy waste in buildings, there is a significant opportunity to transition to cleaner energy sources. For example, oil heating can be replaced by solar thermal, sustainable biomass/biofuels, or heat pumps, while electricity supply can be shifted from fossil fuels such as coal and oil to wind and hydro.[21]

Massachusetts began to address many of these opportunities through the Zero Net Energy Buildings Task Force, created by Governor Deval Patrick in 2008. This stakeholder group, made up of energy and building industry professionals working with the DOER, released a roadmap for the state called *Getting to Zero*[22] in March 2009.

The *Clean Energy and Climate Plan for 2020* takes into account Massachusetts' nation-leading energy efficiency efforts mandated by the Green Communities Act of 2008, which will produce substantial GHG reductions for 2020, and proposes additional measures that will contribute toward meeting the 2020 limit set as part of implementation of the GWSA.

[19] In general, the amount of building space is driven by broader trends such as economic growth, Federal policy relating to real estate and capital markets, and personal preferences. Innovations such as e-commerce, virtualization, and telepresence (telecommuting and teleconferencing) could one day substantially change the amount of building space in use.

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

[21] Electricity supply is discussed further in a separate chapter.

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

All Cost-Effective Energy Efficiency

With the Governor's signing of the Green Communities Act (GCA) of 2008, Massachusetts embarked on a path to greatly increase investments in — and return on investments from — building energy improvements. From 2010 to 2012 — the first three year plan approved by the Department of Public Utilities (DPU) under the GCA mandate to capture all cost-effective energy efficiency opportunities — the state will invest more than $2 billion, with an anticipated return of over $6 billion in savings for customers.

Under the *Massachusetts Clean Energy and Climate Plan for 2020*, additional changes need to be implemented to maximize emissions reductions through energy efficiency. For example, deep energy improvements, which substantially improve building energy performance, should be encouraged in a way they are not in the existing program structure. Commercial and industrial buildings heated with fuel oil should have access to energy efficiency programs in the same way that residential buildings do. Finally, new measures, such as tree planting and retention that can reduce heating and cooling loads over the long-term, even if not so much for 2020, should be supported.

Performance-based Energy Codes

In addition to achieving energy efficency upgrades in existing structures, the Commonwealth needs to set standards for construction and rehabilitation that ensure higher energy performance. New construction in Massachusetts accounts for additions and turnover of around 0.75 percent a year in the total building stock for residential units and 1 percent for commercial space. That translates into turnover of 7 percent to 10 percent of the building stock through 2020, and 30 percent-40 percent by 2050. These buildings have an expected lifetime ranging from 30 to more than 300 years. The design of buildings newly built today and in coming years will have a large and lasting impact on fossil fuel use and corresponding GHG and local air pollution emissions.

Massachusetts has already adopted a pathway to greater energy efficiency in building codes through a commitment in the Green Communities Act of 2008 to adopt the latest International Energy Conservation Code (IECC) from the International Code Council (ICC), the body that develops and maintains model building codes for the United States. In addition to this energy code baseline, which updates every three years, the Massachusetts Board of Building Regulations and Standards (BBRS) adopted a local-option "stretch" energy code for municipalities in 2009. Over 60 municipalities in Massachusetts have already adopted this higher-efficiency code. More significantly, "stretch" is now approaching the norm: The 2009 stretch code for commercial buildings recently became the basis for the 2012 IECC code for commercial buildings, the largest improvement in the energy efficiency of the national model code in its 35 year history.

The *Massachusetts Clean Energy and Climate Plan for 2020* proposes to move away from the traditional approach of "prescriptive" codes, which set minimum standards for each building component or system, and toward "performance" or "outcome-based" codes, which set a maximum energy usage criterion for buildings but allow flexibility to meet that criterion in any number of ways. The Massachusetts stretch code has spearheaded "performance-based" energy codes, through performance targets and testing requirements for new homes and through energy modeling requirements for large commercial buildings.

By shifting to performance-driven energy codes that get progressively more effective in reducing energy needs, new construction in 2020 will use half the energy of the same buildings under a business-as-usual scenario. This results in a total savings over the coming decade of 30 percent to 40 percent of the expected energy use from new construction in residential and commercial sectors, with similar reductions in their total GHG emissions by 2020. Each year this number compounds, making it a critical component of any 2050 plan.

Energy Rating and Labeling of Buildings

In addition, this Plan proposes to use energy rating and labeling of buildings to create greater markets for energy-saving investments in existing structures. Currently, there is little data available on the energy use of existing buildings, which prevents buyers and renters — and their lenders — from placing a value on the energy performance of spaces. Under this Plan, Massachusetts proposes to pilot and then broadly deploy residential building energy labeling that allows apples-to-apples comparisons of home energy performance in much the same way that miles per gallon (MPG) ratings allow fuel efficiency comparisons of cars and light trucks. A pilot program in western Massachusetts beginning in 2011 will seek to integrate this new information on energy use into the real estate marketplace through Multiple Listing Service listings and trainings for contractors, realtors and home appraisers. In addition, Massachusetts will develop a commercial building rating pilot that would deploy both operational energy ratings (based on utility energy bills and the EPA Energy Star Portfolio Manager program) and asset ratings (similar to home energy ratings or vehicle miles-per-gallon) ratings. These two forms of ratings reveal to prospective tenants what impact on energy use previous tenants have had, as well as the inherent energy performance of the building under average tenant use. The DOER has been working with a team from both the public and private sectors to design a commercial building energy rating program, with plans to launch a pilot in eastern Massachusetts in 2011.

Solar Thermal Water and Space Heating

While water and space heating together account for around half of total building energy use and carbon emissions in Massachusetts, it does not require very high-grade fuels (unlike powering aircraft and motor vehicles for example). These large but low intensity heating needs make them excellent candidates for active solar heating which has no fuel expense, and can provide significant heating from a small roof, wall or ground-mounted system. Unlike in the 1970's, the technology for active solar thermal heating is now mature and comes with decade-long warrantees to protect the up-front investment in a solar thermal system. This technology has been broadly adopted and even required in new construction in places as varied as Hawaii, Cyprus, Israel, and Austria (where there is less solar radiation available per square foot than in Massachusetts). However, the market for solar thermal in New England is currently small, and needs support to reach maturity and become a broadly viable option for new and existing construction alike. Solar thermal is only one of several renewable thermal technologies that over time can replace a growing portion of our heating needs that are currently met with fossil fuels.

Buildings as Elements of Livable Communities

While improving the design and efficiency of buildings is the focus of this chapter, we cannot lose sight of the importance of location. When considering energy and GHG gas footprints of homes and businesses, siting is also a critical consideration. The chapter on transportation covers in more

depth the importance of liveable and walkable communities and the necessity of "smart growth" policies as we continue to build infrastructure in our growing economy. Consideration of these factors builds community cohesion and improves both our long-term quality of life and our economic competitiveness.

Heat leakage as shown by infrared camera, identifying where insulation and air sealing are needed. (source: DOER)

Existing Policy

ALL COST-EFFECTIVE ENERGY EFFICIENCY

Policy summary: With the Governor's signing of the Green Communities Act of 2008, Massachusetts embarked on a path toward significant energy improvements in homes and commercial buildings. The Act required that the electric and gas utilities pursue all cost-effective energy efficiency, *i.e.* eliminating energy waste whenever it is cheaper to do so than buying additional supply. From 2010 to 2012 — the duration of the first three year plan — the state will invest more than $2 billion, with an anticipated return of over $6 billion for participants. The program is administered by the investor-owned utilities in the state and the Cape Light Compact, together known as Program Administrators (PAs). The PAs work under the guidance of the Energy Efficency Advisory Council (EEAC), which represents a broad range of stakeholders.

Economy-wide GHG reductions in 2020	6.7 million metric tons; 7.1%[23]
Gigawatt (GWh) electricity savings in 2020	1,600[24]
Million BTU (MMBTU) natural gas savings in 2020	36 million
Million BTU (MMBTU) heating oil savings in 2020	7.7 million
Cumulative net benefits 2010-2020 (discounted)	$17.5 billion[25]
Jobs gained in 2020 (direct and indirect)	19,600[26]

Clean energy economy impacts: From 2010 to 2020, the program will induce investments of $10.2 billion in buildings, creating approximately 19,600 jobs in 2020. In addition, the program will generate $17.5 billion in net benefits, largely in avoided future costs of energy and avoided energy system expansion. These savings will largely enter the local economy rather than flowing out of state and out of the country, while reducing living costs for residents and operating costs for businesses.

Rationale: A substantial amount of energy efficiency is cheaper than energy supplies now provided by coal, oil, natural gas, and nuclear power. However, due to various market barriers, investments in energy efficiency fall short of optimal, either for an individual organization or for

[23] 6.7 million tons is based on expansion of the efficiency programs since 2008, due to the Green Communities Act. The program savings from levels of efficiency spending prior to 2008 are excluded, since the emissions trend in the Business as Usual (BAU) projection is estimated to include them.

[24] Energy savings in 2020 are based on the full value of efficiency programs, including the spending levels that existed prior to 2008, in order to be consistent with DOER required reporting to the Department of Public Utilities (this differs from the calculation of GHG savings, as discussed in prior footnote).

[25] $13.7 billion electric, $3.4 billion natural gas, and $0.5 billion fuel oil, all discounted to 2010 at a 2.5 percent real discount rate. Includes savings from 2010 to 2020 from the full value of efficiency programs, to be consistent with DOER required reporting to the DPU. DPU order 08-50-A directs programs to use a discount rate pegged to the 10-year Treasury note over the previous year. Rather than vary the rate year by year, 2.5 percent was used as a reasonable approximation of the real Treasury rate historically.

[26] Approximately 10,300 jobs from electric efficiency, 7,000 from gas efficiency, and 2,300 from heating oil efficiency. More than two-thirds of the employment gains are "indirect" and "induced" — due to lower energy bills causing greater respending of household and business incomes within the Massachusetts economy, and to purchases by efficiency-related companies from other businesses in the state.

the state as a whole. The PAs, as a primary point of contact with customers on energy, are well-suited to incentivize customers to undertake building energy improvements. Participation in energy efficiency could be increased greatly.

Policy design and issues: The PAs, with guidance from the EEAC and DOER, attempt to reduce consumption of electricity, natural gas, and heating oil by conducting energy assessments on buildings, and providing financial incentives for customers to implement a variety of efficiency measures, such as installing higher-efficiency lighting, HVAC systems and appliances; adding insulation to attics, walls, and basements; and reducing air leakage from buildings. Both technical and financial assistance are provided to developers of new buildings, such as the Energy Star Homes program and customized project support for commercial buildings.

There are a variety of market barriers that make achievement of all cost-effective efficiency a challenge. One of these is customers' lack of up-front capital to pay for efficiency investments, and the PAs are currently addressing this through providing subsidized financing, targeted to different types of customers. Another is the "split incentive" problem for rental space, when a tenant is paying the utility bills but only the owner has the ability to invest in efficiency measures. Efforts are also being made to address this issue.

GHG impact: The programs will reduce emissions by 6.7 million tons in 2020.

Other benefits: By reducing fossil fuel combustion, the program will help reduce criteria pollutants and other hazardous air pollutants, providing public health and environmental benefits.

Cost: From 2010 to 2020, the electricity, natural gas, and oil efficiency programs will generate $27.7 billion of energy savings, at a cost of $10.2 billion, yielding $17.5 billion in net benefits for the state, largely in avoided future costs of energy and energy system expansion.

Experience in other states: Many states have energy efficiency programs operated by utilities within a similar framework. Massachusetts' program is one of the most well established in the nation, and its 2010-12 plan represents the largest per capita investment in energy efficiency in the country.

Uncertainty: It remains uncertain how much energy efficiency there is to be captured and what program elements will capture it.

Expanded Policy

ADVANCED BUILDING ENERGY CODES

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

Economy-wide GHG reductions by 2020	1.5 million metric tons; 1.6%
Energy saved by 2020, million BTU (MMBTU)	28 million
Net cumulative benefit 2011 to 2020 discounted (from new residential construction only[27])	$1.3 billion
Jobs created in 2020 (direct and indirect)	3,000 jobs

Clean energy economy impacts: Building construction is one of the largest economic sectors in the U.S. and is a major employer of skilled labor, with excellent potential for clean energy job growth. Between now and 2020 new construction is estimated to account for 7 percent to 10 percent of the total building stock. In addition, major renovations of existing buildings trigger code compliance requirements, and this will affect a significant percentage of buildings. The avoided fuel and electric costs due to enhanced codes will cut the long-term operational costs of this real estate and increase its durability. In addition, these projects will require more energy and design expertise, generating clean energy jobs in these sectors. In taking a leadership position on energy efficient design and construction Massachusetts-based firms are also likely to become national leaders in green design and to grow demand for their services in the increasingly global building design and engineering sector.

Rationale: Massachusetts has recently moved to the forefront of a national shift toward greater energy efficiency in building codes. This growing attention is due to the underlying economics, emphasized in analyses such as the McKinsey climate studies which point to modernized energy codes as one of the most cost-effective climate mitigation strategies.[28] Further, given the long lifespan of the building stock, decisions made today determine energy demands of the buildings sector for the rest of the century and beyond.

Massachusetts has the opportunity to build on its recent leadership in energy codes by developing a clear roadmap for both residential and commercial code reform over the next decade. Clear and bold action can ensure that we put ourselves on a path to zero-net energy buildings, and provide

[27] Cost data is not broadly available for either new commercial buildings or the residential and commercial renovation and retrofit market.

[28] The November 2007 McKinsey report: "Reducing U.S. greenhouse gas emissions: How much at what cost?" lists "improving energy efficiency in buildings and appliances" at number 1 in its 5 clusters of GHG abatement potential in the U.S. by 2030. http://www.mckinsey.com/clientservice/sustainability/costcurves.asp

improved competitiveness for our nation-leading design, construction and developer communities.

The shift from prescriptive codes that try indirectly to reduce energy waste, to performance-based codes that directly measure and reduce energy waste, is one of the clearest ways to improve energy codes. Historically it was not possible to meaningfully measure or model the energy use of residential or commercial buildings, but the advance of diagnostic tools such as duct-testing equipment, blower doors, and infra-red cameras have revolutionized that process for residential buildings. In larger commercial building spaces, the sophistication of energy models has grown rapidly.

Design issues: Building energy codes are relatively complex, particularly for commercial buildings, and there are numerous stakeholders across the design and construction supply chain to factor into the rate of improvement that is possible. The early "windfall" gains come from redirecting the emphasis of the energy code to more directly drive improvements in energy performance. Once these gains have been achieved the rate of progress will depend somewhat on design innovation and the appropriate application of new technologies that respond to marketplace demands. The dominant commercial building types are also the ones with the most turnover in real estate markets: office, retail and lab space and multi-family rental housing. The Commonwealth is looking to pilot programs in these sectors first, and to initially focus code improvement efforts there.

On the residential side the pathway to zero-net energy homes has already been paved by several industry-leading builders, who build and sell net-zero homes at both market and affordable housing prices. However, the broader market transition will take time, a focused set of building codes, and a supporting framework of training, outreach and technical assistance. More than a third of new residential construction in Massachusetts voluntarily adopted the Home Energy Rating System (HERS) index in 2009, and this has been complemented by more than 60 communities opting into the "stretch" energy code. A steady ratcheting down of the maximum allowed HERS index for new construction allows home builders and their subcontractors the time to retrain and modernize their design practices to meet performance targets without major shocks to the price of construction.

GHG impact: Estimated at 1.6 percent of statewide GHG emissions in 2020, based on an average reduction of over 50 percent in the energy use of new code-built buildings in 2020 versus 2008, and improved levels of energy code compliance.

Other benefits: A stronger emphasis on energy use requires earlier attention to building design and performance considerations than is currently practiced. This generally is the most cost-effective time to find cost savings, and results in the use of more skilled labor early in a project, while reducing energy and material costs later during construction and occupancy. Further, more energy efficient buildings can better manage air quality and moisture in a building through controlled ventilation. Energy modeling forces consideration of benefits such as daylighting that improve health, productivity and quality of life for building occupants. Added thermal insulation both reduces drafts and improves sound insulation, and mechanical ventilation reduces dust and mold build-up in homes.

Costs: On average, up-front design and construction costs are likely to increase marginally. To date, cost estimates have been in the 1 percent to 3 percent range for both residential and commercial buildings that achieve a 20 percent to 30 percent improvement over the base code. In

return for this upfront investment the developer is able to more clearly differentiate new construction as higher-performance than the stock of existing buildings, and the final owner/operator of the building receives significant energy cost savings.

Equity issues: Inability to afford heating fuel is widespread in Massachusetts, and the cost of subsidizing fuel needs of low-income households is borne broadly by ratepayers as a result. Higher-efficiency homes are a direct and sustainable method of addressing this social issue. More efficient homes reduce the cost of homeownership, they directly benefit renters who pay the cost of utilities, and indirectly benefit them when utilities are included in rents. For commercial buildings improved codes reduce the cost of doing business for retail and commercial office tenants, and operating costs fall for all investors in new commercial real estate.

Experience in other states: California is the first state to propose a roadmap to zero-net energy homes and commercial buildings, and their approach has several similarities to that proposed in Massachusetts. However, as our climates are somewhat different the specific measures and building designs differ, particularly given our heating-load dominated residential market. The commercial building sector initiatives in New York City, California, and Washington D.C. show broad support for improvement in building energy performance.

Legal authority: The building energy code is governed by the independent Board of Building Regulation and Standards (BBRS). The Department of Public Safety (DPS), EEA and DOER will continue working together to craft future energy code provisions for consideration by the BBRS. The Commonwealth could also pass legislation to clarify the scope[29] and direction of the building energy code and to provide longer-term certainty for the real estate marketplace.

Implementation issues: The residential sector has begun the market-led transition to performance-based energy codes remarkably smoothly. However, as the rest of the market follows and as energy code requirements increase, the need for training and technical assistance is likely to rise. In order to ensure and improve code compliance, ongoing resources will be needed to provide continued training in best practices to builders, designers and subcontractors working in the new construction and retrofit markets.

The commercial sector is perhaps earlier in the transition to high performance buildings, but the professionalization of design and engineering teams is higher. In order to effectively transition to performance-based codes for commercial buildings improvements and standardization in energy modeling will be needed, and there will be increased demand for building energy modelers. These are new clean energy jobs that require 21st century skill sets, and Massachusetts will only retain its leadership in green building design and engineering by cultivating this workforce.

Uncertainty: With the baseline energy codes in Massachusetts now tied to decisions of the International Code Council (ICC) there is a delegation of authority to this national body. The policy described here would reduce the uncertainty inherent in relying on the ICC by laying out a codes road map for the next three code cycles from 2012 through 2018. The impact of these codes on overall GHG emissions depends greatly on the economic performance of the broader economy and the resulting level of investment in new construction and building renovation.

[29] The mandate of the BBRS is presently limited in regard to areas such as water conservation, siting, and other "green" building considerations that impact energy use and that are addressed in recent "green" codes from ASHRAE and the ICC.

New Policy

BUILDING ENERGY RATING AND LABELING

Policy summary: The current real estate market operates without the explicit consideration of energy performance of the property – a significant factor in future operating costs. Potential building owners or tenants of either residential or commercial buildings make major investments without the ability to compare the energy performance of the buildings they are interested in. This policy would address this market barrier by introducing an energy rating program designed to facilitate "apples-to-apples" comparisons between buildings. Initially in a pilot form, this would be the buildings equivalent of the EPA MPG rating on cars and light trucks. This policy complements existing efforts to track actual energy use through utility billing data, but the ratings are intended to be independent of tenant or user behavior, and are known as "asset" ratings. The DOER is developing pilot programs for new "asset ratings" of both residential and commercial buildings.

Clean energy economy impacts: Building energy labeling is anticipated to enable significant additional investments in energy efficiency. This investment in turn leads to large reductions in fuel expenses and creates and supports clean energy jobs in residential and commercial remodeling and construction. Less spending on imported fuel will keep more money in the state economy and thereby create additional jobs.

Rationale: At present the voluntary market is providing a glimpse of the potential for an "MPG rating" for buildings. For commercial buildings the Leadership in Energy and Environmental Design (LEED) green building rating has become a must-have requirement for class-A office space in cities across the country, including the greater Boston area. But while the LEED program has steadily improved its emphasis on energy costs, it remains a poor proxy for energy savings potential, and instead signifies that the building underwent a more thoughtful design process than is typical elsewhere in the market. In addition, a growing number of relatively energy efficient buildings have opted into the Energy Star Portfolio Manager program for commercial buildings — which allows buildings above the 75th percentile in energy performance to receive an Energy Star designation.

For the residential market a similar story is apparent. The Energy Star homes program has achieved significant market penetration in MA and other states around the country, and LEED for homes is also a growing "green building" presence, alongside several other green homes certification programs.

While these voluntary programs have shown that there is market interest in energy and green design data, their impact has been limited largely to new construction, particularly toward the higher end of the market, leaving existing residential and commercial real estate markets largely unaffected. Initially developed as pilot programs serving the much larger existing buildings market, this policy could become a standardized source of energy comparison information. This would enable investment decisions that improve energy performance once developers are able to demonstrate and market the results of their investment.

Design issues: Any energy benchmarking and rating metric needs to be clear, transparent and trusted if it is to support increased energy efficiency investment. However, residential and commercial real estate markets face different design issues. For the relatively homogenous

residential market, a comparison of total annual energy needs (primarily heating and standardized electric plug loads) is likely to be the most intuitive metric. DOER, in collaboration with three other states and funding from the DOE, is launching a pilot along these lines in western Massachusetts in 2011.

For the more diverse commercial real estate market, an accurate comparison of energy needs per square foot (primarily heating, cooling, ventilation and lighting in office/retail/lab spaces) is the generally accepted metric. DOER in collaboration with a public and private sector team is developing a pilot to launch in eastern Massachusetts.

GHG impact: The GHG impact for this policy is indirect, in that it enables larger and more targeted energy efficiency investments in the covered real estate markets. It is too early to estimate the actual level of GHG savings attributable to this policy. However, given the large number of existing buildings and the equally large level of annual investment made in building renovations, retrofits and other improvements, enabling the market valuation of energy performance has the potential to foster significant private investment in energy-saving measures and hence reduced carbon emissions. Two major constraints to energy efficiency investment are lack of awareness of potential savings, and lack of credible metrics to support financing from lenders. This policy tackles both of these market failures, and enables smarter real-estate investment decisions.

Other benefits: The task of rating and labeling building energy performance is a labor intensive and skilled exercise. The resulting clean energy jobs are paid for from the energy savings and the other actionable building condition information that results from the building assessments. Energy assessments conducted for asset ratings generally uncover operational issues that can affect building durability (such as water damage, mold, and mechanical problems) as well as more energy-specific improvement opportunities. This information on buildings results in better market valuation and reduced investor risk, and also facilitates improved comfort and early identification of any health and life-safety issues.

Costs: The primary costs of energy asset rating and labeling programs is in the initial building assessments. It is critically important that these assessments are conducted in an independent, consistent and professional manner to ensure the integrity of the ratings. At the same time it is important to minimize costs to building owners and property managers. The Commonwealth is moving forward with pilot programs for both residential and commercial building energy rating to better assess the likely costs of implementation and to allow for both technology and process innovations to be tested, to reduce costs prior to any broader statewide deployment.

Equity issues: Providing access to energy use comparison data is likely to have equity benefits for low and moderate income households for whom energy costs represent a significant portion of their disposable income. As a result, there has been relatively high voluntary adoption of the Energy Star homes program by public and affordable housing programs both in Massachusetts and elsewhere in the U.S. Similarly, for the commercial buildings sector it is likely that small business owners and tenants who lease space will be the primary beneficiaries of more transparent and comprehensive access to energy comparison data in making decisions about where to lease and buy commercial space.

Experience in other states: Residential energy labeling has been successfully piloted in various metro-areas in the U.S., and has become a cornerstone of the European Union climate

and energy policy framework for buildings. Notable examples in the U.S. on the residential side include Portland, Oregon; Seattle, Washington; and Austin, Texas. On the commercial side California is moving to a mandatory utility bill disclosure and benchmarking program through Energy Star Portfolio Manager. Similar programs are underway in New York City and Washington D.C. for public sector buildings and commercial office markets. A growing number of property management companies are developing internal metrics to assess building energy assets and performance in order to inform investment decisions across their portfolio. Adopting an "asset" rating, which has credibility for building appraisers in commercial real estate, is a new idea in the U.S., although it has been the policy direction of the European Union for the past several years.

Legal authority: The Commonwealth can likely require energy ratings as part of the building code governed by the independent Board of Building Regulation and Standards (BBRS). Based on the findings of the pilots, DOER and the Department of Public Safety will develop plans for widespread adoption of rating and labeling and their possible incorporation into the building code. However, the state may opt to put such a requirement in legislation in order to provide longer-term certainty for investors and businesses in the real estate marketplace.

Implementation issues: If energy labeling pilot programs are subsequently expanded to a statewide level, the large number of existing buildings to assess and rate mean that it will necessarily take many years to fully implement this policy. As a result, the timing of market coverage will likely vary in different market segments and different geographic areas around the state. Further, in order to be effective energy ratings need to be accessible prior to any major financial transactions, and ensuring awareness and access to this information may be initially difficult while market coverage is low.

Uncertainty: The rate of adoption of energy ratings and labels by different segments of the real estate market, and the impact that this new information will have on efficiency investment decisions, is unknown. A certain threshold level or "critical mass" is needed for both the residential and commercial markets to make full use of energy comparison data in their purchasing and leasing decisions, and it will likely take a few years before a broader trend in energy efficiency investments can be seen in response to these market signals. Availability of sufficient financing to improve properties is also likely dependent on broader economic trends.

New Policy

"DEEP" ENERGY EFFICIENCY IMPROVEMENTS FOR BUILDINGS

Policy summary: To reach our 2050 GHG reduction requirement, energy use in existing buildings must fall dramatically. To accomplish this, it is necessary to begin retrofitting buildings with much higher levels of insulation, less air leakage, and better windows than are typically installed in the retrofit energy efficiency programs. This policy would make rebates and appropriate training and technical support widely available for "deeper" energy improvements for residential buildings

Economy-wide GHG emissions reduced in 2020	0.1 - 0.2 million metric tons; 0.1%-0.2%
Total Fuel Savings in 2020 (MMBtu)	2.7 million
Total Electricity Savings in 2020 (MWh)	79,000
Energy cost savings in 2020	$84 million

Note: energy savings are for the "high" case, with 0.2 million metric tons of CO_2 reductions.

Clean energy economy impacts: Deep retrofits will save large amounts of both electricity and heating fuels, reducing living costs and cutting energy imports; while expanding job opportunities for skilled contractors and construction workers.

Rationale: At present the energy efficiency program administrator (PA)-operated programs provide financial incentives for "moderate" retrofits of residential buildings, such as adding insulation to attics and walls, upgrading fossil-fuel-based heating and cooling equipment, and air sealing. If all the standard measures are done, these improvements typically achieve 20 percent to 30 percent reductions in heating energy use. While a major contributor to our 2020 emissions target, this level of savings is far from adequate for achieving the 2050 requirement of an 80 percent emissions reduction. For 2050 "deeper" measures are needed, higher and more consistent levels of insulation on all the outside surfaces of a building, along with sharp reductions in air leakage. When needed building maintenance is done without adding insulation, such as re-roofing and re-siding, there is a huge "lost opportunity" for achieving energy savings. The PAs currently have pilots that provide incentives for such deep retrofits. This policy would make such incentives a standard part of the PA offerings, with the expectation that their adoption by consumers would gradually rise from now through 2020.

Design issues: Until recently the utilities' pilot only provided incentives for whole-house deep retrofits. The cost of such retrofits is quite high, for both the homeowner and the utilities, and is unlikely to be done broadly. More attractive to homeowners may be "partial" deep retrofits, where one part of a house is done at a time when the owner was planning to do a renovation anyway. The incremental cost of energy saving improvements is greatly reduced when they are integrated with other work on the same portion of a home, such as when replacing a roof, residing exterior walls, or replacing windows. This policy would provide rebates that are substantial enough to attract widespread adoption of deep retrofits, such as rigid insulation installed below the roofing shingles or inside new siding, and triple-pane windows.

Another design option is to continue what some PA deep retrofit pilots are doing currently, paying higher incentives for comprehensive projects that go deeper still, to Net Zero Energy, Passive House and Thousand Homes Challenge levels. Once heating needs are reduced to this level, there are significant savings on heating and cooling equipment. This practice provides additional leveraging and measure bundling advantages, and builds the skills needed to reach the 2050 GHG reduction requirement.

In addition, the particular methods that are used to evaluate programs for cost effectiveness should be reviewed to ensure that deep retrofits can be implemented to the maximum possible extent.

GHG impact: 0.1 to 0.2 million tons in 2020, depending on the rate of adoption by consumers. The state's consultants have projected a relatively small number of project completions, based on (a) homeowners only undertake deep retrofits at the time when they are doing building maintenance anyway, (b) consumer adoption begins at low levels and grows slowly until it reaches 10 percent of normal maintenance projects by 2020. Since these are long-lasting improvements to buildings the cumulative impacts continue growing beyond 2020, contributing substantially to the 2050 reduction requirement.

Other benefits: Substantial reductions in energy use, cost savings to homeowner, and improvements to building comfort.

Costs: Costs to the utility efficiency budgets and to homeowners are significant. For an expanded program that goes beyond the current pilots, impacts on utility budgets would depend on the scale of adoption by consumers.

Equity issues: In most cases the incentives for deep retrofits will be substantially larger than those offered for "moderate" retrofits. This creates possible equity issues between participants and non-participants in the program.

Experience in other states: The pilots currently underway by Massachusetts utilities are at the forefront of deep retrofit efforts in the United States. California has made a commitment to achieving sharp reductions in energy use by existing buildings, and the Province of Yukon in Canada has a program to super-insulate existing buildings.

Legal authority: These kinds of programs fall within the authority of the electric and gas utilities under their existing efficiency programs.

Implementation issues: Deep retrofits involve more complex construction techniques than are needed for conventional construction or moderate retrofits. To achieve the projected energy savings, and to not create or worsen other problems such as moisture and mold issues in a home, the deep retrofit shell must be installed correctly. As less heat is used in a building the drying potential is greatly reduced, so both interior and exterior water management details become critical for the health of occupants and durability of the structure. To avoid other indoor air quality problems, as well as to capitalize on smaller heating loads, shell measures should be carefully integrated with mechanical ventilation and smaller heating equipment that has sealed combustion or forced draft. Further, deep measures, if installed incrementally, should be deployed in a manner that does not hamper future energy improvements. This requires contractors with appropriate deep retrofit expertise, partnered with others with advanced HVAC expertise. At present these skills\teams are in limited supply and there is a need for training of contractors, along with a contractor guidance and inspection component such as in the Energy Star Homes program. Also needed is a system or incentives for a party involved to have long-term responsibility for the energy performance, durability, health, and safety of buildings that undergo deep retrofits.

Uncertainty: The rate of adoption of deep retrofits by consumers, even with substantial utility incentives, is not known and could be lower than projected. Availability of sufficient funds, from utility budgets or other sources, could be a question if the rate of adoption is high.

New Policy

EXPANDING ENERGY EFFICIENCY PROGRAMS TO COMMERCIAL/ INDUSTRIAL HEATING OIL

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

Economy-wide GHG emissions reduced in 2020	0.1 million metric tons; 0.1%
MMBTU oil savings in 2020	230,000

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

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

Design issues: At present there may not be legal authorization for the electric utilities to provide funding to C/I customers in the same way that they do for residential customers. If this is the case then other funding sources will be needed, such as RGGI funds.

GHG impact: Assuming that C/I customers participate at the same rate, relative to their total use of heating oil, as do residential customers at present and as projected for the future, we estimate savings of 0.1 million metric tons of CO_2 in 2020.

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

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

Equity issues: Heating oil customers do not pay into a specific efficiency funding pool, as do electricity and natural gas customers. However, in almost all cases they are also electricity ratepayers, and as with residential customers, if there are highly cost-effective efficiency opportunities available for heating-related measures, it can be argued that this is a good use of utility-administered efficiency funds. If other funding sources are used, equity considerations will depend on the source.

Legal authority: Needs further investigation, depending on anticipated sources of funds.

Uncertainty: Measures to improve the efficiency of building shells, heating systems, and heating distribution systems are well known and there is extensive experience with them, so there is little risk of not being able to achieve cost-effective energy and GHG savings.

New Policy

DEVELOPING A MATURE MARKET FOR SOLAR THERMAL WATER AND SPACE HEATING

Policy summary: A policy framework will be established to achieve a mature and self-sustaining market for solar thermal water and space heating in both residential and commercial buildings. This support for the nascent solar thermal market is part of a broader goal of developing renewable heating technologies (such as clean biomass heating and efficient heat pumps), to facilitate a market transition to renewable fuels as the dominant fuels for heating purposes by 2050. The policy will also establish robust job and business growth in the renewable thermal sector in the Commonwealth.

Economy-wide GHG emissions reduced in 2020	0.1 million metric tons; 0.1%

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

Rationale: Hot water and space heating are large energy users that do not require very high-grade fuels (unlike motor vehicles for example). This makes them excellent candidates for active solar heating, which has no fuel expense and can provide significant heating from a small roof, wall or ground-mounted system. Unlike in the 1970's, the technology for active solar thermal heating is now mature and comes with decade-long warrantees to protect the up-front investment in a solar thermal system. However, the market for solar thermal in New England is currently very small, and needs "infant industry" support to accelerate its growth to the scale needed to maintain continued growth and provide a realistic option to interested customers.

Design issues: Similar to the Solar PV industry in MA prior to its recent exponential growth in the last four years, the small size of the solar thermal market burdens it with high levels of "soft" costs in sales and marketing (finding customers and designing and installing well-sized systems). This forms a barrier to consumer awareness and competitive pricing in comparison to the dominant market share of fossil fuel-based heating systems. The "hard" costs of quality equipment are being driven down by global market growth, and so once Massachusetts can develop a significant demand entrepreneurial companies will likely be able to bring turn-key pricing down considerably. Solar thermal systems require a back-up system in the event of a cold and cloudy week in winter, so most customers will retain their pre-existing fossil fuel heating system and new construction will likely move to on-demand electric or much smaller backup fossil fueled boilers .

GHG impact: For purposes of this Plan, a modest 0.1 million ton reduction in emissions due to solar thermal is forecast. However, larger reductions could be attained through a broader program applying to all renewable thermal technologies, including heat-pumps, biomass/biofuels, and solar thermal. If the displacement of 20 percent of the fuel oil used for thermal energy and 50 percent of propane heating and electric water heating could be attained, this would reduce GHG emissions in Massachusetts by approximately 2 million tons, or slightly more than 2 percent

of total 1990 emissions. This 2020 goal would be for all renewable thermal technologies, including heat-pumps, biomass/biofuels, and solar thermal applications. GHG emissions from biomass and biofuels used for thermal energy are important to consider, but Massachusetts policies will limit the eligibility of feedstocks (advanced biofuels and residue woody biomass) to those which demonstrate real and rapid GHG benefits, such as advanced biofuels and residue woody biomass

Other benefits: Expanding solar thermal energy will create and expand businesses in Massachusetts in a manner similar to our early stimulation of the solar PV market. For solar PV, the Commonwealth has added 1,800 new jobs since 2008 when the solar PV programs were launched. PV installations grew from 3 MW to 35 MW between 2007 and 2010, with another 35 MW in the development pipeline. Jobs will include system marketing, design, finance, installation and maintenance, along with manufacturing and fabrication of solar thermal panels and system components. In addition a mature solar thermal market complements the utility energy efficiency and advanced building energy codes policies. For existing homes in particular, there is a large stock of buildings that are heated with hot water, and where solar exposure is available these distribution systems can be easily retrofitted to provide space heating from renewable solar heated water with the fossil fuel systems retained as back-up systems.

Costs: In order to accelerate the market for solar thermal systems a highly publicized state rebate program analogous to the successful Commonwealth Solar program for PV is recommended. Due to the lower per system costs of solar thermal the MassCEC has proposed launching a pilot program to explore the most effective way to implement such a program. Any state rebate would leverage existing incentives primarily from Federal tax credits and the utility managed zero-interest HEAT loan program.

Equity issues: As with any upfront capital intensive investment, the early adopters of solar thermal systems are often relatively affluent homeowners, large well capitalized businesses, and the public sector, that have the resources to take advantage of the long term benefits of renewable heating both for their bottom-line and co-benefits. However, these early actors catalyze the market, provide useful exposure and marketing, and bring down costs, all of which makes these technologies increasingly accessible and desirable to the broader market. Among the early adopters of solar PV in Massachusetts was the public housing and affordable housing sector, with a notable role played by Boston Community Capital.

Experience in other states: Solar thermal subsidies to support the industry are relatively widespread and have grown in use in U.S. states including: New Hampshire, California, Delaware, Wisconsin, New Jersey, and Arizona. Total state incentives typically account for 25 percent to 50 percent of the system installed cost, but are expected to fall substantially over time. In particular, Arizona, Nevada, North Carolina and Washington D.C. have added solar thermal to the "solar carve-out" of their Renewable Portfolio Standard (RPS) programs, which are primarily designed to support electric renewable energy sources. Massachusetts would also have this option once a pilot rebate period runs its course.

Legal authority: In order to add an incentive for solar thermal to the Massachusetts RPS regulations, new legislation would be required. In the absence of this, the Clean Energy Center is able to provide rebate funding and other incentives to thermal renewables as part of their enabling mandate in the Green Communities Act of 2008.

Implementation issues: The perceived barriers to solar thermal adoption can be summarized in the following four areas:

1. Upfront cost of system
2. Lack of consumer education and confidence
3. Shortage of experienced solar hot water designers
4. Permitting costs and inspections

All of these can be addressed in a well designed pilot, followed by a broader program.

Uncertainty: Projections of the rate of adoption of solar thermal systems in response to a well designed solar thermal incentive program are highly uncertain. The precise rate at which rebates or other incentives would be taken up by the private market is also unknown. However, the lessons of the Commonwealth Solar Rebate program for PV and the experiences of other states are instructive. As with any alternative to fossil fuels, the volatility in the price of oil and to a lesser extent the price of natural gas over the coming decade is a critical uncertainty.

New Policy

TREE RETENTION AND PLANTING TO REDUCE HEATING AND COOLING LOADS

Policy summary: Trees help to reduce heating and cooling loads in buildings. This policy would provide incentives to plant new trees around existing housing, and retain trees within new housing developments, to conserve energy and reduce GHG emissions. This pilot program might be feasible within current utility efficiency programs, or might require new funding and/or regulatory authority.

Economy-wide GHG emissions reduced in 2020	100,000 metric tons in 2020, 300,000 tons in 2035 from trees planted by 2020

Clean energy economy impacts: On the order of 500 direct jobs per year from the scale of tree planting envisioned here, in nurseries, planting, and maintenance. Reduced energy costs and lower fuel imports.

Rationale: Strategically located around housing, trees can significantly reduce cooling and heating loads.[30] Retaining trees when new homes are built, and planting new ones around existing housing, can be a low-cost means of saving energy and reducing GHG emissions. Optimally trees should be located on the southeast and southwest sides of a building to provide shade and reduce air conditioning load. Evergreen trees planted on the north and northwest sides (given prevailing winds in Massachusetts) provide wind breaks and can reduce winter heating needs. Retaining and planting trees could be subsidized by the electric and gas utilities on the same basis that they provide incentives for other efficiency measures.

Design issues: For existing residential buildings, incentives could be provided to owners to plant new trees in the correct locations. For new housing development, incentives could be provided to developers to retain existing tree cover, and to particularly keep trees in the optimal locations for cooling and heating savings. Another option would be to provide incentives to municipal governments that pass local planning ordinances requiring developers to follow specific tree retention practices. Because trees generally take 15 years to reach their full shade potential, this policy would need to begin soon to have much impact by 2020. On the other hand, even if impacts by 2020 are small, they will rise after 2020 as trees mature, contributing to the 2050 GHG requirement.

[30] Studies of large scale tree-planting programs in New York, Chicago, and Philadelphia resulted in a 1.7C average reduction in maximum air temperature in the hottest areas. Chicago heat island reduction measures reduced annual cooling degree days by 39. "Energy Savings for Heat-Island Reduction Strategies in Chicago and Houston (including updates for Baton Rouge, Sacramento, and Salt Lake City*," S.* Konopacki and H. Akbari, 2002, Lawrence Berkeley National Laboratory LBNL-49638; "Shade trees reduce building energy use and CO2 emissions from power plants," H. Akbari, 2002, *Environmental Pollution* 116: S119-S126; "Energy conservation potential of urban tree planting," E.G. McPherson and R.A. Rountree, 1993, *Journal of Arboriculture* 19(6):321-331. Trees also reduce ambient air temperature through evapotranspiration. Per-tree calculation: a single white spruce with dbh 8inches is projected to save 1.1MBTU in heating energy for a single family home in Boston. (Casey Trees, based on the USFS iTree model). Toronto area heat energy savings: single family residences saved 3 percent (built pre-1980) and 2.5 percent (after 1980); efficient R-2000 houses 2 percent; row-houses 1.6 percent (built before 1980) and 1 percent (built after 1980) (Konopacki and Akbari, 2002).

GHG impact: About 100,000 metric tons CO_2e potential by 2020 under realistic assumptions of possible participation. Savings become much greater over time, rising to 300,000 tons in 2035 from the trees planted/retained by 2020, because most will not have reached their full growth until well past 2020. (Note that GHG savings from trees sequestering CO_2 are real but are not included here. Due to data problems, tree sequestration is not included in the 1990 baseline emissions estimate, nor are reductions or increases in sequestration in the years since then included. Without those numbers it is not valid to include sequestration gains due to a policy measure.)

Other benefits: Trees significantly improve the quality of life for immediate residents and the neighborhoods around them. This may have other secondary benefits which have not been quantified — such as higher real estate values, better-maintained homes, lower crime, etc.

Costs: Depending on the scale and scope of these programs, their costs could vary greatly. More than most efficiency programs, the benefits accrue over a long time period. Pilot programs between state agencies and utilities will allow for analysis of cost and benefits, as well as identifying implementation issues. One current estimate is on the order of $150 per tree for purchase and planting.

Equity issues: To fairly distribute benefits to urban and lower-income residents, it would be essential to ensure that the tree planting take place on a large scale in cities as well as around suburban homes, despite the likelihood of greater siting difficulties. As with the existing efficiency programs, this could be a particular challenge for rental housing, where landlords often lack the incentive to cut energy costs when tenants are paying the electricity and/or heating bills. Greater efforts would need to be made to achieve participation in rental properties.

Experience in other states: Utility-funded tree-planting programs are already in place in several cities and states. Sacramento, CA has avoided the cost of constructing a new 19 MW power plant by planting over 450,000 trees next to homes. With funding from the Sacramento Municipal Utility District (SMUD), the Sacramento Shade (for residences) and Neighbor Woods (for public spaces) Programs aim to plant 5 million trees by 2025. Residents are eligible for up to 10 free trees. SMUD estimates that each tree provides $90 in annual benefit.[31] In Iowa, the Municipal Tree Planting Program is a partnership between the non-profit Trees Forever and four utilities, in which the utilities provide funding for community planting programs.[32] Here in Massachusetts, Grow Boston Greener is a collaborative effort of the City of Boston and its partners in Boston's Urban Forest Coalition to increase the urban tree canopy cover in the city by planting 100,000 trees by 2020.

31 The partnership between the Sacramento Municipal Utility District and Sacramento Tree Foundation has been ongoing since 1990. http://www.smud.org/en/residential/trees/Pages/index.aspx or http://www.sactree.com/doc.aspx?25 . Riverside, California program: http://www.riversideca.gov/UTILITIES/resi-treepower.asp. Pasadena, Alameda, and a number of other California utility companies have similar programs. Initiatives to capture environmental savings from trees are also underway in more temperate climates. The Department of Public Services in Portland, Maine will deliver and plant trees that residents purchase at local nurseries. The "Treebate" program in Portland, Oregon offers residents a rebate on trees they purchase and plant (funded for water quality). Washington, DC residents can receive a $50 rebate for each eligible species of tree.

32 www.treesforever.org

Legal authority: PAs have the authority to conduct pilots and to expand these into new efficiency programs, based on approval of the Energy Efficiency Advisory Council and the DPU. Pilots will help determine whether and over what time period energy savings exceed costs. The results of such pilot programs will help determine the value and feasibility of tree planting and retention activities.

Implementation issues: This would be a pioneering program in the northeast, and so a variety of program approaches to achieving participation, planting trees effectively, and maintaining them could occur.

Uncertainty: We do not know the degree to which residents will be willing to participate, even with subsidies; nor the degree to which developers and landlords will participate; nor municipalities for a program design in which they require developers to retain trees.

Existing Policy

FEDERAL APPLIANCE AND PRODUCT STANDARDS

Policy summary: The federal government sets energy efficiency standards for appliances, electronics, and other products. Under President Obama, DOE has planned an accelerated schedule for setting new standards between 2009 and 2013. Nationwide these are expected to yield major savings in electricity (11.5 percent of total consumption in 2020), fuel, costs to homeowners and businesses, and carbon dioxide emissions, with Massachusetts getting its proportional share.[33]

Savings (above current trends)[34]

Economy-wide GHG emissions reduced 2020	0.5 million metric tons; 0.6%
Electricity saved — Gigawatt hours (GWh) 2020	1,040[35]
Natural gas, fuel oil saved — MMBtu	2.9 million
$ value energy savings in 2020	$330 million
Cumulative net benefits 2011-2020 (discounted)	$2.7 billion
Jobs gained 2020 (direct and indirect)	1,200 jobs

Clean energy economy impacts: Reduction of $330 million in costs in 2020 will improve cost of living for residents and reduce operating costs for businesses, also helping to keep jobs in the state.

Rationale: As with most efficiency measures, appliance and product efficiency faces market barriers that result in consumers making short-term purchasing decisions that don't reflect the optimal financial decisions long-term. To some degree this occurs because products, particularly appliances, are often bought on an emergency basis when the old item has failed. By mandating that products be built to specifications that will minimize their lifecycle costs, including both capital and energy costs, DOE can drive large savings.

Policy design and issues: The federal government sets nationwide standards, in some cases, due because climate conditions standards vary by region (such as with windows), but in other cases DOE has not made this distinction, as with heating system efficiencies. For this reason, Massachusetts applied for a federal waiver to set a standard for gas furnaces higher than the 80 percent federal standard, due to our colder climate. DOE denied Massachusetts' waiver request; although it has said that it is looking to develop a higher standard for the entire northern tier of the country.

[33] "Ka-BOOM! The Power of Appliance Standards. Opportunities for New Federal Appliance and Equipment Standards," American Council for an Energy-Efficient Economy and Appliance Standards Awareness Project, July 2009.

[34] Because federal standards have existed in the past and exist today, the state's consultants estimate that half the savings from forthcoming standards are already embedded in the "business as usual" trend lines; so only half the savings expected from the planned federal standards are included here. Also, the savings given here for 2020 include a portion of savings over the lifetime of products purchased by 2020, some of which occur after 2020.

[35] "State-Level Benefits from Potential Federal Appliance Standards," Appliance Standards Awareness Project, 2009.

GHG impact: ACEEE and the Appliance Standards Awareness Project (ASAP) forecast that the forthcoming standards will reduce GHG emissions by 1.0 million tons in 2020. The Commonwealth's consultants estimate that half of these reductions are already counted in the business-as-usual (BAU) trend for electricity emissions in 2020, and so 0.5 million tons are counted as a reduction versus the BAU.

Other benefits: The standards yield large savings in electricity and costs. In parallel with the GHG reductions, half of the savings are counted in the existing trends, so the incremental gains are estimated at 1,040 gigawatt hours of electricity and $200 million in 2020.

Costs: Incremental costs of production vary for each product, and are required to be less than the lifetime energy savings in each case in order for DOE to set a standard. Sample costs are $52 for a refrigerator, $50 for a clothes dryer, and $2 for microwave ovens. There have been reports of more frequent or more expensive repairs needed for some items, such as the computer boards for variable speed motors in refrigerators.

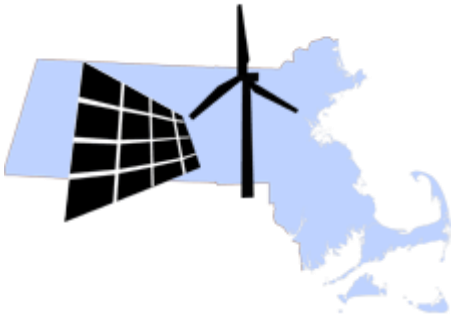
Equity issues: Not significant, due to low incremental cost of attaining higher efficiency standards.

Experience in other states: This is a nationwide program.

Legal authority: The federal government has preempted authority over efficiency standards for products; states can apply for waivers.

Implementation issues: None known.

Uncertainty: Energy savings per product are dependable due to mass production and quality standards. Durability of products can be an issue, and higher frequency of replacements would reduce energy savings due to the embodied energy in manufacturing of products.



Electricity Supply

The vast majority of existing power plants burn fossil fuels to generate electricity, producing millions of tons of pollution. Additional electricity generation technologies include nuclear, hydro, wind, solar, and eligible biomass, which vary in their emissions profiles. The character of the electric power sector as a whole is determined by three key factors: the demand for electricity across sectors, existing generation capacity by technology type, and actual generation, which depends on how much of each type of existing capacity is utilized to meet demand. There are several approaches related to each of these factors that can push the Commonwealth toward a clean energy future for electricity supply.

Demand for electricity can be reduced by improving the energy efficiency of our end-use devices, such as refrigerators and office equipment, as is discussed in the buildings section of this Plan. Both generating capacity and actual generation of clean energy technologies can be increased by a spectrum of activities based on the maturity of the technology.[36] Grants and other direct investments are best suited for research and development and early-stage companies or projects. A Renewable Energy Portfolio Standard can create market demand for all qualifying technologies, while specific requirements for particular technologies can target support for emerging technologies. By setting a price for carbon dioxide emissions from power plants by auction, the Regional Greenhouse Gas Initiative (RGGI) provides the power generating market with a transparent, stable, technology-neutral signal that influences both new investments and current operations. And implementation of Federal Clean Air Act rules encourages generators to retire or upgrade their dirtiest plants.

In order to achieve the GHG emission limit set by the Secretary, the *Massachusetts Clean Energy and Climate Plan for 2020* relies on progress in each of these areas made since 2007, along with proposed new measures to move toward a cleaner electricity supply.

Massachusetts Clean Energy Center

The Green Jobs Act of 2008 created the MassCEC to accelerate job growth and economic development in the state's clean energy industry. MassCEC serves as a clearinghouse and support center for the clean energy sector, making direct investments in new and existing technologies, clean energy companies, and workforce development to meet the skill needs of this growing industry.

In November 2009, an Act Relative to Clean Energy transferred the state's Renewable Energy Trust Fund to MassCEC. The Trust Fund was created in 1998 by the Legislature to provide financial assistance for development of renewable energy projects. With funds and programs to support clean energy development, entrepreneurship,

[36] A framework for effective clean electricity policies by technology/market maturity has been developed by the International Energy Agency. http://www.iea.org/Textbase/npsum/DeployRenew2008SUM.pdf

workforce development, and installation, MassCEC is a unique one-stop shop for growing a clean energy economy.

Renewable and Alternative Portfolio Standards

The RPS is used in more than 20 states and in other countries to create demand for renewable energy technologies such as wind, solar, biomass, and small hydro that are not yet price competitive with conventional power sources.[37] In Massachusetts, retail sellers of electricity are required to obtain a growing share of their supply from new renewable sources, thereby creating a demand for new projects. The eligible renewable resources are categorized into "classes" of similar maturity and type ("technology banding"). For example, wind, eligible biomass, anaerobic digestion, and small hydro are all in Class I while solar is carved out into a separate class. Beginning in 2003, the share of total electricity supply required to come from Class I resources increased one-half percent a year, reaching 4 percent in 2009. Starting in 2010, the required percentage increased by 1 percent a year, and will rise to 15 percent by 2020. There is also an Alternative Portfolio Standard (APS) for other clean energy technologies that don't involve renewables, such as combined heat & power (CHP).

In addition to requiring increasing amounts of renewables in the market, the Department of Energy Resources (DOER) has taken steps to assure that the kind of renewables that receive state incentives produce GHG savings over time. In 2009, DOER commissioned a study from the Manomet Center for Conservation Sciences to explore the lifecycle GHG implications of biomass energy plants. The results of the study, published in 2010, questioned long-held assumptions about the carbon-neutrality of biomass electricity technologies, and DOER is currently in the midst of finalizing RPS regulations to assure that biomass projects are only eligible for the RPS if they yield true and substantial GHG reductions.

The Green Communities Act of 2008 (GCA) also made several other changes to further drive investment in the renewable energy market enabled by the RPS. It requires that the electric distribution companies solicit bids for long-term contracts of 10 to 15 years from new renewable energy projects. Lack of such a long-term power purchase agreement is often a stumbling block for renewable energy projects to obtain financing. In addition, operators of *distributed* renewable electricity generation such as rooftop solar panels and community wind turbines are now eligible to sell excess electricity back into the grid at the price they pay (known as "net-metering"), effectively having their electric meters turn backwards. Finally, distribution utilities were granted authority to each build and own up to 50 megawatts (MW) of solar generation. There are 11 MW underway or completed thus far.

Regional Greenhouse Gas Initiative (RGGI)

Massachusetts is one of 10 states participating in the RGGI. The initiative, which began in January 2009, establishes a region-wide constraint on CO_2 emissions from fossil fuel-fired power plants. The current program design calls for the cap to remain at the initial level for six years (2009 to 2014), and then to decrease by 2.5 percent per year for the next four years, for a total reduction of 10 percent by 2018. RGGI provides a transparent and stable signal to the electricity market to plan future investments with an understanding that higher emitting generators will need a greater number of emissions allowances than

[37] Large hydro dams are considered a mature technology that requires no market support and are typically not included in Renewable Portfolio Standards.

cleaner generators. Proceeds from the auction of allowances have been effectively used to fund a range of energy efficiency programs in the state, resulting in cost savings for residential and business consumers.

Clean Energy Imports

Canada has substantial hydro-electric resources, which have very low emissions and are available at relatively low cost, but transmission lines that deliver this resource to southern New England are currently at full capacity. One effort to tap more of this resource is the Northern Pass transmission line being developed by NSTAR and Northeast Utilities, in partnership with Hydro Quebec (HQ) and with the support of the Patrick-Murray administration. When this power line is completed, at HQ's expense, it will bring to New England enough inexpensive clean power to serve up to 15 percent of Massachusetts' present electricity demand. Additional transmission lines may also be possible.

Federal Clean Air Act Implementation

The Supreme Court, in its 2007 decision *Massachusetts vs. Environmental Protection Agency,* ordered the EPA to regulate GHG under the Clean Air Act (CAA) as "pollution which may reasonably be anticipated to endanger public health and welfare." While the CAA is federal law covering the entire country, it is largely implemented by the states, which are often better suited to understand local industries and conditions. Implementation of the CAA will provide the dirtiest power plants the choice of making upgrades in control technology of those plants or retiring them.

Cleaner Energy Performance Standard

From 2005 to 2009, the electricity portfolio serving Massachusetts became more than 20 percent cleaner. This was largely the result of how much of the time each existing power plant was operated and which fuel they utilized, rather than investment in new capacity. The major changes were the nearly complete phase-out of fuel oil by 2007 because of high oil prices, a reduction in coal operation relative to natural gas since 2007 because of low natural gas prices, and a doubling of large hydro imports into New England from Canada. These developments demonstrate that the electricity sector even as it exists can operate more cleanly.

This Plan will provide a signal to electricity suppliers to maintain and improve upon these cleaner energy portfolios by proposing a Clean Energy Standard, which would require electricity suppliers to increasingly favor low-emissions and no-emissions sources in the mix of electricity delivered to their customers. This could be designed to favor in the long-term sources like wind, solar, and hydro, which emit no GHGs, but also initially favor cleaner fossil fuels like natural gas, to act as a bridge to a clean energy future.

Existing Policy

RENEWABLE AND ALTERNATIVE PORTFOLIO STANDARDS (RPS, APS)

Policy summary: The Massachusetts RPS was created as part of electricity restructuring in Massachusetts in 1997 and then expanded in the Green Communities Act of 2008[38]. The Portfolio Standards require retail electricity suppliers — both distribution companies and other retail suppliers — to buy a percentage of their portfolio of electricity sales from eligible resources, including renewable, certain highly efficient, and other eligible sources.

Economy-wide GHG emissions reduced 2020	1.1 million metric tons, 1.2%

Clean energy economy impacts: Over the period from 2010 to 2020, the Massachusetts RPS classes will stimulate $360 million in annual investment, or $3.9 billion in cumulative investment in clean power generation that would have not occurred on its own. This is expected to create approximately 900 full-time construction jobs throughout that period.

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

Policy design: The Massachusetts Portfolio Standards include "technology banding" in classes, with the Green Communities Act expanding the number of classes to the following: Class 1 — New Renewables; Class 1 — Solar Carve-Out; Class 2 — Existing Renewables; and the Alternative Portfolio Standard (APS), which covers several preferred electricity sources, including combined heat & power (CHP), flywheel energy storage, and gasification with permanent sequestration of carbon dioxide. Suppliers meet their commitments by buying Renewable and Alternative Energy Credits (RECs and AECs), the accounting mechanism for ensuring that every unit of eligible energy generated is counted exactly once in terms of state requirements. As a result of the Green Communities Act, the Portfolio Standards will require 15 percent of electricity supply to be from new Class 1 renewable resources, such as wind, solar, small hydro and eligible biomass and anaerobic digestion, by 2020. In total, RPS classes 1 and 2 and the APS will account for 27 percent of electricity supply in that year.

GHG impact: 1.1 million tons of emissions will be avoided in 2020, from the expansion of the RPS due to the Green Communities Act, not including the RPS requirements that existed prior to the Act. Savings from the APS, which are projected to come primarily from CHP, are included in "all cost effective energy efficiency" savings under that policy.

Other benefits: As with other electric sector policies, the Portfolio Standards result in reduced burning of fossil fuels and therefore reduced local air pollution and improved public health. For example, a study by the independent National Research Council found that coal use around the country resulted in 20,000 premature deaths annually.[39]

[38] DOER's annual RPS/APS report for 2009 has a more detailed summary and charts at: http://www.mass.gov/Eoeea/docs/doer/rps/rps+aps-2009annual-rpt.pdf

[39] Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use, National Research Council. www.nap.edu/catalog.php?record_id=12794

Cost: There is a great deal of uncertainty in cost estimates for the RPS, due to unknown future changes in fuel prices, federal policies, and technology. Just in the last three years REC prices have dropped by a factor of three. A more detailed electricity supply study is underway. Although some renewable power is relatively high-cost, the Standards also help to reduce electricity prices throughout New England, due to the mechanics of the regional electricity market. Power, like many other commodities, is bought and sold both under longer-term contracts and in a "spot" market. The spot market price is set by the most expensive supply needed to meet demand at a particular time. New clean energy resources that have low operating costs displace the most expensive supply needed to meet demand, thereby reducing prices for all spot market power and providing savings to all customers.

Experience in other states: Twenty-four states have some type of Portfolio Standard. Key features of successful programs are those which provide transparency, longevity, and certainty to the market. Repeated changes to the program design create concern in the market.

Legal authority: RPS authority derives from electricity restructuring statutes from the late 1990s as well as the Green Communities Act.

Implementation issues: The RPS (Class I) program compliance began in 2003. After several years in which eligible renewable generation fell short of requirements, and while project development continued to make progress, the program has successfully met its annual compliance obligation with new renewable energy since 2007. In 2009, the minimum standard of 5 percent was met, though an increasing portion of the generation is coming from imports from New York and adjacent Canadian provinces into the New England region.

Since the restructuring of energy markets in Massachusetts in 1997, supply contracts between the electric distribution companies and power generators have typically been for only three months to one year, far too short a period to allow financing of the high capital costs involved in developing renewable generating facilities. This has been a contributing factor in limiting supplies of RPS-eligible renewables in Massachusetts. To rectify this problem, the Green Communities Act required that the distribution companies solicit proposals from renewable energy developers and enter into cost-effective long-term contracts for at least a limited amount of renewable energy, in order to facilitate the financing of renewable energy generation. Such contracts can assist renewable energy developers in obtaining financing by providing assurance of revenues from sales of RECs and electricity over a number of years.

Uncertainty: Siting constraints both for generation nearby or for transmission to remote resources could constrain the renewable supply. In addition, restructured markets like New England may lack parties to enter into long-term power purchase agreements that are often required for financing of renewable energy projects, particularly at a time of low natural gas prices.

Existing Policy

REGIONAL GREENHOUSE GAS INITIATIVE (RGGI)

Policy summary: Massachusetts is one of the 10 Northeast and Mid-Atlantic states participating in a regional effort to limit carbon dioxide emissions from electric generating units in the region[40]. The program, which began in January 2009, establishes a region-wide cap on CO_2 emissions from fossil fuel-fired power plants in the region. The current program design calls for the cap to remain at the initial level for six years (2009 to 2014), and then to decrease at 2.5 percent per year for the next four years, for a total reduction of 10 percent by 2018.

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

Clean energy economy impacts: Over $120 million in auction proceeds has been invested in energy efficiency projects across the Commonwealth since 2009, creating jobs in the clean energy economy. In addition, the efficiency investments will reduce electricity and fuel costs for property owners, leaving them with savings to be invested elsewhere in the local economy.

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

Policy design: Recent trends in relative fuel prices, weather, investments in energy efficiency, and the downturn in the economy have resulted in actual total regional emissions much lower than anticipated. The RGGI states, along with broad stakeholder engagement, are currently in the process of a comprehensive program review which will include evaluation of program success, program impacts, additional reductions, imports and emission leakage, and offsets.

GHG impact: RGGI has a regional emissions cap, providing for a 10 percent reduction in CO_2 emissions across the 10-state region by 2018, and there is no specific limit on emissions deriving from the power plants in a particular state. Massachusetts' significant policies for electrical energy efficiency and renewable electricity are supported, in part, by proceeds from the RGGI auctions. Therefore, in this Massachusetts-specific analysis, emissions reductions are attributed to all of these programs in combination.

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

[40] The states participating in the RGGI are CT, DE, MA, MD, ME, NH, NJ, NY, RI, VT.

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

Experience in other states: Other states are in the process of developing and implementing similar programs. These efforts include the Western Climate Initiative and the Midwest Climate Accord.

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

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

New Policy

MORE STRINGENT EPA POWER PLANT RULES

Policy summary: The EPA is in the midst of proposing and implementing a variety of regulations that will affect the nation's power plant fleet, impacting their allowable water and air emissions. It is likely that the owners of some older, smaller power plants will find it is not economical to retrofit their plants to meet EPA's new regulations, and they will instead choose to shut down the plants. In Massachusetts, it is possible that two of the state's older coal-fired power plants will close. The Somerset Power Station in Somerset last ran in January 2010, and its permits will eventually expire if it is not restarted. The owner of the Salem Harbor Station in Salem has indicated that it expects the plant to close within five years.[41]

Economy-wide GHG emissions reduced 2020	1.2 million metric tons; 1.2%

Rationale: Power plant emissions have severe consequences for human health.

Policy design: Among the new rules being proposed by EPA are air emissions regulations addressing the transport of power plant pollution from one state to another (Clean Air Transport Rule, or CATR). Power plants contribute to high levels of ground-level ozone and fine particulates. These rules will require significant reductions in nitrogen oxides and sulfur dioxide emissions, which will tend to favor more efficient, cleaner power plants.

The Clean Air Act also requires EPA to propose air emission limits to control the release of mercury and other hazardous substances contained in power plant fuels (National Emission Standards for Hazardous Air Pollutants) and Maximum Available Control Technology standards). In addition, under Clean Water Act Section 316(b), cooling water intake structures may need to be redesigned to minimize the adverse environmental impact associated with the entrainment of fish, shellfish and their eggs and larvae by power plants drawing in large volumes of water to condense steam used in making electricity. Finally, Coal Combustion Residuals disposal regulations will ensure the safe disposal of coal ash.

Legal authority: EPA has the authority to issue new rules under the Clean Air and Clean Water Acts.

GHG impact: If these rules result in power from two older Massachusetts power plants being displaced by natural gas-fired power plants, there would be a net 1.2 million metric ton reduction in CO_2e in 2020.

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

[41] See http://www.boston.com/business/articles/2010/11/28/old_plant_begins_to_break_spell_over_salem_mass/

Expanded Policy

CLEAN ENERGY IMPORTS

Policy summary: Canada has substantial hydro-electric resources, which have very low emissions, and are available at relatively low cost and with no need for renewable energy subsidies (see Renewable Portfolio Standard, above). The amount of Canadian hydro has risen to 8.5 percent of New England's electric consumption, but transmission lines that deliver this resource to southern New England are at full capacity, preventing any additional Canadian hydro from getting to our market. One effort to tap more of this resource is the Northern Pass transmission line being developed by two Massachusetts utilities, NSTAR and Northeast Utilities, in partnership with Hydro Quebec (HQ) and with the support of the Patrick-Murray administration. When this power line is completed, at HQ's expense, it will bring to New England enough inexpensive clean power to serve up to 15 percent of Massachusetts' present electricity demand. Additional transmission lines may also be possible.

Clean energy economy impacts:[42] The project represents an infrastructure investment in the region by Hydro Quebec estimated at $1.1 billion. It will create hundreds of jobs related to clearing and site work, harvesting, construction and materials, including electrical, professional, and technical services. While the vast majority of these jobs will be in New Hampshire and Quebec, it is likely to have spillover effects in Massachusetts.

Economy-wide GHG emissions reduced in 2020	5.1 million metric tons, 5.4%

Rationale: Canadian hydro resources are extensive and have low operating costs. The transmission lines necessary to bring more Canadian hydropower to load centers in southern New England do not have to be financed by ratepayers apart from the price of delivered electricity, which will be sold in the competitive market.

Policy design: This policy involves working with the Massachusetts utilities to help overcome any hurdles.

GHG impact: The Northern Pass transmission line alone would provide 1,200 MW of clean electricity, enough to power nearly 1 million homes. This would result in up to 5 million tons of emissions reduction in the Commonwealth, depending on how much of the power is utilized in Massachusetts versus other states.

Other benefits: Like other electric sector policies, by incentivizing the reduced operation of fossil fuel plants, these additional low-emissions electricity imports would help reduce criteria and hazardous pollutants in the air (NOx, SO_2, mercury, and fine particulate matter). These reductions will have public health and environmental benefits. In addition, additional hydro imports will significantly improve the region's fuel diversity, improving energy security and price stability.

Cost: There are no additional costs to this effort to ratepayers or taxpayers. The power is expected to be sold in the market. In fact, as a "price-taker" in the market, it is possible that it would lower the wholesale electricity price and therefore reduce costs for business and residential

[42] www.northernpass.us/transmission_project_impact.pdf

consumers. According to Northeast Utilities, a comprehensive analysis by Charles River Associates (CRA) shows that, even with conservative assumptions, the Northern Pass line will reduce energy prices in the wholesale market, potentially saving New England customers $200 million to $300 million in annual energy costs.

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

Legal authority: DPU and DOER have already begun working with utilities and ISO-New England on increasing such imports.

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

New Policy

Clean Energy Performance Standard (CPS)

Policy summary: From 2005 to 2009, the electricity portfolio serving Massachusetts became nearly 20 percent cleaner. The major changes came from substitution of natural gas for coal and oil, doubling of imports of hydro power from Canada into New England, and the up-rating — or increasing of capacity — of existing nuclear plants regionally. This demonstrated that mature technologies have made a significant contribution to a cleaner electricity grid, without the federal or state incentives required for developing earlier stage technologies. They have an important role to play moving forward.

A market-based framework is needed to provide a clear signal to the electricity market to improve upon the cleaner energy portfolios of the last few years and to encourage projects such as the Northern Pass line (see "Clean Energy Imports" above). One approach to be considered is a Clean Energy Performance Standard (CPS), which applies an output-based performance standard to either portfolios of retail electricity sellers or to generators in terms of tons of pollution per megawatt-hour of electricity. As the performance standard becomes more stringent over time, the electricity market uses the least-cost mechanism for meeting it. The existing RPS fits neatly into this framework as a technology-specific means of meeting the standard.

Clean energy economy impacts: The CPS is a transparent and stable market-based framework that provides market certainty and enables investments to be made. It would encourage further replacement of power plant capital stock with cleaner technologies and cleaner fuels while disadvantaging dirtier power plants in the electricity marketplace.

Rationale: By being performance-based rather than technology-based, the CPS allows the market to find the least-cost approach to achieving a cleaner energy portfolio. In addition, it could empower electricity suppliers to manage their portfolios, akin to the CAFE standard for vehicles, offering cleaner products to interested customers to help meet their portfolio targets.

Policy design: Design issues include setting the targets; creating tracking mechanisms, particularly for system power; allowing tradability among suppliers, and minimizing "shuffling," in which generators shift cleaner power to Massachusetts and dirtier power to other states. Resolving these and other design issues would require substantial consultation with the electricity industry.

GHG impact: The potential GHG impacts are substantial; however, they are completely dependent on the targets set and include the impacts from both the RPS and the clean energy imports. Therefore no additional GHG reductions from this potential policy were included in the overall estimates.

Other benefits: Like other electric sector policies, by providing incentives for the reduced operation of the dirtiest plants and greater operation of cleaner ones, a CPS reduces criteria and hazardous pollutant emissions (NO_x, SO_2, mercury, and fine particulate matter). These reductions will have public health and environmental benefits.

Cost: In the near-term, a CPS is likely to have a limited impact on electricity prices for consumers. [43]

Experience in other states: Generator-level performance standards for new generators have recently been considered or implemented in several states and countries. However, portfolio-level performance standards for retail sellers of electricity or tradable performance standards for existing plants are less common, but have been analyzed recently. California has been working on a preferred loading order meant to encourage dispatch of lower emissions resources.

Legal authority: DOER and DPU will begin analysis of possible paths forward for creating a CPS, including regulatory or legislative avenues, as well as cost-benefit and implementation issues.

Uncertainty: The CPS ensures a cleaner energy portfolio over time. However, since it sets a limit on the carbon intensity of electricity generation, it does not constrain overall emissions. For example, if demand growth exceeded expectations, overall emissions would grow. Effective implementation of energy efficiency policies are a critical complement to mitigate this risk.

[43] Carolyn Fischer and Richard G. Newell, "Environmental and Technology Policies for Climate Mitigation". http://rff.org/rff/Documents/RFF-DP-04-05-REV.pdf

Transportation

Transportation is second only to buildings in responsibility for GHG emissions in the state, and is a fast-growing emissions sector. The vast majority of emissions come from cars and trucks, although air travel is a rapidly rising emissions source. There are several means of addressing transportation emissions, all of which Massachusetts has been pursuing — improving vehicle efficiency, moderating the growth in auto travel through providing alternatives to it, and promoting the development and use of vehicle fuels that yield lower GHG emissions than petroleum-based fuels. The *Massachusetts Clean Energy and Climate Plan for 2020* takes into account state and federal measures to improve vehicle efficiency, reduce vehicle miles traveled, and increase use of lower-carbon fuels, and proposes additional measures that will contribute toward meeting the 2020 limit.

Improving Vehicle Efficiency

Improving vehicle efficiency has been primarily a federal government responsibility, implemented through Corporate Average Fuel Economy (CAFE) standards first put forth in 1975 by the National Highway Traffic and Safety Administration (NHTSA). These standards had been stagnant for many years, but were raised in the 2007 federal Energy Independence and Security Act. Under President Obama, the standards were raised sharply in 2010, from 27.5 miles per gallon currently to 35.5 MPG (in 2016), and for the first time NHTSA and the Environmental Protection Agency (EPA) issued joint regulations that will control both fuel efficiency and GHG emissions from cars and light trucks.

During the period when federal CAFE standards were stagnant, the state of California passed its own law to regulate GHG emissions from light vehicles, under a longstanding waiver provision of the federal Clean Air Act. Massachusetts law requires adoption of California's standards if they are stricter than the federal ones, and the Commonwealth did so in December 2005. These standards apply to model year 2009 and newer vehicles. However, the federal government requires California to obtain a waiver of federal law in order to impose its own emission standards. In 2007 EPA denied California's waiver request, although it was later approved under President Obama.

In October 2010, NHTSA and EPA announced that they would propose regulations to require improved efficiency and lower GHG emissions from medium- and heavy-duty vehicles, including delivery trucks, buses and semi trucks (tractor trailers). These will also yield substantial GHG reductions in Massachusetts.

This Plan proposes a complementary measure to improve the overall efficiency of light-duty vehicles in Massachusetts: providing incentives to consumers to purchase more fuel-efficient vehicles. Such incentives would involve varying charges and/or rebates on vehicles according to their GHG emissions per mile (similar to fuel use per mile) — such as varying the sales tax on new cars, the annual vehicle excise tax, or registration fees. The variable charges could be designed to be revenue-neutral to consumers as a whole and to the state, with tax increases and decreases balancing each other.

Reducing Vehicle Miles Travelled (VMT)

Massachusetts has a number of programs to rein in the growth of driving, which is generally measured by vehicle miles traveled (VMT). Most of these programs have as their primary purposes improving mobility options for state residents by providing alternative methods of travel and reducing congestion on the roads, and reducing air pollutants that damage human health, such as nitrogen oxides, carbon monoxide, and particulates. Among these are support for public transit and for infrastructure that improves conditions for bicyclists and pedestrians. The state also operates programs that encourage ride-sharing among commuters, van pooling, and employer-based methods for reducing single-occupancy travel to work.

The amount of driving is greatly influenced by patterns of new housing and business development in the state. The more spread out development is, the more driving people must do to get to work and school, to shop and participate in other activities. Although decisions on development are primarily up to local governments and the private sector, the state has several policies designed to influence them. The state has issued *Sustainable Development Principles* to guide state agency programs, as well as investment in land and infrastructure. The principles call for encouraging building homes "near jobs, transit, and where services are available," and encourage the creation of pedestrian-friendly neighborhoods — practices known as "smart growth". Adherence to the principles is aided by the Commonwealth Capital program, under which about $600 million annually in grants and loans for municipalities is distributed in part on the basis of communities meeting sustainable development criteria.

The Massachusetts Department of Transportation (MassDOT) took a major step forward in June, 2010 with its "GreenDOT" policy directive, which commits MassDOT to "be a national leader in promoting sustainability in the transportation sector." Among the three primary goals of GreenDOT is reducing GHG emissions, in part through implementation of the Global Warming Solutions Act.[44] Critical to the specific efforts under GreenDOT is consideration of GHG impacts in statewide and regional transportation planning, and in the selection of particular projects that receive funding in the regional and statewide transportation plans.[45] GreenDOT also specifies several other efforts (to be discussed later in this Plan), such as enhanced support for alternative modes of transportation and promotion of "eco-driving" (fuel-saving auto maintenance and driving practices). GHG emissions from auto travel can also be reduced by enabling more efficient roadway operation through the use of intelligent transportation systems and mitigating "bottlenecks" that create local congestion, if such mitigation is designed so that it does not expand overall system capacity, facilitate increased auto travel, nor increase GHG emissions over time.

This Plan proposes several new policies to aid in the effort to limit miles traveled. First, an extension of policies to steer new development toward smart growth — through a new law designed to improve local zoning, provide assistance to communities to help them develop zoning policies, and require that state infrastructure funding

[44] MassDOT Policy Directive on GreenDOT, Jeffrey B. Mullan, Secretary of Transportation, June 2, 2010.

[45] Although Green DOT is now an "existing" state policy, it was released subsequent to completion of ERG's February 2010 report on the impacts of the state's current GHG reduction policies, and so was not included in those numerical estimates. Therefore in the present document the impacts of GreenDOT are treated as "new" policies.

decisions take into account impacts on GHG emissions.

Second, the Plan proposes that the state implement a pilot program of "Pay As You Drive" (PAYD) auto insurance, with the possibility of its expansion later. PAYD is an innovation that many studies have shown would significantly reduce miles driven,[46] by converting a fixed annual cost into a cost that varies by the amount of driving. In addition, average insurance costs across all drivers would fall, as less driving also means fewer accidents, and there would be significant reductions in traffic congestion, particularly in urban areas.

Reducing the Carbon Content of Vehicle Fuel

Emissions controls on cars have greatly cut emissions of health-damaging pollutants such as nitrogen dioxide. But such controls are unable to reduce carbon dioxide emissions from petroleum fuels, the primary GHG pollutant. As a result, to limit the GHG emissions from vehicle fuel, it is necessary to find alternatives to gasoline and petroleum-based diesel fuel, such as bio-diesel, ethanol, natural gas, and electricity.

In recent years, the actual GHG benefits of liquid biofuels made from food crops, such as corn-based ethanol and soy-based bio-diesel, have been questioned. When one examines the entire lifecycle of such fuels, including their impacts on food supplies and deforestation, it is unclear whether and to what degree GHG emissions are reduced compared to petroleum fuels. As a result, Massachusetts has concentrated its efforts on supporting non-food crop based or "advanced" biofuels, and has required that alternatives to petroleum demonstrate significant GHG benefits.

In 2008, Governor Patrick signed the Clean Energy Biofuels Act, which has several parts. First, it exempts non-food crop based, or cellulosic, biofuel from the state's gasoline tax. Second, it requires that initially 2 percent of the diesel fuel and home heating fuel sold in the state consist of bio-diesel, rising to 5 percent in 2013. However, the bio-diesel must be shown to yield a 50 percent reduction in GHG emissions compared to petroleum diesel. A lack of supply of such fuel, along with other obstacles to implementation, have caused the state to delay implementation of the content mandate. Third, the Act instructs the state to pursue development of a "low carbon fuel standard" (LCFS) on a regional basis throughout the Northeast. The LCFS concept originated in California, where the legal target is to reduce the average carbon content of motor fuel 10 percent by 2020. During the past two years Massachusetts has been leading an effort by the Northeast and Mid-Atlantic states to construct such a standard. A target for the Northeast/Mid-Atlantic LCFS has not been set.

In addition, two federal laws are designed to bring more alternative fuels into the market. First, Title II of the federal Energy Independence and Security Act of 2007 creates a "renewable fuel standard," which requires that such fuel used in the U.S. will rise from 4.7 billion gallons in 2007 to 36 billion gallons in 2022. Of that, "advanced biofuel" must rise from 0.6 billion gallons in 2009 to 21 billion gallons in 2022, and cellulosic biofuel must rise from 0.1 billion gallons in 2010 to 16 billion gallons in 2022. Renewable fuels must be produced from

[46] See, for example, "Pay-As-You-Drive Auto Insurance: A Simple Way to Reduce Driving-Related Harms and Increase Equity," Jason E. Bordoff and Pascal J. Noel, The Hamilton Project, The Brookings Institution, July, 2008; Pay-As-You-Drive Auto Insurance In Massachusetts: A Risk Assessment And Report On Consumer, Industry And Environmental Benefits, MIT Professor Joseph Ferreira, Jr. & Eric Minikel Commissioned by Conservation Law Foundation & Environmental Insurance Agency, November 2010.

renewable biomass, replace other transportation fuel, and achieve at least a 20 percent reduction in GHG emissions on a lifecycle basis for "new facilities." (Existing facilities, such as those producing corn-based ethanol, and their expansion are exempt from the GHG criterion.) Advanced biofuel excludes ethanol derived from corn starch, and must yield at least a 50 percent lifecycle reduction in GHG emissions, while cellulosic biofuel must achieve a 60 percent reduction.

Second, the federal Energy Improvement and Extension Act of 2008 provides a $2,500 tax credit for the first 250,000 light-duty plug-in hybrid electric vehicles sold until 2015, requiring that each must have a battery capacity of at least 4 kW. The tax credit rises with battery capacity to a maximum of $7,500.

This Plan relies primarily on development of a regional Low Carbon Fuel Standard, along with the federal policies described above, to obtain reductions in the average carbon content of vehicle fuels; which constitutes one of the three main methods of reducing GHG emissions from transportation.

Existing Policy

FEDERAL AND CALIFORNIA VEHICLE EFFICIENCY AND GHG STANDARDS

Policy Summary: The EPA and the National Highway Traffic Safety Administration (NHTSA) have set harmonized standards for light-duty vehicle MPG and GHG emissions for model year 2012 through 2016 vehicles. The standard is raised from 27.5 MPG at present to 35.5 MPG in 2016. California has harmonized its standards with the federal standards through 2016, but is expected to propose stricter standards for model year 2017 to 2020 vehicles, and Massachusetts law requires the Commonwealth to adopt the California standards. In combination, the EPA and California standards are forecast to yield a 17 percent reduction in GHG emissions in 2020 (primarily from lower gasoline consumption, but also with some reduced emissions from vehicle air conditioning systems).

Economy-wide GHG emissions reduced in 2020	2.4 million metric tons; 2.6%
Cumulative net benefits discounted, 2012-lifetime of vehicles (fuel savings and other social benefits, less increased vehicle costs)	$8.0 billion
Jobs gained in 2020 (direct and indirect)	6,200 jobs

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

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

Rationale: Federal fuel economy (CAFE) standards were first enacted in 1975 but have been relatively stagnant since the 1980s. Federal law raised them in 2007, but the Obama administration proposed an accelerated schedule through 2016. Improving the fuel economy of vehicles is one of the most effective tools to reduce energy consumption and GHG emissions.

Design issues: The federal regulations continue the practice of having different standards for cars and light trucks, although two-wheel drive SUVs will be reclassified as cars. EPA/NHTSA project the fraction of vehicles sold in the two categories; average MPG and fuel savings could be lower than expected if a higher proportion of light trucks are sold.

GHG impact: 2.4 million tons in 2020 for Massachusetts, based on EPA/NHTSA and California projections.

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

Costs: About $3.4 billion in additional vehicle costs through 2020, far outweighed by $11.4 billion in reduced fuel costs (all in net present value).

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

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

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

Implementation issues: None.

Uncertainty: See discussion under "design issues" concerning the distribution of sales between cars and light trucks.

New Policy

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

Policy summary: The EPA and the DOT have announced complementary programs to reduce GHG emissions and improve fuel efficiency, respectively, for medium- and heavy-duty vehicles, such as the largest pickup trucks and vans, combination tractors[47], and all types and size of work trucks and buses in between, for model years 2014-2018.

Economy-wide GHG emissions reduced in 2020	0.3 million metric tons; 0.3%
Motor fuel savings in 2020[48]	$140 million per year
Cumulative net benefits (discounted) 2011-lifetime of vehicles	$240 million
Jobs gained in 2020 (direct and indirect)	1,000 jobs

Clean energy economy impacts: Using commercially available technologies, a payback period of one to two years is estimated for the majority of vehicles. Vehicles with lower annual miles would have payback periods of four to five years. For example, an operator of a semi truck could pay for the technology upgrades in under a year, and have net savings up to $74,000 over the truck's useful life.[49] Large reductions in fuel use will improve air quality. Less spending on imported fuel will keep more money in the Massachusetts economy and thereby create jobs.

Rationale: Transportation is projected to account for close to 40 percent of total GHG emissions in Massachusetts in 2020, and medium- and heavy-duty vehicles are projected to account for 13 percent of transportation sector emissions. These vehicle standards will reduce fuel consumption and GHG emissions while providing regulatory certainty for manufacturers.

GHG impact: 0.34 percent of statewide GHG emissions in 2020, based on a reduction of 6.4 percent in emissions from medium- and heavy-duty vehicles.

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

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

[47] Also known as semi trucks that typically pull trailers.

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

[49] "EPA and NHTSA Propose First-Ever Program to Reduce Greenhouse Gas Emissions and Improve Fuel Efficiency of Medium- and Heavy-Duty Vehicles: Regulatory Announcement," Report No. EPA-420-F-10-901, October 2010.

Existing Policy

Federal Renewable Fuel Standard and Regional Low Carbon Fuel Standard

Policy summary: Title II of the federal Energy Independence and Security Act of 2007 creates a "renewable fuel standard," which requires that the volume of renewable fuels used in the U.S. will rise from 4.7 billion gallons in 2007 to 36 billion gallons in 2022. In a similar fashion, Massachusetts' biofuels law, passed in 2008, instructs the state to pursue development of a "low carbon fuel standard" (LCFS) on a regional basis throughout the Northeast. The LCFS (first developed by California) would require that the average carbon intensity of vehicle fuels fall by a specific percentage compared to petroleum fuels.

Economy-wide GHG emissions reduced in 2020	1.5 million metric tons; 1.6%

Clean energy economy impacts: To the degree that imported petroleum used in Massachusetts can be replaced by feedstocks such as solid waste, forest residues, and other cellulosic material, money that would otherwise go overseas is retained in the regional economy. If advanced fuels (including electricity powering plug-in hybrid and all-electric vehicles) eventually become less expensive than petroleum fuels, consumer costs are expected to fall. There are significant economic development opportunities in growing feedstocks, converting those into fuel, and in research and development. The report of the Massachusetts Advanced Biofuels Task Force forecast that the sector could employ 2,500 people in the state by 2025.

Rationale: The carbon intensity (or GHG emissions per unit of energy used) of fuel is one of the three main ways that emissions from motor vehicles can be reduced. In theory, if crops or other plants are used to produce fuel, the emissions from burning the fuel can be canceled out by the re-growth of plants on the same land absorbing equal amounts of carbon dioxide during its growth. Given the United States' large supply of land and agricultural produce, this is a logical method of reducing the use of petroleum. In addition, if electric vehicles become prominent, they would reduce the carbon intensity of fuels, since electric motors are far more efficient at powering motor vehicles than are gasoline engines.

Policy design and issues: Under the Federal RFS, supplies of "advanced biofuel" (including cellulosic) must rise from 0.6 billion gallons in 2009 to 21 billion gallons in 2022, and cellulosic biofuel by itself must rise to 16 billion gallons in 2022. Advanced biofuel excludes ethanol derived from corn starch, and must yield at least a 50 percent lifecycle reduction in GHG emissions, while cellulosic biofuel must achieve a 60 percent reduction. Renewable fuels that don't qualify as advanced can constitute up to 15 billion out of the 36 billion total gallons of fuel; they must still be produced from renewable biomass, replace other transportation fuel, and achieve at least a 20 percent reduction in GHG emissions on a lifecycle basis for "new facilities." Existing facilities, and expansion of such facilities, such as those producing corn-based ethanol, are exempt from the GHG criterion, leaving some question as to how much of the non-advanced fuel will actually meet the 20 percent criterion.

As required by the Biofuels Act, during the past two years Massachusetts has been leading an effort by the Northeast and Mid-Atlantic states to develop a Low Carbon Fuel Standard in the region. The LCFS concept originated in California, where regulations require a reduction in the

average carbon content of motor fuel of 10 percent by 2020. Targets and timelines for the Northeast/Mid-Atlantic LCFS are being developed. Unlike the RFS, the LCFS is a "technology neutral" standard — rather than requiring specific volumes of different fuels, it allows fuel suppliers to choose any motor fuel in any quantity — including petroleum, biofuels, natural gas, electricity, and other possibilities. First, the average carbon intensity of each fuel is determined. If the intensity of a particular fuel exceeds the annual target, then suppliers of this fuel have a "deficit" and must purchase credits from sellers of fuels that have a carbon intensity below the annual target.

A major issue for the RFS and the LCFS is calculating the carbon intensity of different fuels. This requires examining the entire lifecycle of a fuel, including, for example, how electricity is generated and how crops are grown — calculations that are difficult to do with any degree of precision. Important numerically, and controversial, are the carbon impacts from what is known as "indirect land use change" (ILUC). When large amounts of food crops are used for fuel (corn for ethanol, soybeans or rapeseed for biodiesel), this may cause the need for more food production. Forests may be cut down to expand the amount of land on which crops can be grown, causing reductions in the CO_2 sequestered by trees and soil. The US EPA and the California Air Resources Board (CARB), along with the European Union and specific European countries, are currently calculating ILUC for each fuel, but each source has published different numbers. The Northeast and Mid-Atlantic states are examining which methodologies and figures are best to use, and these choices substantially affect how much "credit" each fuel would receive under the LCFS.

There are a number of other design issues involved in constructing a regional LCFS for the 11 states currently involved, and an interstate group of agency staff, along with an interstate agency — the Northeast States for Coordinated Air Use Management (NESCAUM) — have been addressing design issues for the past two years.

GHG impact: For purposes of this Plan, the LCFS is estimated conservatively to achieve a 5 percent reduction in the average carbon content of vehicle fuel by 2020, with greater reductions in following years. The LCFS is more specifically focused on GHG reductions than the federal RFS. Without the LCFS, the RFS by itself might yield about a 3 percent reduction, depending on what reductions are actually achieved from corn-based ethanol produced throughout the U.S.

Other benefits: Possible reductions in other air pollutants, depending on which fuels are used in place of petroleum.

Costs: NESCAUM is working on a regional economic analysis which will be available in early 2011. This analysis will include estimates of cost and benefits to the region and to each state.

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

Experience in other states: California has adopted regulations for implementation of its LCFS, which goes into effect in 2011.

Legal authority: Massachusetts' biofuels law gives the state the authority to implement the LCFS. In other participating states, new regulations or legislation will be necessary, or both.

Implementation issues: As with any interstate policy, achieving agreement on how to implement a uniform policy among a number of states presents many complexities. The

interstate effort currently underway, led by Massachusetts and NESCAUM, is addressing these. For example, distribution infrastructure for new fuels and vehicles may be needed. This would require large capital investments (e.g., liquid fuel distribution for biofuels, charging stations for electricity, etc.) and it is unclear whether the incentive system created by the LCFS will be sufficient to draw out that investment. Nor is it clear whether the auto manufacturers will develop the vehicles needed to utilize the fuel, particularly in the case of plug-in hybrid and all-electric vehicles. Complementary policies may be necessary for all parts of the system to be developed in tandem.

Uncertainty: As a technology-neutral policy, the LCFS is not picking between the several possibilities for alternatives to petroleum, and it is uncertain at this time which ones will succeed best in terms of eventual cost, and what that cost will be.

New Policy

CLEAN CAR CONSUMER INCENTIVES

Policy summary: There are various means by which the Commonwealth could provide incentives for consumers to shift their vehicle purchases to more fuel-efficient (or lower GHG) models. This includes varying the rates on new car sales taxes, annual auto excise (property) taxes, and registration fees, with rates raised on low-MPG vehicles and reduced on high-MPG ones. The change could be designed to be revenue-neutral to consumers as a whole and to the state.

Economy-wide GHG emissions reduced in 2020	0.2 - 0.4 million metric tons; 0.2% - 0.5%
Motor fuel savings (at $3.34/gallon[50]) in 2020	$110 - $230 million
Cumulative net benefits (discounted) 2011-2020 for higher end of annual benefits	$570 million
Jobs gained in 2020 (direct and indirect)	1,700 jobs

Clean energy economy impacts: Large reductions in fuel costs for consumers, and less spending on imported fuel, which keeps more money in the Massachusetts economy and thereby creates jobs. For a tax or fee that varies with CO_2 but is still a percentage of vehicle price or value, and is revenue neutral to the state, costs would fall for a majority of auto buyers or owners (possibly around 60 percent), because the most expensive vehicles also tend to get the worst MPG and these would bring in much greater revenues.

Rationale: Transportation is expected to account for close to 40 percent of total GHG emissions in Massachusetts in 2020, and light vehicles by themselves (cars, SUVs, minivans, pickups) around 28 percent of the total. The efficiency of the vehicles themselves is probably the easiest factor to influence among the several that determine vehicle emissions (the others being miles traveled and carbon content of the fuel). Although the federal government preempts authority over setting efficiency standards for automakers, the state does have the ability to influence consumer choice through tax and fee policies. Given the state's budget realities, a policy that combines incentives and disincentives can be accomplished without a loss of tax revenue.

Design issues: The simplest design, which has been proposed in California and Europe, is a charge measured in cents per gram of carbon per mile driven, or cents per gallon per mile driven, varying linearly from a minimum to a maximum rate. This would provide the strongest incentive, but would not be tied to the price of the vehicle. A tax or fee that varied by carbon emissions but was a percentage of vehicle sales price or current value (for vehicle property taxes or registration fees) would concentrate the impact on buyers of more expensive vehicles, but would provide a weaker incentive to buy fuel-efficient vehicles.

In addition, there could be rate variations designed to assist particular groups of drivers, such as those with large families who need vehicles with seating capacity for six or more, or contractors who need trucks for their businesses.

The tax or fee design could be revenue-neutral to the state and to consumers as a whole, with reductions and increases in payments balancing out. The sales tax on motor vehicles in

[50] EIA forecast for 2020, in constant 2009 dollars.

Massachusetts is currently 6.25 percent, as for all non-exempt products. Preliminary modeling by the state, with the rates varying from 0 percent to twice the current sales tax rate, found that expensive, low-MPG vehicles would yield a large tax revenue increase. In order to maintain revenue neutrality, the entire tax schedule would shift down, with the most efficient vehicles (hybrids) having a negative rate (receiving a rebate) while the top rate would be significantly below 12.5 percent.

GHG impact: For a variable sales tax, the impact would vary from around 0.2 million to 0.4 million metric tons, due to an improvement of 1 percent to 2 percent in average vehicle fuel efficiency, as estimated by Cambridge Systematics, Inc. For a change to vehicle excise taxes or registration fees, the dollar amounts are lower and the impact would be lower. In the table above, the larger impact is from a straight fee on CO_2 emitted per mile driven, that replaces the current sales tax, as has been proposed by California. The smaller impact is from a fee that varies according to CO_2 emissions but is a percentage of vehicle purchase price.

Other benefits: Fewer large, heavy vehicles on the road will reduce injury and death rates from accidents. Reduced fuel usage will cut emissions of other air pollutants that cause human health damage.

Costs: Minimal costs to administer. The state would devise tax or fee rate schedules and provide these to auto dealers or the Registry of Motor Vehicles (RMV). Dealers already handle the sales tax through an electronic connection to the RMV.

Equity issues: Lower-income households tend to buy used cars, whose sales tax rates will not change under this proposal. For new vehicles, size, weight and gas consumption are highly correlated with purchase price, so the tax increases will tend to be felt by higher-income purchasers, with buyers of smaller, cheaper cars seeing decreases in their sales taxes. Beyond the initial purchase price, virtually all drivers whose vehicle choice is modified by the incentive mechanism will see substantial savings in gasoline costs over time.

Experience in other states: California has proposed a version of the sliding-scale sales tax, with the tax varying directly with CO_2 emissions, in their climate planning process, and legislation is pending.

Legal authority: Legislation is required to change the tax rates. In some cases, fees such as registration fees can be changed by agencies without new legislation. EEA and MassDOT will conduct a study to examine critical implementation challenges and possible regulatory or legislative paths forward.

Implementation issues: Changes will be needed to the RMV's computer systems. In order to maintain revenue neutrality, it will probably be necessary to adjust fees, rebates or tax rates over time.

Uncertainty: The degree of consumer response to changes in taxes or fees is not precisely known, so the gains in reduced emissions and the exact tax revenues will only be seen with experience.

New Policy

PAY AS YOU DRIVE (PAYD) AUTO INSURANCE PILOT

Policy Summary: PAYD would convert a large fixed annual premium into a variable cost based on miles traveled, creating a major incentive to reduce discretionary driving, while cutting the overall cost of insurance due to fewer accidents. Miles driven would fall substantially, along with CO_2 emissions and costs for gasoline, accidents, and congestion. The Commonwealth plans to conduct a PAYD pilot program initially, and, depending on results, consider working with the insurance industry to make this payment method more widely available in future years. Benefits from PAYD would depend on its degree of adoption by insurance companies and consumers.

Benefits from full-scale PAYD implementation

Economy-wide GHG emissions reduced	0.4 - 2.0 million metric tons; 0.4% - 2.1%
Motor fuel savings (at $3.34/gallon) in 2020	$160 - $830 million
Accident savings (medical costs, property damage, etc.) and reductions in insurance premiums in 2020	$160 - $800 million
Congestion savings (reduction in lost time) in 2020	$50 - $250 million
Total $ savings 2020	$370 - $1,880 million
$ savings per person in the state 2020	$60 - $290
Cumulative net benefits discounted 2011-2020 (for middle option)	$5.3 billion
Jobs gained in 2020 (middle policy option, direct and indirect)	2,500 jobs

Note: The lower end of the benefits range is for a voluntary system, higher end is for a mandatory system with the entire insurance charge on a per-mile basis. A middle option, with a mandatory system that has a flat charge for the first 2,000 miles and a per-mile charge beyond that, would yield about 1.0 million tons GHG reduction in 2020, from a 5 percent reduction in vehicle miles traveled.

Clean energy economy impacts: For a reduction of 5 percent in VMT (middle policy option), motor fuel spending would fall by $440 million at 2020 projected gas prices. Less spending on imported fuel will keep more money in the Massachusetts economy and thereby create jobs. A Brookings Institution study estimated that rates would fall for two-thirds of drivers, while rising for one-third. Benefits would accrue particularly to lower-income drivers, who need a vehicle for employment but can save money by controlling non-essential driving. Less congestion will improve quality of life.

Rationale: Transportation is expected to account for close to 40 percent of total GHG emissions in Massachusetts in 2020, and light vehicles by themselves (cars, SUVs, minivans, pickups) around 28 percent of the total. One way to reduce emissions is by reducing VMT. At present, insurance premiums do not vary by VMT (though there is precedent in current discounts for low usage, such as 5,000 miles/year) and so they have little impact on people's driving habits. If insurance were converted into a per-mile charge it would give drivers a new incentive to limit their driving when they can.

Design issues: Design of the program would depend upon the results of the pilot program. It is expected that the per-mile rate would not be uniform, but rather would vary by the traditional rating factors, including location and driver experience. Thus, miles driven would only be one

factor determining rates. For example, an inexperienced driver living in Boston would likely pay a per mile rate substantially higher than that of an experienced driver living in western Massachusetts. Because insurance companies set their rates by accident costs within a geographic area, PAYD would not favor urban residents over suburban or rural ones. PAYD would be "revenue neutral" within an area, favoring low-mileage drivers over high-mileage ones.

GHG impact: 0.4 percent to 2.1 percent of statewide GHG emissions in 2020, based on a reduction of 2 percent (for a voluntary system) to 9.5 percent (for a mandatory system with charges entirely by the mile) in vehicle miles traveled.[51] A nationwide study by the Brookings Institution found that PAYD insurance would reduce VMT by 8 percent.

Other benefits: Accidents, and the associated injuries, deaths, and monetary costs, would fall greatly, particularly in congested areas. In the middle policy option, there would be an estimated reduction in crashes of 11,000, 7,000 fewer injuries, and 36 fewer fatalities, yielding $420 million in total benefits, part of which would accrue to drivers in lower insurance rates. Congestion, and the lost time and money that result, would also fall significantly, particularly in urban areas, according to Cambridge Systematics. There would also be reductions in other air pollutants from motor vehicles, which will have health benefits.

Costs: On average, insurance costs would fall across all drivers. Costs would vary by driver, rising for high-mileage drivers who are unable to modify their driving habits. If mileage is monitored through annual safety inspections, as is done at present, there would be little additional cost for either drivers or the state. VMT could also be monitored through telematic devices in cars, which currently cost $100 to $200 per unit. These costs will probably fall as the devices become more common, and wouldn't be needed for vehicles that already have GPS systems. A gradual transition could be made by requiring the devices for new cars, but allowing use of the safety inspection data for older cars.

Equity issues: The study by MIT Professor Joseph Ferreira for Massachusetts finds that accident costs are related to miles driven, and therefore having insurance rates tied to VMT improves fairness among drivers. Initially rates would increase for approximately one-third of drivers, but ultimately rates should decline for a higher fraction of all drivers due to reduced accident costs. Relative rates for different population groups — inexperienced drivers, adults, and senior citizens — would not change significantly, nor would relative rates between different areas of the state.

The most recent data available on vehicle miles traveled by income level is for 2001, and only at the national level.[52] It shows that on average middle-income families drive about three-fourths as much as high-income families, and that low-income families drive about half as much as high-income ones. A Brookings Institution study found that, nationwide, lower-income households would generally save money due to PAYD while higher-income households would, on average, pay more, as shown in Figure 7.[53]

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[51] *Pay-As-You-Drive Auto Insurance In Massachusetts: A Risk Assessment And Report On Consumer, Industry And Environmental Benefits,* Joseph Ferreira, Jr. and Eric Minikel, Conservation Law Foundation, 2010; estimate by Cambridge Systematics for voluntary system.

[52] Table A2, U.S. Per Household Vehicle-Miles Traveled, Vehicle Fuel Consumption and Expenditures, 2001," EIA.

[53] Jason E. Bordoff and Pascal J. Noel *Pay-As-You-Drive Auto Insurance: A Simple Way to Reduce Driving-Related Harms and Increase Equity,* The Brookings Institution, July 2008.

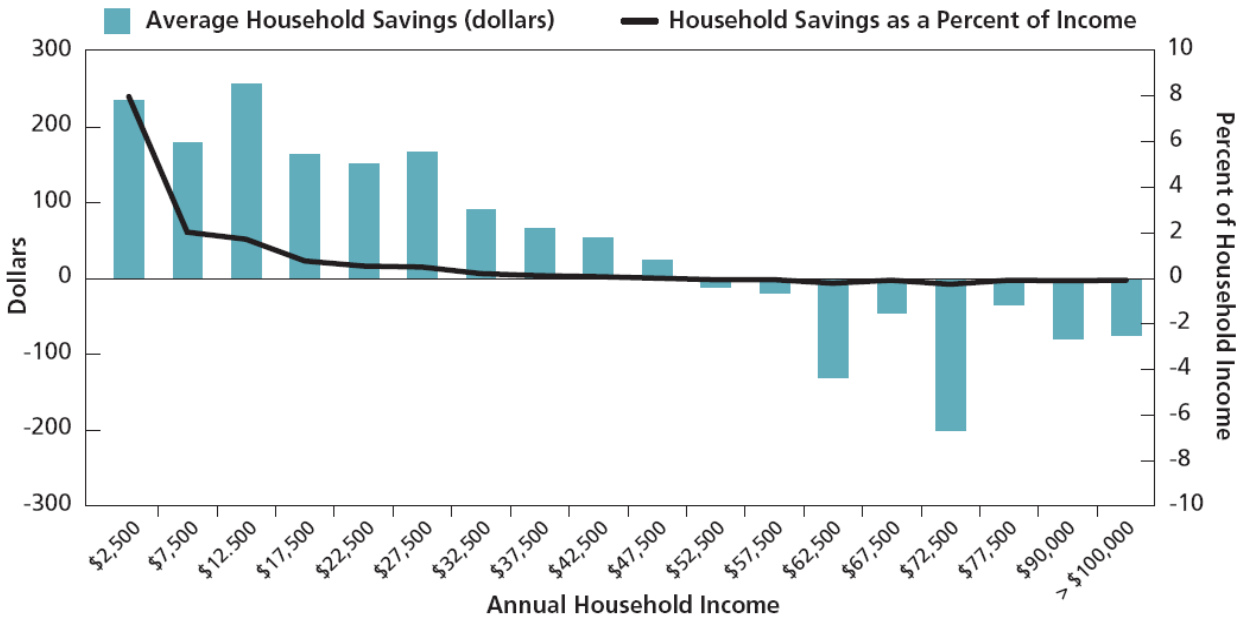

Figure 7. Estimated Household Savings from PAYD, by Annual Household Income (*source: Bordoff and Noel)*

Experience in other states: PAYD does not exist as a mandatory system anywhere in the U. S., but several insurance companies have pilot programs, including Progressive Insurance and GMAC. Pilots are also taking place in the United Kingdom. Several states are attempting to encourage PAYD, including Texas, California, and Oregon. The Federal Highway Administration is making available about $10 million for PAYD pilots in the next fiscal year. Fourteen states have PAYD in their climate action plans. Maryland forecasts that PAYD has the potential to reduce GHG emissions there by 1 million tons in 2015 and 4.3 million tons in 2020.[54]

Legal authority: The state's Division of Insurance has authority over auto insurance rates. At present the Division can allow companies to offer PAYD but cannot require them to do so. Legislation would be needed to require companies to provide PAYD as an option, or to require them to put all policies on a per mile basis.

Implementation issues: If the state does not require insurance companies to offer PAYD, insurance companies are unlikely to do so, as has been the case in other states. If the policy is optional for drivers, only a fraction may choose it, greatly reducing the impacts on GHG emissions and savings for drivers. Monitoring VMT through annual inspections carries the risk of errors, and will significantly reduce the incentive mechanism, by giving drivers feedback only once per year. Use of a telematic device that can be used to bill drivers monthly for their insurance would be more effective in influencing driver behavior. Information on costs could also be provided on a real-time basis through an on-board device or through a web site look-up. Some drivers might have privacy concerns about their driving being monitored telematically, even if the information is limited to VMT. In addition, the Brookings study argues that the cost of the telematic devices exceeds the benefits to the companies, so that incentives may be needed in order to achieve the social benefits of lower pollution, accidents, and congestion.

Uncertainty: Projections of the impact of PAYD on driving may not be correct, with actual VMT reductions lower than expected. In addition, administrative costs could be higher than expected.

[54] Center for Climate Strategies, www.climatestrategies.us/, 11/12/10.

Existing Policy

SUSTAINABLE DEVELOPMENT PRINCIPLES

Policy summary: In 2007, the Patrick-Murray Administration updated the Massachusetts *Sustainable Development Principles* to guide creation and implementation of state agency policies and programs, as well as investments in land and infrastructure. Municipalities, through policies like Commonwealth Capital, are also encouraged to modify their planning, regulatory, and funding actions to achieve consistency with the principles. The principles include promoting clean energy, in the form of energy efficiency and renewable power generation, in order to reduce GHG emissions and consumption of fossil fuels. They also encourage reductions in vehicle miles traveled (VMT) through actions such as the creation of "pedestrian-friendly" districts and neighborhoods that mix commercial, civic, cultural, educational, and recreational activities with parks and homes. In regard to housing, the principles call for building homes "near jobs, transit, and available services."

State investments, particularly those in infrastructure, have an important influence on where and how growth occurs. The principles are intended to guide policies, programs, and expenditures, particularly those that affect where and how development occurs. Making state investments consistent with the principles increases the amount of growth that takes place in locations and densities that reduce VMT and GHG emissions and have other clean energy benefits.

Economy-wide GHG emissions reduced in 2020 (in conjunction with Commonwealth Capital and MEPA)	0.1 million metric tons; 0.1%

Clean energy economy impacts: *Sustainable Development Principle* #9 — Promote Clean Energy — explicitly encourages clean energy practices, aiding development of clean energy jobs and reduced energy costs. Also, *Sustainable Development Principle* #1 — Concentrate Development and Mix Use, along with *Sustainable Development Principle* #7 — Provide Transportation Choice, can enable significant transportation cost reductions for residents and business due to reduced vehicle ownership and fuel consumption. Finally, Principle #1 will help to increase building efficiency and make district energy and combined heat and power more feasible.

Rationale: The principles provide a value statement and basic guide that state and municipal employees, business interests, land owners, developers, conservation groups, and others can turn to when making choices about their actions and investments. State policies, such as Commonwealth Capital, have the principles as their foundation. These policies expand upon the principles and provide an incentive to implement them.

Policy design: Readily implemented, since legislation is not required and regulatory changes would be minimal. However, improving the consistency of a large number of programs with the principles will require Executive leadership, perseverance, and a willingness to overcome obstacles.

One example of a state program that has utilized the *Sustainable Development Principles* is the Commonwealth Capital Program. More than $600 million in grants and low interest loans are awarded annually based in part on Commonwealth Capital scoring. Municipal smart growth/smart energy consistency is assessed through a Commonwealth Capital application. Resulting scores are

part of the proposal evaluation process for each grant or loan program. The more smart growth/smart energy oriented a community is, the more likely it is to receive funding. Since 2005, 315 out of 351 of the Commonwealth's communities have applied at least once and hundreds of new plans and regulations have improved municipal consistency with the *Sustainable Development Principles* by 10 percent (the median score has risen from 63 to 76 out of a possible 140).[55]

GHG impact: Existing smart growth policies, including the *Sustainable Development Principles*, are estimated to reduce GHG emissions by 0.1 percent in 2020. Recent studies[3] have shown integrated land use strategies can produce GHG reductions of between 2.7 percent and 4.4 percent from the baseline by 2050 depending on how aggressively the Commonwealth implements smart growth policies and practices.

Other benefits: Development consistent with the principles would lower operational and capital costs to government and society, improve energy conservation, better protect natural resources, increase housing and transportation choice, lower housing and transportation costs, improve public health, and enhance social and environmental justice.

Costs: There are predicted to be no incremental costs, as this policy simply requires more consistent decision making, particularly regarding the investment of current state resources in growth inducing infrastructure.

Equity issues: Smart growth increases affordability by reducing housing and transportation costs. It enhances access to jobs and services for those who can't/don't drive and provides a higher percentage of new jobs in urban areas where unemployment tends to be highest. Those who want to build commercial/industrial projects or live in homes in places and patterns that are inconsistent with the principles may pay more as these projects will no longer receive a state subsidy.

Experience in other states: Many states have successfully used sustainable development or smart growth principles to guide policies, programs, and investments.

Legal authority: See Smart Growth Package for possible expanded scope of funding subject to principles, either via an Executive Order or codification in legislation.

Implementation issues: Consistency of state policies, programs, and expenditures with the principles is not universal, and consistency is not always a prominent consideration in the decision making process.

Uncertainty: Calculating VMT and GHG benefits requires assumptions about how state policies, programs, and particularly spending will change to conform to the principles, as well as how dependent upon, or influenced by, state investments development is. Also, it is hard to predict how communities and developers will respond to incentives and other policies that encourage them to embrace the *Sustainable Development Principles*.

[55] See www.mass.gov/commcap for more information, including detailed analyses of past results and the 2011 application.

New Policy

GREENDOT

Policy summary: GreenDOT is the Massachusetts Department of Transportation's sustainability initiative, announced through a Policy Directive in June 2010 by the Secretary of Transportation. The Commonwealth's consultants, Cambridge Systematics, Inc., estimated that, if fully implemented, GreenDOT could achieve 2.1 million tons of GHG reductions in 2020 and the Secretary's Directive adopts this level as its target.

GreenDOT is intended to fulfill the requirements of several state laws, regulations, Executive Orders, and MassDOT policies, including the Global Warming Solutions Act, the Green Communities Act, the Healthy Transportation Compact, and the "Leading by Example" Executive Order Number 484 by Governor Patrick. MassDOT will work closely with MassDEP and the Advisory Group in determining the best regulatory and guidance framework for achieving the goals set forth in the Policy. GreenDOT is focused on three related goals: reduce GHG emissions; promote the healthy transportation modes of walking, bicycling, and public transit; and support for smart growth development.

GreenDOT encompasses a number of different program areas, which are described briefly below: statewide and regional long-range transportation planning, transportation project prioritization and selection, "complete streets" design guidelines, rail transportation, bicycle and pedestrian transportation, promotion of eco-driving, sustainable design and construction, system operations, facilities management, and travel demand management.

Transportation long-range planning and project prioritization and selection: Long-range planning documents, including statewide planning documents (e.g. the Strategic Plan, State Freight Plan, and MassDOT Capital Investment Plan), as well as the long-range Regional Transportation Plans from the Metropolitan Planning Organizations (MPO), must address MassDOT's three sustainability goals and plan for reducing GHG emissions over time. Similarly, the shorter-range regional and state Transportation Improvement Programs (TIPs and STIP), under which particular projects are chosen for funding in the coming four years, must be consistent with the Commonwealth's GHG reduction target. This will require that the MPOs and MassDOT balance highway system expansion projects with other projects that support smart growth development and promote public transit, walking and bicycling. In addition, the project programming mix included in the RTPs, TIPs and STIP can contribute to GHG reduction through prioritizing roadway projects that enable improved system operational efficiency, without expanding overall roadway system capacity.

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

Project design and construction: The MassDOT Highway Division Project Development and Design Guide requires that all projects must adhere to a "complete streets" design approach, meaning that new and redesigned roads must provide appropriate accommodation for all users,

including pedestrians, bicyclists, and public transit riders. These modes of transportation will also be promoted by several other means. These include taking steps to see that more projects move forward through the Transportation Enhancements Program, extending the Bay State Greenway, improving accommodations for bicycles and pedestrians on bridges, and improving bicycle parking facilities at MBTA stations.

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

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

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

Eco-driving: Fuel efficiency can be improved greatly by maintaining vehicles properly, driving within the speed limit, and accelerating more gently. The EPA estimates that "smart driving" can improve fuel efficiency by up to 33 percent, and EcoDriving USA estimates that Massachusetts' drivers, with 5.4 million registered autos, could save about 4 million tons of CO_2 emissions annually if eco-driving practices were followed. MassDOT will promote eco-driving through: internal education for staff and contractors; external education of all Commonwealth drivers through website content, RMV manual and testing content, signage, and brochures; and development of a plan to improve tire inflation infrastructure.

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

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

Expanded Policy

SMART GROWTH POLICY PACKAGE

Policy summary: Development patterns significantly influence vehicle miles traveled (VMT), which could be substantially reduced by additional "smart growth" that makes it easier for households and businesses to decrease the number and distance of vehicle trips. Diffuse single use development accessed by car results in 30 percent[56] more VMT than compact mixed-use growth. Massachusetts already has several policies promoting smart growth, but new, complementary policies are necessary to achieve our smart growth targets. Such policies would focus on influencing infrastructure investments by state agencies and planning decisions made by local governments.

Economy-wide GHG emissions reduced in 2020	0.4 million metric tons; 0.4%
Motor fuel cost savings in 2020	$190 million
Jobs gained in 2020 (direct and indirect)	1,100 jobs

Clean energy economy impacts: Large transportation cost reductions can be expected for residents and business due to reduced vehicle ownership and fuel consumption. High density mixed-used development will increase building efficiency and make district energy and combined heat and power more feasible.

Rationale: Development of forests and open spaces increases GHG emissions in two ways: lost sequestration capacity and released carbon that had been stored in standing trees, and increased VMT due to sprawl. The Patrick-Murray Administration's historic commitment to land conservation has permanently protected over 72,000 acres from development, preserving one of our most valuable carbon sinks, and this initiative will continue into the future. Meanwhile, better land use patterns will be important for reducing or eliminating projected VMT increases and realizing GHG reductions from the transportation sector, which is expected to account for close to 40 percent of total GHG emissions in Massachusetts in 2020, with light vehicles (cars, SUVs, minivans, pickups) accounting for about 28 percent of the total. The Plan assumes that aggressive implementation of current land use policies can result in a 0.4 million metric tons of GHG reduction in 2020, based on getting 80 percent of new residential development to occur in mixed-use areas that are bike and pedestrian friendly and higher than typical density. Strict adherence to and continued enhancement of current policies, along with the implementation of new policies and programs will be necessary to realize the 2020 and 2050 GHG targets.

Design issues: Existing state policies include (a) GreenDOT — which prioritizes transportation projects that preserve the existing system, support denser "smart growth" development, and promote increased ridership, walking, and biking; (b) the MassWorks Infrastructure Program, that provides a one-stop shop for infrastructure funds via six separate programs, and promotes consistency with other state initiatives such as smart growth, Chapter 40R, and the 43D Expedited Permitting Program; and (c) the South Coast Rail Executive Order, which supports the South Coast Rail Economic Development and Land Use Plan by ensuring that agencies review

[56] See: Growing Cooler: The Evidence on Urban Development and Climate Change.

their policies, actions and investments to support and implement plan recommendations including priority development and preservation areas. Complementary policies are needed in order to achieve the 80 percent smart growth target. These are:

1. Reform state planning, subdivision, and zoning statutes — Pass the Land Use Partnership Act or similar legislation that provides municipalities a better framework for planning and zoning, enhanced tools to plan for and manage growth, and incentive to reduce VMT and GHG emissions through better development.
2. Provide technical assistance and undertake a smart growth promotional campaign — Expand efforts to help establish zoning and other land use regulations that reduce VMT. Provide direct technical assistance by state employees, tools such as model zoning, and grants to hire professional assistance. Also, use public appearances, the media, etc., to promote smart growth by pointing out its many benefits.
3. Require state infrastructure spending to include smart growth development in the criteria for funding decisions — State investments, particularly those in infrastructure and buildings, influence where and how growth occurs. Enhanced use of these investments to promote mixed-use, high-density development is critical to attainment of targeted VMT reductions resulting from better land use. This could be accomplished either via Executive Order or through legislation that codifies the *Sustainable Development Principles* and requires all agencies permitting, building, or funding infrastructure projects to take into account a set of smart growth criteria.
4. Significantly increase incentives to municipalities to plan and zone for development that reduces VMT — Much as the Green Communities Program has succeeded in persuading many communities to adopt desired practices - including the Stretch Code - strengthening existing incentives and offering new ones can persuade communities to use their regulatory authority in ways that reduce VMT. Enhance existing incentives such as Chapter 40R, Commonwealth Capital, and the Growth District Initiative, and implement new ones such as "Municipal Challenge Grants" that recognize the GHG benefits of development practices that preserve forest cover. Grants could be awarded to communities that institute an open space zoning bylaw that protects 50 percent of a parcel as forest, limits lot clearance to one-third acre per house, and requires best management practices for lot layout and tree preservation.

GHG impact: Existing policies will reduce GHG emissions by 0.23 percent in 2020[57] and recommended enhancements will realize additional reductions. Recent studies[58] have shown integrated land use strategies can produce GHG reductions of between 2.7 percent and 4.4 percent from the baseline by 2050, depending on how aggressively the Commonwealth implements smart growth policies and practices.

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

[57] See: Eastern Research Group: Final Report to the Climate Protection and Green Economy Advisory Committee.

[58] See: Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions

Other benefits: Smart growth is as much as 70 percent cheaper for governments than the same amount of sprawl. It simply costs less to provide infrastructure (streets, schools, sewers, etc.) and services (like police and fire protection) to denser, more contiguous households than to far-flung, low-density communities.[59] Studies found that New Jersey and Rhode Island would save $1.3 and $1.5 billion, respectively, over 20 years.[60] It enhances public health by reducing air pollution and increasing physical activity, and enhances quality of life by improving neighborhoods, reducing travels times, and lowering costs. This, in turn, enhances economic competitiveness by appealing to prospective employees. Finally, it reduces development of open space, including forested land that sequesters carbon.

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

Experience in other states: Delaware, Maryland, New Jersey, New York, Rhode Island, and others have implemented smart growth programs that have improved growth patterns and thereby reduced VMT.

Legal authority: Legislation is needed to reform state planning, zoning and subdivision statutes and to codify and require agencies to implement the *Sustainable Development Principles*. The Commonwealth may also need to permit certain funding programs to implement municipal incentives and to authorize additional funding for incentives and technical assistance.

Implementation issues: It will be important achieve high levels of cooperation from all stakeholders, including development interests and local communities.

Uncertainty: Projected VMT and GHG reductions are taken from national level analyses and are not Massachusetts-specific. While state investments in infrastructure and buildings will help to steer growth to desirable locations and forms, developers can still finance their own projects and build in ways that result in excessive VMT. In addition, it is hard to project how many communities will take advantage of state incentives and whether growth will occur in these communities rather than others zoned for sprawl.

[59] http://www.brookings.edu/opinions/2003/0413metropolitanpolicy_katz.aspx?p=1

[60] See: Impact Assessment of the New Jersey State Development and Redevelopment Plan.

Non-Energy Emissions

Greenhouse gas emissions from activites not related to energy use represent a small but important part of statewide GHG emissions. Although these sources currently represent only 7 percent of total emissions, many of the gases emitted by these processes have a high global warming potential (GWP), thousands of times greater than CO_2. Furthermore, projections of future emissions, including the Commonwealth's 2020 BAU scenario, show steady growth in industrial emissions while emissions from most energy-related sectors — transportation excepted — are projected to level off or even decline.

Specific industrial processes that emit significant quantities of GHGs in Massachusetts include: leakage of refrigerant chemicals from commercial equipment and motor vehicle air conditioners, leakage of SF_6 from electric power transmission and distribution, and combustion of plastics in solid waste incinerators. The measures proposed in this section of the *Massachusetts Clean Energy and Climate Plan for 2020* address these sources of GHG emissions.

Reducing Leaks and Finding Substitutes for High GWP gases used in Refrigeration and Air Conditioning Units

The Montreal Protocol, which was designed to protect the ozone layer, has led to the substitution of ozone depleting substances with non-ozone depleters — hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) — in a range of applications including: insulating foams, refrigeration and air-conditioning, fire suppression, solvent cleaning, and propellants used in aerosols. Unfortunately, HFCs and PFCs are very potent GHGs. EPA has determined that the use of these chemicals comprises the most significant portion of non-energy related industrial emissions. This Plan will address emissions from the use of these chemicals in light duty motor vehicle air conditioning and commercial and industrial refrigeration.

For motor vehicle air conditioning, Massachusetts will adopt the California Air Resources Board (CARB) emissions standards for new motor vehicles (see Transportation). These standards will apply to model year 2017 vehicles and beyond, and include measures to both reduce leaks of high GWP gases and require use of lower GWP refrigerants. These measures are estimated to remove 0.27 $MMTCO_2e$ in 2020.

For refrigerants in stationary commercial and industrial equipment, the focus will be on reducing leaks from, and finding replacements for non-residential refrigeration equipment with units containing at least 50 pounds of refrigerant. It will build on EPA's voluntary program for grocery stores — in which many Massachusetts stores currently participate. CARB's November 2010 regulation phasing in leak detection and repair requirements will serve as a model for this program. The largest of these sources will report their emissions under Massachusetts GHG reporting rule and EPA's November 2010 mandatory reporting rule. The total impact estimated for this program is up to 1.18 $MMTCO_2e$ in 2020.

Reducing Leaks and Finding Substitutes for High GWP Gases Used in Electricity Distribution and Transmission

This policy will reduce emissions of sulfur hexafluoride (SF_6) gas from leakage where it is used to insulate switchgear in electricity transmission and distribution systems. It will build upon EPA's current voluntary program for SF_6 reduction and could ultimately include enforceable limits on leakage rates as well as best management practices. CARB has proposed a similar program. The impact of this policy is up to 0.15 $MMTCO_2e$ reduction by 2020.

Reducing Emissions from Disposal of Plastic Waste

Emissions associated with the combustion of plastics that remain in our solid waste streams can be minimized by greater diversion of plastics to recycling. Plastic recycling is already a priority in the Commonwealth and results in other environmental benefits, including the reduction of toxics in the environment and the growth of green jobs. This policy, implemented through the *Solid Waste Master Plan*, will aim to minimize the volume of plastic going to disposal in the Commonwealth, and instead divert these materials to recycling. Plastic diversion programs that include increasing assistance to cities and towns, increasing producer responsibility, and building markets for recycled materials are estimated to reduce GHG emissions by 0.3 $MMTCO_2e$ by 2020.

New Policy

REDUCING GHG EMISSIONS FROM MOTOR VEHICLE AIR CONDITIONING

Policy summary: The California Air Resources Board (CARB) is developing regulations to reduce emissions associated with motor vehicle air conditioning (MVAC).[61] Massachusetts General Law[62] mandates that the Massachusetts Department of Environmental Protection (MassDEP) adopt CARB's emission standards for new motor vehicles if they are more stringent than federal standards. CARB's standard aims to minimize emissions of high GWP refrigerants from MVAC through the adoption of standards for new light-duty vehicles. These standards include measures to reduce direct GHG emissions from MVAC systems, such as by using low GWP refrigerants and reducing leaks, as well as measures to reduce indirect emissions of other pollutants through improvement in the efficiency of the AC system (e.g., more efficient compressors, fans and motors; systems that avoid over-chilling and reheating; and technologies to reduce heat gain in the passenger cabin).

Annual benefits from improved motor vehicle air conditioning

Economy-wide GHG emissions reduced 2020	0.3 million metric tons CO_2e; 0.3%
Net cumulative $ savings statewide 2018-2020[63]	$50 - $130 million
Net annual $ savings per vehicle	$40 - $90

Clean energy economy impacts: Several of the measures aimed at reducing refrigerant leakage and making MVAC more efficient also have a positive impact on fuel economy and can be expected to reduce fuel costs for owners. Vehicle owners who pay less for fuel will have more money to spend on other purchases — producing a positive ripple effect on the economy as a whole, including the creation of in-state jobs. Reducing leakage may also reduce the frequency with which vehicles need to be serviced for refrigerant recharge.

Rationale: Transportation is expected to account for close to 40 percent of total GHG emissions in Massachusetts in 2020, and light vehicles by themselves (cars, SUVs, minivans, pickups) are around 28 percent of the total. MVAC emissions account for about 9 percent of GHG emissions from cars and light trucks. Air conditioning use is estimated to account for approximately 5.5 percent to 5.9 percent of vehicle fuel use in the US (although this figure is lower in Massachusetts).

Design issues: CARB is developing draft regulations. After the California rules are finalized and approved by EPA, MassDEP would adopt the CARB regulations if they are more stringent than federal standards.

GHG Impact: 0.27 million metric ton reduction in CO_2e in 2020. The policy applies to new vehicles starting with model year 2017. Since the policy addresses emissions from new motor vehicles, benefits will grow progressively as older vehicles are replaced in the active vehicle stock

[61] http://www.arb.ca.gov/cc/hfc-mac/mvac-gwp/mvac-gwp.htm

[62] http://www.malegislature.gov/Laws/GeneralLaws/PartI/TitleXVI/Chapter111/Section142K

[63] Derived from California cost estimates, given in year 2000 dollars.

(average of 10 years), with greater benefits after 2020 once the fleet has been fully replaced with compliant vehicles.

Other benefits: Between 2018 and 2020, the policy is estimated to save vehicle owners $50 million to $130 million statewide, or $40 to $90 per vehicle per year. In addition, there will be reductions in tailpipe emissions of non-GHG pollutants due to reduced fuel combustion, which will benefit public health.

Costs: Estimated annual per-vehicle costs and savings from MVAC policy (2000$).

Item	**Values in 2020**
Alternative refrigerant	$30 - $80
Improved system (leak tightness and efficiency)	$50
Gross incremental cost ($/year/vehicle)	$80 - $130
Annual fuel and refrigerant savings	$170
Net annual savings	$40 - $90

Equity issues: Incremental savings from the policy are expected to be distributed over all classes of vehicles. However, initially the higher upfront vehicle purchase costs will affect higher income drivers more, since lower income drivers tend to buy used cars. But lower income drivers will enjoy the savings only after compliant vehicles become available in the used car market.

Experience in other states: Fourteen jurisdictions use CARB's auto emission standards, including Maine, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, Oregon, Washington, Arizona, Washington, D.C., and Bernalillo County, New Mexico.

Legal authority: Massachusetts General Law Chapter 111, Section 142K mandates that MassDEP adopt and implement CARB emission standards for new motor vehicles if such standards are more stringent than federal standards.

Implementation issues: Because light-duty vehicle efficiency standards for 2011 through 2020 (CAFE and California's vehicle GHG standards, both accounted for in existing policies) allow manufacturers to meet the standards partly through voluntarily reducing MVAC emissions, this policy discounted the benefits from MVAC emissions reductions. But manufacturers could choose to voluntarily implement even greater MVAC reductions under CAFE than assumed here, which would result in lower combined benefits of the efficiency and MVAC policies.

The policy calls for measures — in particular the switch to substitute refrigerants — that are still in development. While there are strong incentives to develop and refine the necessary technologies to meet existing requirements (e.g., EU regulations, other CA regulations), there is still a risk that estimated reductions may not be achievable.

Uncertainty: At least one study has highlighted the risk that more stringent emissions standards in selected states may reduce scrapping of used non-compliant cars and/or may result in car manufacturers achieving reductions in adopting states while potentially allowing for larger emissions and less efficient vehicles in other states. If so, these dynamics could reduce the effectiveness of the policy in achieving the projected emissions reductions in the short run.

New Policy

STATIONARY EQUIPMENT REFRIGERANT MANAGEMENT

Policy summary: This policy aims to minimize emissions of high Global Warming Potential refrigerants used in stationary non-residential equipment through:

- facility registration, leak detection and monitoring, leak repair, system retrofit and retirement, required service practices, and recordkeeping and reporting; and
- eventual replacement of non-residential refrigeration equipment at the end of its life by equipment using no-GWP or lower GWP substances, where such alternatives are available and practicable.

The policy would affect facilities with refrigeration units containing at least 50 pounds of refrigerant, beginning with a voluntary pilot program focused on leak detection and repair.

Economy-wide GHG emissions reduced 2020	1.2 million metric tons CO_2e; 1.3%
Net annual $ savings statewide	$1.6 million
Cumulative $ savings statewide 2012-2020, discounted[64]	$14 million

Clean energy economy impacts: Additional jobs in companies that engage in refrigeration system leak detection and repair. Cost savings to affected facilities from lower use of chemicals to refill systems.

Rationale: Common refrigerants include several types of hydrofluorocarbons (HFC). These chemicals have global warming potentials up to 12,000 times more potent than CO_2. Emissions from this source category have been growing steadily since the 1990s, in part due to the replacement with HFC of ozone depleting refrigerants targeted under the Montreal Protocol.

Design issues: California Air Resources Board (CARB) finalized a regulation[65] effective November 19, 2010, phasing in requirements for a leak detection and repair program for refrigeration units containing a charge of 50 pounds of refrigerant or greater. Massachusetts could implement a voluntary program that transitions into utilization of California's regulations as a model. Most of the businesses involved have been subject to similar EPA regulation on ozone-depleting chemicals used in refrigeration.

GHG impact: 1.2 million metric ton reduction in CO_2e in 2020.

Implementation issues: Implementing a program to reduce refrigerant emissions requires development of an inventory of facilities using large quantities of refrigerants. The number of facilities can be estimated from the Economic Census 2007,[66] a profile of U.S. businesses conducted every five years by the US Census Bureau. In addition, MassDEP will receive 2010 refrigerant emission data from large emitters by April 15, 2011, under the mandatory

[64] In 2008 dollars, discounted at a 5 percent rate from current year.

[65] http://www.arb.ca.gov/regact/2009/gwprmp09/gwprmp09.htm

[66] http://www.census.gov/econ/census07/, U.S. Census Bureau reporting 1,305 supermarkets and other groceries; 34 warehouse clubs and supercenters; 29 refrigerated warehousing and storage facilities; 523 cold product merchant wholesalers; and 153 cold manufacturing facilities in Massachusetts.

Massachusetts GHG emissions reporting program. MassDEP has already established relationships with larger supermarket store chains through efforts to encourage composting of food waste and reduce use of disposable shopping bags.

A number of Massachusetts grocery stores participate in EPA's voluntary "GreenChill Advanced Refrigeration Partnership,"[67] including Hannaford Bros., Price Chopper, Shaw's Supermarkets, and Whole Foods. In September 2009, a Star Market in Chestnut Hill became the first U.S. store certified at the Platinum level under EPA's GreenChill Store Certification program, while a Whole Foods store in Dedham received Silver certification in August 2009.[68]

On November 8, 2010, EPA signed final regulation 40 CFR 98 "Mandatory Reporting of Greenhouse Gases," Subpart L "Fluorinated Gas Production" and Subpart Q "Importers and Exporters of Fluorinated GHGs Inside Pre-charged Equipment or Closed-cell Foams,"[69] which require manufacturers and importers of substances including high GWP refrigerants to report GHG emissions, beginning with 2011 emissions reported by March 31, 2012.

Costs: Costs incurred by regulated entities pertaining to leak detection and repair can be divided into technology costs (equipment upgrades to automatic leak detection), operation and maintenance costs (leak detection, inspection, repair, annual program fee), and recordkeeping costs (data management and reporting). CARB's analysis of a similar policy indicates 2020 compliance costs ranging from $14 per facility with systems containing 50 to 200 pounds of refrigerant, $30 per facility with systems containing up to 2,000 pounds, and savings of $8,700 per facility with systems containing 2,000 pounds or more (net savings for larger facilities, due to economies of scale in reducing leakage).

CARB estimated savings of $2 per metric ton CO_2e in the year 2020 after the proposed regulation is fully implemented. This estimate may understate the actual net savings, since it does not account for rising refrigerant prices, energy savings due to optimized system operation, or benefits from mitigated climate impacts. Based on the number of facilities estimated to be affected by the policy (about 2,000) and an estimated distribution of the facilities by size, the policy is estimated to provide net savings of $1.6 million per year statewide.

Legal authority: MassDEP has authority to promulgate a regulation under Massachusetts General Law Chapter 111, Section 142 to create an enforceable refrigerants control program to prevent air pollution.

Uncertainty: Technical risks associated with leak detection and repair are expected to be relatively small. The practices promoted by the policy are already established. Implementation risks relate to the number and diversity of facilities that may be affected by the policy, which could complicate compliance assistance, verification, and enforcement. The effectiveness of the policy depends on facility owners actually implementing the practices called for in the policy, which may in turn depend on ensuring that technicians are trained and aware of the requirement.

[67] http://www.epa.gov/ozone/partnerships/greenchill/

[68] http://www.epa.gov/ozone/partnerships/greenchill/certcenter.html

[69] http://www.epa.gov/climatechange/emissions/subpart/dd.html

New Policy

REDUCING SF_6 EMISSIONS FROM GAS-INSULATED SWITCHGEAR

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

Economy-wide GHG emissions reduced 2020	0.2 million metric tons CO_2e; 0.2%
Net cumulative $ costs statewide 2011-2020 (2008 $'s)[70]	$0.9 - $1.5 million

Clean energy economy impacts: There would be an expected increase in in-state employment for companies engaged in SF_6 leak detection and repair and potential for technological innovation, company formation, and jobs in solid-state (non-gas insulated) switch gear.

Rationale: SF_6 is a GHG that is 23,900 times more potent than CO_2 and has an atmospheric life of 3,200 years. One pound of SF_6 has the same global warming impact as 11 tons of CO_2. Approximately 80 percent of SF_6 consumption and emissions are estimated to result from the leakage and handling losses from GIS. Mitigation options for this equipment focus on reducing leakage and handling losses. Best practices include SF_6 leak detection and repair, and recovery and recycling.

Design issues: California Air Resources Board (CARB) has proposed a regulation[71] requiring GIS owners to reduce SF_6 emissions from electrical equipment throughout California 1 percent per year over a 10-year period. The initial allowed annual emission rate would be set at 10 percent of the total amount of SF6 that could leak; with the allowed annual rate declining to 1 percent in 2020. Massachusetts could use CARB's regulations as a model.

A number of Massachusetts utilities participate in EPA's voluntary "SF_6 Emission Reduction Partnership for Electric Power Systems,"[72] including: National Grid, NSTAR, and Western Massachusetts Electric Company. EPA does not publish any state- or utility-specific data from its voluntary program. On November 8, 2010, EPA signed final regulation 40 CFR 98 "Mandatory Reporting of Greenhouse Gases," Subpart DD "Use of electric transmission and distribution equipment,"[73] which requires reporting emissions from GIS, beginning with 2011 emissions reported by March 31, 2012.

As part of its development of a SF_6 emissions reduction program, CARB distributed a survey[74] requesting information from stakeholders on SF_6 emissions from the electricity sector "to

[70] In 2008 dollars, not discounted.

[71] http://www.arb.ca.gov/regact/2010/sf6elec/sf6elec.htm

[72] http://www.epa.gov/electricpower-sf6/

[73] http://www.epa.gov/climatechange/emissions/subpart/dd.html

[74] http://www.arb.ca.gov/cc/sf6elec/survey/sf6survey.doc

determine SF_6 GHG emission reduction potential and to assist ARB staff in developing appropriate control strategies." After consideration of any 2010 SF_6 emission data MassDEP receives by April 15, 2011 as part of the first mandatory Massachusetts SF_6 emission data reporting, MassDEP could consider whether a survey similar to CARB's would provide useful information for designing a regulation.

GHG impact: 0.15 million metric ton reduction in CO_2e in 2020.

Costs: According to CARB's analysis of a similar policy, the expense of compliance ranges from savings of $1/metric ton CO_2e (in the case of SF_6 recycling) to a cost of $55/metric ton CO_2e (in the case of GIS repair and replacement), depending on the measure necessary to meet the emission limits in any given year. Entities are assumed to use the cheapest methods first and progressively move to more expensive methods to achieve further reductions. Some entities may not incur a cost for reducing SF_6 emissions for some or all years to 2020, if their leak rates fall below a year's allowed limit. CARB estimates the cost effectiveness of the policy at about $18 per metric ton CO_2e reduced in the later years of the policy when the allowed leakage rate has declined to 1 percent. Similar cost effectiveness may be achieved in Massachusetts if the baseline practices and electric infrastructure profiles are comparable.

Equity issues: Full implementation of this policy may impose additional compliance costs on utilities, which could be passed on to customers — although that additional cost would be miniscule. CARB's analysis of the proposed regulation estimated the incremental cost that could be passed on to electricity ratepayers at $0.000016 to $0.000025 per kilowatt-hour as a result of the policy. This represents an increase of less than 0.02 percent relative to average residential electricity rates in Massachusetts, or about 1.5 cents for the average monthly residential electricity bill.

Legal authority: MassDEP would need to promulgate a regulation to create an enforceable SF_6 control program. MassDEP presently has the authority to regulate such air pollutants under Massachusetts General Law Chapter 111, Section 142; and it's authority over GHG emissions is amplified by the Global Warming Solutions Act.

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

Expanded Policy

REDUCING GHG EMISSIONS FROM PLASTICS

Policy summary: Solid waste is generated by residences and businesses across Massachusetts. Diverting high-carbon-content materials, such as plastics, from the waste stream can reduce emissions released after materials are discarded, and for some part of the waste stream, incinerated. These diverted materials can then be recycled into other products. Diverting plastics from the waste stream under this Plan will result in materials with a lower carbon content being combusted at Massachusetts municipal waste–to-energy facilities, reducing emissions of CO_2. Looking only at in-state emissions reductions, MassDEP conservatively estimates the reduction potential from diverting a portion of plastics from solid waste disposal in 2020 at 0.3 million metric tons of CO_2e per year.

Economy-wide GHG emissions reduced 2020	0.30 million metric tons CO_2e; 0.3%
Annual $ savings statewide in 2020	$8 to $11 million
Cumulative $ savings statewide 2009-2020[75]	$69 to $92 million

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

Rationale: The Commonwealth periodically prepares a *Solid Waste Master Plan* in accordance with Massachusetts General Law Chapter 16 Section 21. The solid waste sector includes sources of GHG emissions, such as landfills and municipal waste combustors, and plastics constitute a significant portion of the emissions. As detailed in a press release[76] that accompanied release of the most recent *Draft Solid Waste Master Plan*, "…The main objectives of the draft master plan include maximizing recycling, improving the environmental performance of solid waste facilities and developing integrated solid waste management systems. The draft master plan calls for a dramatic increase in residential, business and institutional recycling and composting, with an emphasis on paper and organics recycling…".

GHG impact: 0.3 million metric ton reduction in CO_2e in 2020.

Costs: According to the *Draft Solid Waste Master Plan*: "Diverting material from disposal, whether through upfront waste reduction, reuse, recycling or composting, can save significant disposal costs. Current disposal fees in Massachusetts typically range from $60 to $80 per ton. If we are able to achieve our goal of reducing disposal by 2 million tons per year by 2020, that would result in annual avoided disposal costs of $120-$160 million. Plastics diversion alone constitutes some $8 million to $11 million of the total $120 million to $160 million in annual avoided disposal costs.

Implementation issues: Public hearings have been held on the Commonwealth's *Draft 2010-2020 Solid Waste Master Plan: A Pathway to Zero Waste*.[77] All public comments have been received and are being reviewed.

[75] Based only on reduced disposal costs.

[76] http://www.mass.gov/dep/public/press/0710swmp.htm

[77] http://www.mass.gov/dep/recycle/priorities/dswmpu01.htm#swmp

Cross-cutting Policies

Introduction

Several policies do not fit neatly into the categories of buildings, electricity supply, transportation or non-energy emissions. These are state actions that drive clean energy adoption across all of these domains.

The Massachusetts Environmental Policy Act (MEPA) Office, which conducts the environmental review process for all large development projects, requires proponents to assess the environmental impact of a project and analyze alternatives in an effort to avoid, minimize and mitigate damage. This necessarily includes the buildings, energy supply, and transportation impacts of a project. The state's Leading By Example program, established by Governor Patrick, requires state agencies to reduce energy costs and lower emissions in state buildings, in vehicle fleets, and through green procurement. The Green Communities Division of DOER works closely with municipalities to help cities and towns lower their energy costs and adopt energy efficient technologies, add renewables to their energy mix, and make their fleets more fuel efficient. Though not, for the purposes of the *Massachusetts Clean Energy and Climate Plan for 2020*, discrete policies with their own measurable impacts on GHG emissions, they contribute to (and their impacts are accounted for within) numerous other initiatives contained in this Plan.

Finally, the Global Warming Solutions Act itself requires all state agencies, departments, boards, commissions and authorities to consider climate change impacts, such as GHG emissions, when they issue permits, licenses and other administrative approvals.

Expanded Policy

MEPA GHG Policy and Protocol

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

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

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

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

GHG impact: To date, more than 90 projects have been at least partially reviewed in accordance with the MEPA GHG policy, and 32 projects have completed MEPA review with a finding that their GHG analysis adequately complied with the MEPA GHG Policy. Projects that have completed review have achieved an average reduction of 19.5 percent in stationary-source GHGs below an equivalent code-compliant project. Mobile source GHG reductions have ranged from zero to 25 percent, with an average of 5.8 percent. In total, the MEPA GHG Policy has resulted in commitments to reduce GHG emissions by over 70,000 tons per year to date. However, it is likely that a portion of these reductions, and many of the potential future reductions under the MEPA

Policy, may be duplicative of the reductions achieved by other state policies designed to increase efficiency, encourage renewable energy generation, and reduce vehicle miles traveled.

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

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

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

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

Therefore, implementation of the MEPA GHG Policy is mandatory under the MEPA statute.

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

Expanded Policy

LEADING BY EXAMPLE

Policy summary: The Leading by Example (LBE) Program, established in April 2007 by Governor Patrick's Executive Order (EO) No. 484, works to lower costs and reduce environmental impacts at all Executive Branch agencies, as well as the 29 public institutions of higher education and several quasi-public authorities. The program oversees efforts to reduce energy use at the state's 70 million square feet of buildings and fuel use among the thousands of light and heavy duty vehicles, expand recycling programs, reduce water consumption, promote environmentally preferable purchasing, facilitate the construction of high performance state buildings, and reduce carbon emissions across state government. EO 484 sets the following targets for state government: 25 percent reduction from a 2002 baseline in GHG emissions by 2012, 40 percent by 2020, and 80 percent by 2050; 20 percent reduction from a 2004 baseline in energy use intensity by 2012 and 35 percent by 2020; and an increase in consumption of renewable electricity to 15 percent of total electric use by 2012 and 30 percent by 2020. The EO also established a "Massachusetts LEED Plus" building standard for new construction and major renovation projects that requires all state government projects to achieve LEED certification and perform 20 percent better than the Massachusetts energy code.

The LBE Program is overseen by EEA and Administration and Finance, working collaboratively with state agencies such as the DOER (clean energy policies and project implementation), Division of Capital Asset Management (construction and energy projects) and Operational Services Division (procurement) to track state government energy use and GHG emissions, oversee the funding and implementation of dozens of clean energy projects annually, and provide technical assistance and training for dozens of agencies and hundreds of staff each year.

Despite the advances made by the LBE program, there is currently no single entity charged with managing and procuring low-cost, clean energy across all public agencies, authorities, and facilities. The Administration has proposed and will continue to work toward the development of a Common-wealth Energy Solutions program, which will end the separate decision-making by multiple agencies and provide an opportunity for a comprehensive, integrated strategy from procurement (taking advantage of economies of scale) to continuous monitoring and management of energy performance.

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

Rationale: With approximately 70 million square feet of buildings, state government operations result in significant amounts of fuel consumption annually, including approximately 900 million kWh of electricity, 50 million therms of natural gas, 15 million gallons of fuel oil and more than million gallons of diesel fuel and gasoline. This consumption results in over 800,000 tons of GHG emissions and expenditures exceeding $220 million. Given this large impact, there is clearly a huge opportunity to reduce energy usage and associated carbon emissions. Such efforts will also demonstrate to other institutions and the private sector that large-scale energy reduction and renewable energy efforts are both feasible and fiscally desirable.

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

GHG impact: GHG emission impacts are directly related to energy reduction and renewable energy efforts at state facilities. If the 2012 targets in EO 484 are met, this would result in a reduction of approximately 200,000 metric tons of GHGs.

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

Costs: Although exact costs are unknown, it is anticipated that over $200 million worth of clean energy projects will be implemented by 2012. Project costs will, for the most part, be funded through the Massachusetts Clean Energy Investment Program (CEIP), a newly developed program that is designed to provide low-rate bond financing paid for out of project savings. This program results in a positive cash flow early in the project and overall simple paybacks of between 10 and 20 years. Additional financing through 2012 and thereafter will be targeted through 3rd party financing, forward capacity market payments, Renewable Energy Credits, utility incentives, and, where available, renewable energy rebates.

Equity issues: There are no known equity issues.

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

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

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

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

Existing Policy

GREEN COMMUNITIES DIVISION

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

Clean energy economy impacts: The five required criteria to be designated a Green Community help municipal governments to reduce their own energy costs, and those of local residents and businesses; and help to achieve siting of wind, solar, and other renewable energy installations.

Rationale: Municipal governments are substantial consumers of fossil-fuel energy, primarily for buildings and secondarily from vehicles. The Energy Reduction Plan along with the Fuel Efficient Vehicle Policy required for designation as a Green Community results in municipalities reducing their energy consumption from municipal operations by a minimum of 20 percent. Through zoning they can have a major impact on the ability of renewable energy facilities to find suitable locations. And by deciding to adopt the "stretch" energy code (see Buildings) — another requirement for Green Communities designation — they significantly improve the energy efficiency of new construction and major renovations.

Policy design and issues: The Division provides technical assistance to communities to help them qualify for Green Community designation and state grants. To become Green Communities, municipalities must meet five criteria:

- Adopt a local zoning bylaw or ordinance that allows "as-of-right-siting" of renewable and/or alternative energy R&D facilities, manufacturing facilities or generation units;
- Adopt an expedited permitting process related to the as-of-right facilities;
- Establish a municipal energy use baseline and establishing a program designed to reduce use by 20 percent within five years;
- Purchase only fuel-efficient vehicles for municipal use, whenever such vehicles are commercially available and practicable; and
- Require all new residential construction over 3,000 square feet and all new commercial and industrial real estate construction to reduce lifecycle energy costs (such as adoption the Stretch Code).

The Green Communities Act allows funding of up to $10 million per year for the designation and grant program from the proceeds of Regional Greenhouse Gas Initiative (RGGI) allowance auctions and other sources. The Green Communities Division also serves all Massachusetts cities and towns as a one-stop shop for energy efficiency and renewable energy opportunities, helping them understand all the state programs at their disposal and providing streamlined delivery of those programs.

To achieve the goal of serving all 351 cities and towns in Massachusetts, the Green Communities Division offers a number of programs and services in addition to its signature Green Communities Grant Program. Other services include an energy assessment program in collaboration with the investor-owned utilities, technical assistance with energy savings performance contracting, stimulus grant programs and support, an online energy information system for tracking energy consumption and making decisions about how to reduce consumption, webinars and guidance documents and tools, a website and listserv for disseminating information and four Regional Coordinators to provide direct support to cities and towns.

GHG impact: GHG emissions are directly related to energy reduction and renewable energy efforts in municipalities. The first 35 Green Communities committed to reducing their energy consumption by 822,000 MMBTUs in five years. The newest 18 committed to a reduction of 592,000 MMBTUs over five years.

Other benefits: Additional benefits include reduced energy costs and a lower burden on Massachusetts taxpayers. Projects funded through the Green Communities Division can pilot new technologies and system management. In addition, the work done by municipalities to become designated as a Green Community requires buy-in of its residents, with meeting many of the criteria requiring a Town Meeting vote. This has resulted in a major grassroots movement to educate the larger citizenry on the benefits of reducing energy consumption and creating clean, renewable energy projects.

Costs: Up to $10 million per year, funded through the proceeds of Regional Greenhouse Gas Initiative (RGGI) emissions allowance auctions (see Electricity) and other sources.

Equity issues: There are no known equity issues. G grants are based on a $125,000 base for each designated Green Community, plus additional amounts tied to per capita income and population, and for municipalities that provide as-of-right siting for renewable energy generation. There are 53 designated communities from the Berkshires to Cape Cod, ranging in population from 990 to 621,000 residents.

Experience in other states: We are aware of no similar programs in other states. The Green Communities Division is believed to be the first of its kind in the nation.

Legal authority: The Green Communities Act of 2008 created the Division and the designation and grant program and authorized funding for it. The Board of Building Regulation and Standards approved the Stretch Code as an option for municipalities to adopt.

Implementation issues: As of December 2010, 53 communities had attained designation as Green Communities, thereby qualifying for funding from the Division. In addition, as of December 2010, 64 cities and towns had passed the Stretch Code.

Uncertainty: The Green Communities Division and Grant program are new and have created considerable excitement among Massachusetts cities and towns. It will be important in going forward to continue engaging municipalities in a manner that maintains that excitement. In addition, proceeds from the RGGI auctions, the main source of funding for the Division, are difficult to predict.

New Policy

CONSIDERATION OF GHG EMISSIONS IN STATE PERMITTING, LICENSING & ADMINISTRATIVE APPROVALS

Policy Summary and Rationale: Section 7 of the Global Warming Solutions Act states, "In considering and issuing permits, licenses and other administrative approvals and decisions, the respective agency, department, board, commission or authority shall also consider reasonably foreseeable climate change impacts, including additional GHG emissions..." in the context of environmental review. The body of landmark energy legislation that has been passed in the last four years established new expectations for how we manage energy, plan transportation, build our buildings, and generate and distribute electricity. The official approvals by state agencies, departments, boards, commissions and authorities often have implications for clean energy adoption and GHG emissions. EEA, in collaboration with other state and quasi-public agencies, will develop a plan to implement this requirement in selected agency actions.

III. Implementing the Global Warming Solutions Act

Setting the 2020 Limit

Section 4. (a) The secretary shall adopt the 2020 statewide GHG emissions…which shall be between 10 per cent and 25 per cent below the 1990 emissions level … (Global Warming Solutions Act of 2008; M.G.L. Chapter 21N)

Setting the statewide GHG emissions limit for 2020 was based on two years of analysis and public comment, and followed a process set forth in the Act.

In March 2009, the Executive Office of Energy and Environmental Affairs (EEA) established the Climate Protection and Green Economy Advisory Committee to provide input on the 2020 limit and measures to reduce GHG emissions in accordance with the Global Warming Solutions Act (GWSA). As required by the GWSA, the Advisory Committee included members representing the following sectors: commercial, industrial and manufacturing; transportation; low-income consumers; energy generation and distribution; environmental protection; energy efficiency and renewable energy; local government; and academic institutions. Advisory committee meetings were held throughout 2009 and 2010 and subcommittees were set up to examine technical aspects of possible policies.

In parallel and integrated with the activities of the Advisory Committee, EEA convened a technical working group consisting of staff from EEA, the Department of Environmental Protection (MassDEP), the DOER, the Department of Transportation (MassDOT), and the Executive Office of Housing and Economic Development (EOHED). This team spearheaded the technical analysis.

Overseen by this state agency technical working group, most of the analytical work was undertaken by a team of consultants, led by Eastern Research Group (ERG) and including several other firms with extensive expertise in specific sectors — Cambridge Systematics, Inc. on transportation, Synapse Energy Economics on electricity supply and energy use in buildings, and Abt Associates on the non-energy emissions sources. A variety of specialized models and data sources were used by the consultants for the various sector analyses. All the supporting data was then entered into the LEAP (long-range energy alternatives planning) model of Stockholm Environment Institute–U.S., another member of our consulting team. LEAP provides a convenient and sophisticated tool for integrating all the sectors and for running various policy scenarios. It was used both for the 2020 analysis and for development of hypothetical scenarios to reach the long-range 2050 reduction mandate. Finally, additional analysis of scenarios for shifting the motor vehicle fleet to lower-carbon alternatives to petroleum fuel was conducted by Ventana Associates, using system dynamics modeling.

The first step in the analysis was to determine what Massachusetts 1990 emissions level was and what the predicted "Business as Usual" (BAU) emissions trajectory to 2020 would be. MassDEP issued its *Statewide Greenhouse Gas Emissions Level: 1990 Baseline and 2020 BAU*

Projection[78] on July 1, 2009. The primary finding of this report was that, despite year-to-year variation, the trend line of GHG emissions has been relatively stable since 1990 and is predicted to remain relatively stable through 2020. Even though there has been robust economic growth in Massachusetts since 1990, GHG emissions have remained stable because the fuel mix in electricity generation shifted toward natural gas (which is less carbon-intensive than coal or oil), the Massachusetts economy shifted toward services, and the limited energy efficiency programs in place during that period moderated growth in energy use. The BAU estimate for 2020 is essentially a straight-line extrapolation of the 1990-2008 stable trend. This approach was chosen because the 1990-2008 period included both recessions and economic booms, and the underlying trends of that period are likely to continue, whereas attempts to create a more dynamic model of GHG trends in the future would unavoidably involve making a wide range of untested assumptions.

The next step in the analysis was to determine the expected GHG reductions by 2020 that would result from the policies and programs implemented or initiated since the beginning of the Patrick-Murray Administration, not including new policies that would be implemented under authority of the GWSA. In April 2010, Eastern Research Group submitted a report to the Advisory Committee, *Initial Estimates of Emissions Reductions from Existing Policies Related to Reducing Greenhouse Gas Emissions*. This report found that the energy efficiency, renewable energy, and transportation measures required by the Green Communities Act, the Advanced Biofuels Act, various state government executive actions, and the federal government would result in emissions being reduced to approximately 18 percent below 1990 levels by 2020 — roughly the midpoint of the 10 percent to 25 percent range required by the GWSA.

Following that report, EEA issued a Draft Climate Implementation Plan: A framework for meeting the 2020 and 2050 goals of the Global Warming Solutions Act. In the Implementation Plan, Secretary Bowles signaled his intention to set a 2020 emissions reduction requirement of 18 percent to 25 percent below 1990 levels and, for the final plan to achieve this limit, to give greatest consideration to those measures that show potential for significant energy cost savings and/or job creation.

In May 2010, Eastern Research Group submitted an additional report, *Cost-Effective Greenhouse Gas Mitigation in Massachusetts: An Analysis of 2020 Potential*. For this report, the consultants were asked to consider what additional GHG reductions would be technically feasible with cost-effective policies beyond those already in place. This report showed that it would be technically feasible to reduce emissions by up to 35 percent below 1990 levels by 2020 with additional policies that are cost-effective.

Both the draft implementation plan and the analysis of 2020 potential were used to focus a series of eight public hearings that were held in June 2010, as required by the Act. Nearly 200 individuals and organizations provided oral or written comment on the 2020 emissions reduction requirement and on policy measures to meet the requirement. The vast majority of commenters called for the Secretary to set the GHG limit at 25 percent below 1990 levels, the maximum allowed under the statute. A range of suggestions also pointed to a variety of

78 Statewide Greenhouse Gas Emissions Level: 1990 Baseline and 2020 Business As Usual Projection, Massachusetts Dept. of Environmental Protection, July 1, 2009.

different policy mechanisms that EEA should analyze in preparing the final implementation plan.

Following the hearings, EEA further consulted with the Climate Protection and Green Economy Advisory Committee and tasked the Advisory Committee's technical subcommittees, technical staff at EEA agencies, MassDOT, EOHED and other state agencies, and third-party consultants with analyzing a wide range of actions, policies, regulations, and legislation that could achieve additional clean energy gains and emissions reduction by 2020 and beyond. The Secretary then directed the technical teams to conduct in-depth analyses of those additional measures that satisfy criteria of cost-effectiveness while reducing GHG emissions. These in-depth analyses focused on GHG reduction potential; cost; clean energy economy impacts (cost of living, number and quality of jobs, reduced spending on fuel imports, etc.); implementation and design issues; experience in other states or jurisdictions; other co-benefits; equity issues; and uncertainties.

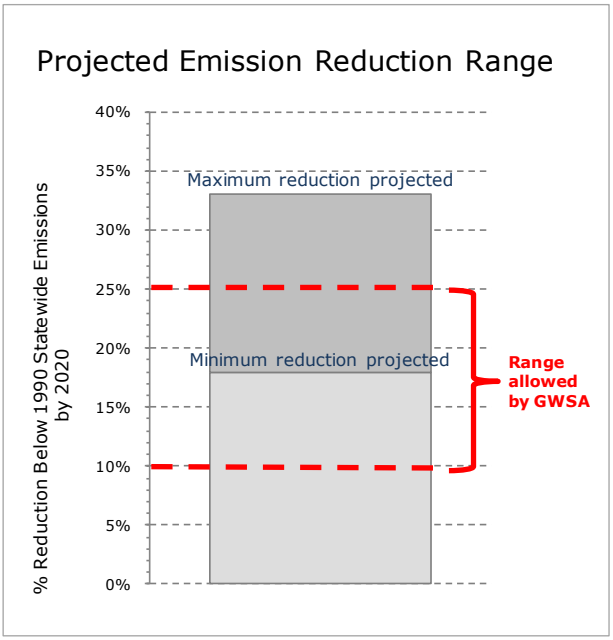

Figure 8. Projected emission reduction range below 1990 by 2020. The range results from uncertainties in Business as Usual (BAU) emissions, policy designs, and impacts of individual policies.

Table 2 (on page 91) displays the portfolio of policies incorporated in the *Massachusetts Clean Energy and Climate Plan for 2020*, and the associated potential contribution to GHG reduction below 1990 levels by 2020 for each policy. In aggregate, these policies, which include measures put in place since 2007 and new initiatives proposed in this Plan, are projected to achieve emissions reductions in the range of 18 percent to 33 percent by 2020 (see Figure 8). The lower end of this range represents a scenario in which Business as Usual (BAU) emissions are higher than projected and actual emission reductions from the policies as implemented are at the low end of estimates. The higher end of the range represents a scenario in which BAU emissions are lower than projected and implementation success is relatively high. A mid-range estimate for the portfolio of policies results in GHG emissions approximately 27 percent below 1990 levels by 2020.

Table 2. The Portfolio of Policies	**middle estimate % reduction below 1990**
Buildings	**9.8%**
All cost-effective energy efficiency/RGGI	7.1%
Advanced building energy codes	1.6%
Building energy rating and labeling	---
"Deep" energy efficiency improvements for buildings	0.2%
Expanding energy efficiency programs to C/I heating oil	0.1%
Developing a mature market for solar thermal water/space heating	0.1%
Tree retention and planting to reduce heating and cooling loads	0.1%
Federal appliance and product standards	0.6%
Electricity	**7.7%**
Expanded Renewable Portfolio Standard (RPS)	1.2%
More stringent EPA power plant rules	1.2%
Clean energy imports	5.4%
Clean energy performance standard (CPS)	---
Transportation	**7.6%**
Federal and California vehicle efficiency and GHG standards	2.6%
Federal emissions and fuel efficiency standards for medium and heavy-duty vehicles	0.3%
Federal renewable fuel standard and regional low carbon fuel standard	1.6%
Clean car consumer incentives	0.5%
Pay As You Drive (PAYD) auto insurance (pilot program, possible expansion later)	1.1%
Sustainable Development Principles	0.1%
GreenDOT	1.2%
Smart growth policy package	0.4%
Non-Energy Emissions	**2.0%**
Reducing GHG emissions from motor vehicle air conditioning	0.3%
Stationary equipment refrigerant management	1.3%
Reducing SF_6 emissions from gas-insulated switchgear	0.2%
Reducing GHG emissions from plastics	0.3%
Cross-cutting Policies	---
MEPA GHG policy and protocol	---
Leading by Example	---
Green Communities Division	---
Consideration of GHG emissions in State permitting, licensing and administrative approvals	---
Overall reductions versus 1990 (adjusted for uncertainty in Business as Usual (BAU) emissions, policy designs, and impacts of individual policies)	
High BAU emissions and low policy impacts	**18%**
Middle BAU emissions and policy impacts	**27%**
Low BAU emissions and high policy impacts	**33%**

Note: the overall reduction is adjusted for overlap among policies, so is smaller than the sum of the individual policies. Individual lines may not sum to subtotals due to rounding.

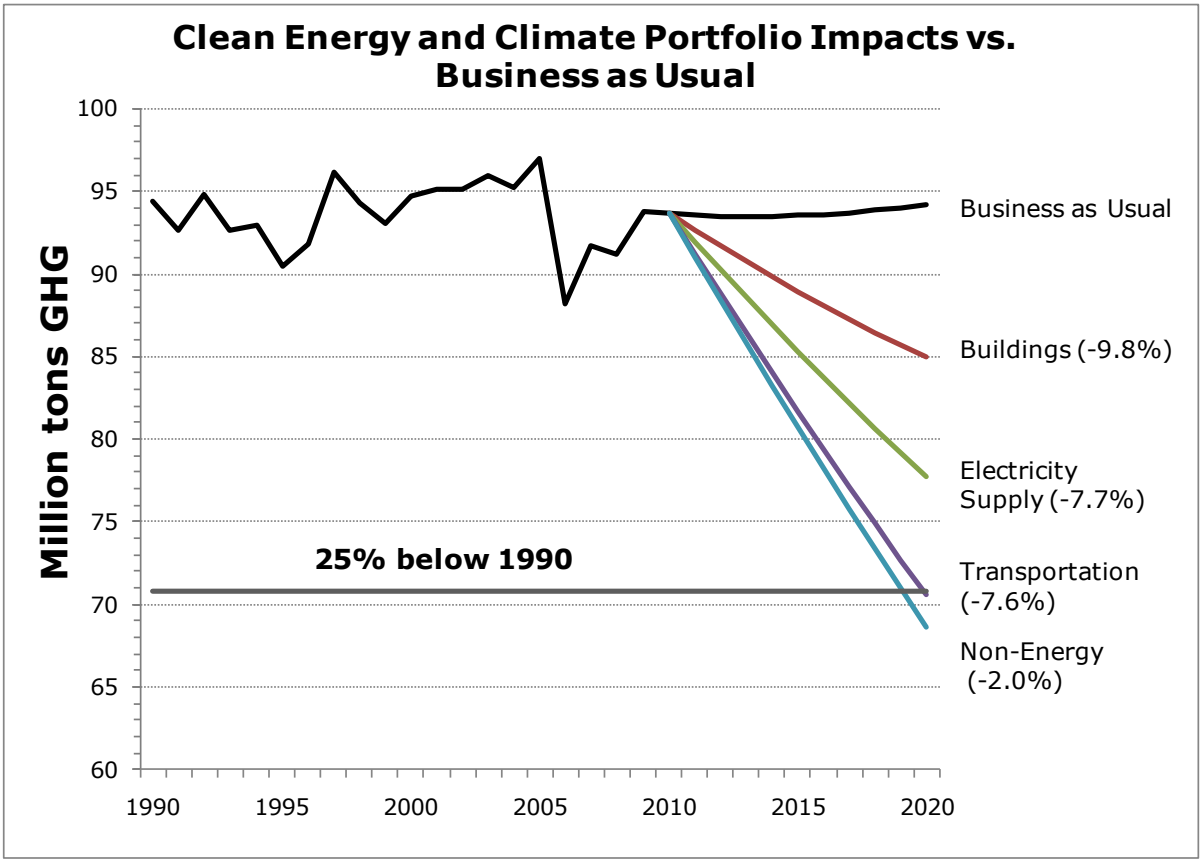

Figure 9. Emissions reductions by sector for the portfolio of policies, at the mid-range estimate of 27 percent below 1990 levels by 2020.

Based on these analyses, input from the Advisory Committee, and full consideration of the public comments received, EEA Secretary Ian Bowles determined that a responsible and achievable GHG emissions reduction limit for 2020 that maximizes opportunities to realize energy cost savings, increase energy independence, and promote growth in clean energy jobs in Massachusetts is 25 percent — the high end of the range for 2020 authorized by GWSA, but the middle of the range of possible outcomes for the policies incorporated in this Plan.

In setting this limit, the Secretary took into account the statutory mandate of 80 percent reduction by 2050, which led him to set the 2020 limit as high as is practical. He also did so based on his understanding that the portfolio of measures outlined in the Integrated Portfolio section of this Plan, discounted for uncertainty and potential implementation constraints, provides enough flexibility and redundancy for the Commonwealth to achieve the 2020 reduction limit of 25 percent.

Putting the Plan into Action

In 2011, state agencies responsible for each new measure will complete program development and consultative processes with stakeholders, in order to create an implementation plan for each policy outlined in this Plan. Given the portfolio nature of the policies included in the Plan, there will naturally be a diversity of processes to move each policy forward. For example, some require pilot programs (such as the Pay As You Drive pilot program that is dependent on Federal Highway funding). Others require expansion of existing programs (such as energy efficiency). Still others may require legislation even as administrative actions move them forward (such as the expansion of renewable energy credits from electricity to include thermal energy).

As part of continued policy development, more detailed cost and benefit information will be analyzed and used to design programs to maximize a cost-effective transition to an equitable clean energy future, which includes well-distributed green jobs and business growth, as well as GHG gas reduction.

In order to monitor progress in implementing the Plan, the Climate Protection and Green Economy Advisory Committee will remain in existence, and the Secretary of EEA will present an annual progress report to the Committee by December 31 of each year. In preparation for that annual report, all responsible agencies (EEA agencies, MassDOT, EOHED, and others) will report to the EEA Secretary by October 31 of each year on their progress toward implementation. The Secretary will, in turn, compile a complete report for the Climate Protection and Green Economy Advisory Committee. The first full progress review required by the Act will be in 2015.

Engaging Citizens to Realize our Clean Energy Future: Individuals, Cities & Towns, and Regional Planning Agencies

Throughout the development of this Plan, there has been ongoing interest on the part of the Advisory Committee and the public concerning the need for continued citizen engagement in reaching the clean energy and climate goals set forth in the Global Warming Solution Act.

During the course of eight public hearings held across the state and in written comments, EEA learned of many projects and activities that Massachusetts citizens, non-governmental organizations (NGOs), universities, business groups, and municipalities are engaged in to reduce GHG emissions and work toward a clean energy future. EEA and the Commonwealth's agencies recognize the value of these efforts and commit to work together and support them as we collectively strive to implement this Plan.

Individuals are already making clean energy decisions such as making their homes more energy efficient, and are eager for information about how they can do so where they work, shop and play.

As of December 2010, 53 communities had attained designation as Green Communities, becoming eligible for funding to go greener as a result; and 64 communities have adopted the "stretch code," a local-option building code that sets a standard of 20 percent to 30 percent more energy efficient than the Commonwealth's recently adopted statewide code. Earlier this year, the city of Boston adopted a wide-ranging climate action plan that was developed through extensive community engagement. In addition, a variety of independent climate and energy initiatives at the municipal level are developing practices and information that state agencies can learn from and support.

Regional planning organizations, in particular, are valuable partners for the state to work with in crafting solutions tailored to the unique challenges and opportunities of their regions. Some already have sustainability and/or smart growth programs that result in GHG reduction. For example, the Pioneer Valley Planning Commission and Franklin Regional Council of Governments recently released a clean energy plan that charts a path toward greater energy independence and the use of cleaner and more efficient energy in the Valley. The process of creating and now implementing the plan has been a prime example of state, regional and local government collaboration, and engagement of citizens, non-governmental organizations (NGOs) and the private sector.

NGOs of all types are making effective use of their community roots to raise consciousness about the risks of climate change and the opportunities for a clean energy future. College and university students are informed, organized and eager to help shape their energy and climate future; these students gave impassioned testimony at every public hearing.

As the Commonwealth agencies responsible for implementing parts of this Plan develop their programs, they will look for opportunities to work with and support these ongoing efforts. Most state agencies have a local presence and networks that can facilitate coordination with local groups; for example, MassDEP has four regional offices and DOER has a Green Communities coordinator located in each of them. MassDOT also has regional offices as well as established relationships with regional planning organizations and regional transit authorities. Pilots and demonstration projects conducted as agencies develop their respective programs under this Plan will provide excellent opportunities to involve local groups in state initiatives.

The work of individuals, municipalities, universities, business organizations, NGOs, and regional planning organizations will be essential to the Commonwealth's success in implementing this Plan and making the transition to a clean energy economy.

IV. Beyond 2020: The Road to 80 Percent Lower Emissions in 2050

Scenarios for a Clean Energy Future

The clean energy economy of 2050 will be very different than the fossil fuel dominated economy of today. With many of the policies embodied in this report in place, 2050 would find a Massachusetts where energy costs are less volatile and comprise a smaller part of budgets. Businesses, households, municipalities and institutions are better able to manage their energy needs. Renewable and alternative sources of energy have largely displaced fossil-based sources, and a smart grid and advanced technology store and release to the grid as needed the electricity generated during the night by massive wind farms off the coast of the Northeast. Both small and large-scale solar installations are ubiquitous across the state.

In this scenario, global geopolitics has dramatically changed also, and United States foreign policy is no longer influenced by the politics of petroleum, natural gas, and coal. National security has been strengthened by an economy driven by homegrown sources of energy that no longer depend on fossil fuel from unstable regions or from countries that do not share the interests of the U.S.

By 2050, the clean energy cluster in Massachusetts has matured, much as the biotechnology and health care sectors matured in the early part of the 21st century. Small entrepreneurial companies and multi-nationals, R&D, manufacturing, and service companies make up a varied and dynamic clean energy economic landscape. Massachusetts plays a dominant role in the global market for technologies in offshore wind, solar PV and thermal, electricity storage and energy management. Massachusetts architects and engineers are leaders internationally in green building design and building energy management. Massachusetts companies that have pioneered battery technology have robust partnerships with American, European, Indian and Chinese car and truck manufacturers.

And, by 2050, GHG emissions will, by law, be 80 percent less than what they were in 1990, and the air will be cleaner.

Even as we chart the course through 2020, it is critical to plan for the path to 2050. Getting to this clean energy future will require significant innovation in policy, technology and business practices. Unlike the 2020 limit, which can be met with actions that we take here in Massachusetts, reaching 80 percent reductions below 1990 emission levels, as required by the Global Warming Solutions Act, will mean broad changes that are beyond the reach of Massachusetts alone. Between 2010 and 2050, much will change — in the economy, in federal regulation, and in technology — that will make possible GHG emission reductions that would be unthinkable today. With the nation-leading requirements of the GWSA, Massachusetts should — and must — stay ahead of the curve. But as it reaches for the more ambitious mandates of 2030, 2040, and 2050 required by the GWSA, Massachusetts can only build on changes percolating throughout the U.S. economy, not strike out entirely on its own.

But in imagining, and planning for, a path to the mandated GHG emissions reduction of 80 percent in 2050, it is important to ask now "How do we get there?"

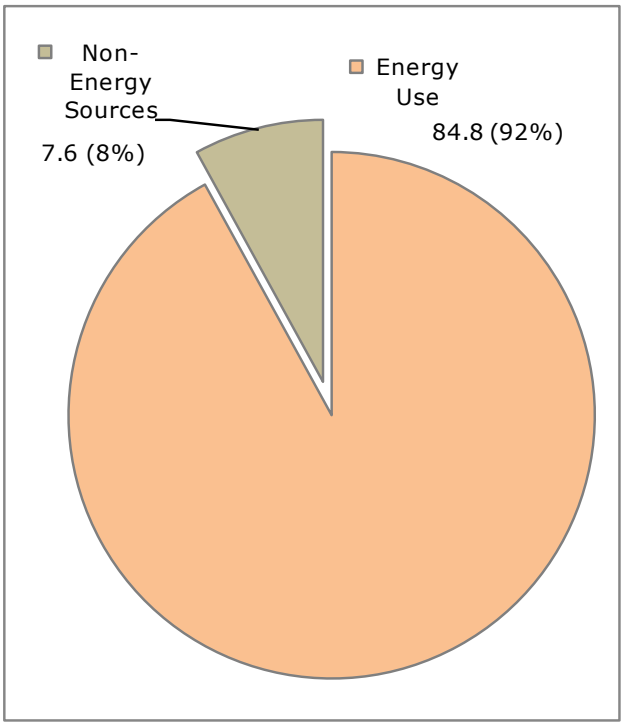

Figure 10. Massachusetts GHG Emissions in 2007 (MMTCO$_2$e and %)

It helps to consider the sources of GHG emissions in Massachusetts. As Figure 10 shows, the vast majority of our state's emissions come from energy use. Burning carbon intensive fuels for transportation, in buildings, and for electricity generation accounted for about 92 percent of statewide GHG emissions in 2007. The rest of the emissions — a scant 8 percent — were from activities other than fuel combustion, such as wastewater treatment and agriculture (both of which emit methane and other GHGs).

Broadly speaking, it is possible to lower GHG emissions from energy use in three ways:

Efficiency — Finding means to deliver the same services (e.g., miles traveled by passenger vehicles, indoor air temperature) using less energy. Examples include weatherizing buildings so they consume less energy to provide comfortable indoor spaces, and higher fuel efficiency standards for passenger vehicles and light trucks so that less fuel is combusted for every mile traveled.

Conservation — Making lifestyle choices that lower energy use even in the absence of efficiency improvements. An example is reducing non-essential driving.

Cleaner energy sources — Substituting low carbon energy sources for the carbon intensive fuels we use today. An example is generating electricity from wind or solar energy instead of from fossil fuels.

The first two of these approaches target energy demand, while the third focuses on energy supply.

This chapter explores how these approaches could be combined with cuts in non-energy emissions to hit the 2050 target required for Massachusetts. It presents the results of scenario modeling of the state's energy system and economy, conducted to assess conditions that would allow achievement of the 2050 limit. The first part characterizes the modeling process and explains how the two scenarios presented here were devised. A summary of the scenarios and their emissions and energy projections follows, along with implications for Massachusetts clean energy and climate policy. The chapter goes on to review policies which will either have small impacts by 2020 or may not be needed to reach the 2020 emissions limit, but are critical to achieving the 2050 limit.

Scenario Modeling: Purpose and Process

In order to understand the challenges and opportunities of meeting the 80 percent by 2050 goal, the EEA began by modeling scenarios of statewide energy use and GHG emissions. The scenarios comprised all modes of transportation, residential and commercial buildings, electricity generation, and numerous other factors.

Assisted by technical consultants, EEA used the scenarios to project potential futures for Massachusetts that would allow attainment of the 2050 goal. In this sense, the scenarios were not so much predictions or forecasts as thought experiments: they showed possible ways to cut GHG emissions under various conditions. A central consideration in crafting the scenarios was that they be plausible. To that end, the modeling team limited itself to technology that is currently available or expected to emerge shortly. The team also consulted published scientific and technical literature and other government and academic modeling projects for insights into plausibility.

After experimenting with several scenarios, the modeling team developed two that achieved the 80 percent target (within a reasonable margin of error): one stressing electrification and clean electricity supply; and another prioritizing efficiency and conservation measures. The next sections describe these scenarios. The team also determined that the target could be attainable in a scenario of substituting low carbon biofuels for fossil fuels. However, as such a scenario is basically equivalent to the electrification scenario — replacing clean electricity with clean biofuels — it is not treated here.

Scenario Descriptions: Narratives and Assumptions

SCENARIO 1 — ELECTRIFICATION: A RESIDENT'S VIEW

Houses are better insulated and ventilated than they were 40 years ago. Many houses look like those from the Massachusetts 2010 Zero Energy Challenge — there are a number in your neighborhood. Increasingly, homeowners are turning to electric heat pumps for space and water heating. The cost of these systems has been dropping for a number of years, and it's now standard practice to include them in new houses. Solar hot water and residential photovoltaic (PV) installations are also commonplace. You rented out your rooftop to a solar PV company last year, cutting your electricity bill in half.

You still drive to work each day, but you do it in a highly efficient electric car. When you take public transportation, you're generally in an electric vehicle as well — whether a train, bus, or subway. You hardly see any petroleum-powered vehicles anymore, except for airplanes and some trucks. But even those use a 40 percent biofuel blend.

Most commercial buildings are more energy efficient than they were in 2010; a significant fraction look like the advanced green buildings of that era. Just as in houses, electric heat pumps, solar hot water, and PV arrays are increasingly the norm in commercial buildings.

You work in an industrial setting — at a advanced battery manufacturer that supplies batteries for the new fleets of cars, minvans, and trucks that are coming out of Detroit — and business is booming. Gross state product has more than doubled since 2010, while industry's fraction of it is unchanged. Meanwhile, the energy intensity of industrial operations has been falling, and many firms have retooled their processes around electric power (instead of fossil fuels). Your employer recently replaced most of the equipment on the shop floor with new high-efficiency models, improving productivity and cutting operating expenses.

The electrification scenario meets the challenge of the 2050 goal by pairing widespread electrification in transportation, buildings, and industry (i.e., switching from fossil fuels to electricity) with an extremely clean electricity supply. These changes are backed up by energy efficiency gains throughout the economy and progress toward reducing non-energy GHG emissions. Table 3 lists the major assumptions defining the electrification scenario. The narrative in the sidebar describes what you might experience if you were a resident of Massachusetts in 2050.

Table 3. Electrification Scenario	
Sector	**Assumption**
Statewide	The population of Massachusetts grows to 7.6 million people by 2050 (about 18% higher than today).
	Gross state product (GSP) grows to $930 billion (2008$) by 2050 (approximately 150% higher than today). This increase is based on the historical rate of per capita income growth in Massachusetts.
Transportation	By 2050, 90% of light duty vehicles are pure electric, 5% are plug-in electric, and 5% are hybrids.
	By 2050, passenger and freight vehicle efficiency improves substantially. For example, holding vehicle size constant, the energy intensity of hybrid gasoline cars (energy required per mile traveled) falls about 31% between now and 2050.
	By 2050, transit service doubles and number of people per vehicle increases 20% from today's levels.
	By 2050, commuter rail and intercity rail in Massachusetts are completely electric; 90% of buses are electric.
	By 2050, 40% of commercial aircraft and road freight miles are powered by biofuel that produces 70% fewer GHG emissions than burning gasoline.
	Growth in annual commercial air travel miles stops in 2020.
Residential and Commercial Buildings	By 2050, only 16% of houses have the same energy use profile as a typical house today; 40% match the energy performance of today's advanced green houses. New and upgraded houses mainly use electric heat pumps for space and water heating.
	By 2050, only 20% of commercial buildings have the same energy use profile as a typical commercial building today; 40% match the energy performance of today's advanced green commercial buildings. New and upgraded buildings mainly use electric heat pumps for space and water heating.
Industry	Rising at the same rate as GSP, industrial output in Massachusetts grows to $162 billion (2008$) by 2050.
	40% of industrial energy comes from electricity in 2050.
	Between now and 2050, industrial energy intensity (energy required per $ of output) decreases 2% per year on average.
Electricity Generation	By 2050, 100% of the electricity consumed in Massachusetts comes from near zero carbon sources: renewables, pre-2000 nuclear facilities, and a small amount of biomass, and this constitutes 112% of what total Massachusetts electricity use was in 2007, or 9 times the amount of low-carbon supply in 2007. The state no longer uses any electricity from natural gas, coal, or oil.

Scenario Descriptions: Narratives and Assumptions

SCENARIO 2 — EFFICIENCY AND CONSERVATION SCENARIO: A RESIDENT'S VIEW

Every house in the state uses less energy per square foot than a typical house did 40 years ago. Improved lighting, insulation, appliances, and heating and cooling systems are universal. Houses remaining from 2010 have been equipped with these enhancements (to a greater or lesser degree), and new houses include them as a matter of course. Nearly half of all houses meet efficiency standards only attained by the best "green" prototypes in 2010. Yours is one of them: when you bought it 10 years ago, you had a deep energy improvement performed before moving in. The contractor installed an electric heat pump for heating and cooling, solar hot water collectors, and a PV array, among other improvements. Residents statewide are increasingly choosing these technologies to meet household energy needs. They're also opting for markedly smaller homes, prompting a reduction in the size of new houses and conversions of large dwellings into multi-family residences.

For several decades, the trend in passenger vehicles has been toward more efficient cars. Light trucks have fallen out of favor except with trades people who need them for work, as have SUVs except for those who need true off-road capability, with the number on the road dropping 75 percent since 2010. Drivers are carpooling more, and everyone thinks twice about single-purpose drives to the store or the mall. You still have that hybrid, but your spouse made the switch to an electric car a few years ago, and you take the electric when you travel together. More and more, you use public transportation when you can. It helps that transit service is more widespread and frequent than it used to be. You don't travel by plane as much as you once did, either; for short and middle distance trips, you go by high-speed train or your car, and you take long trips less often.

Like everyone you know, you work in a building that's substantially more energy efficient than commercial buildings were in 2010. Half of today's buildings would have been considered advanced green buildings in 2010, and many use electric heat pumps instead of fossil fuels.

Industrial output in Massachusetts has more than doubled since 2010, while the energy intensity of industrial production has fallen by almost two thirds. Enterprises requiring a skilled, educated workforce continue to locate in the state, contributing to steady economic growth.

The efficiency and conservation scenario achieves the 2050 goal through a combination of maximal efficiency gains in all sectors and consumer choices favoring energy efficiency and conservation. Complementing these developments are some fuel switching toward electricity, a significant (but not total) de-carbonization of the electricity supply, and cuts in non-energy emissions. Table 4 shows the principal assumptions underpinning the efficiency and conservation scenario, and the sidebar provides a parallel narrative — what you might experience under this scenario if you were a resident of Massachusetts in 2050.

Table 4. Efficiency and Conservation Scenario

Sector	Assumption
Statewide	The population of Massachusetts grows to 7.6 million people by 2050 (about 18% higher than today).
	Gross state product (GSP) grows to $930 billion (2008$) by 2050 (approximately 150% higher than today). This increase is based on the historical rate of per capita income growth in Massachusetts.
Transportation	By 2050, 60% of light duty vehicles are pure electric, 20% are plug-in electric, and 20% are hybrids.
	By 2050, passenger and freight vehicle efficiency improves even more than in scenario 1, with (for example) the energy intensity of hybrid gasoline cars falling about 36% between now and 2050.
	Consumer preferences shift toward more efficient cars. By 2050, technologies allow cars to use one third less energy than it otherwise would have.
	Apart from those who need special functions, consumers shift away from light trucks and passenger vehicles built on light truck chassis (SUVs). By 2050, the share of trucks in the light duty vehicle fleet drops to 10 percent (from around 40 percent today).
	By 2050, utilization of cars and light trucks rises to 2.0 people/vehicle (compared to 1.6 today).
	By 2050, less non-essential driving causes the total number of miles traveled in light duty vehicles to be 15% lower than it would otherwise have been.
	By 2050, transit service increases 2.5 times and ratio of people-per-vehicle rises 30% from today's levels.
	By 2050, 40% of commercial aircraft and road freight miles are powered by biofuel that produces 70% fewer GHG emissions than gasoline.
	Annual commercial air travel miles drop 50% between 2010 and 2050 as regional and intercity rail increases.
Residential and Commercial Buildings	By 2050, no houses have the energy use profile of a typical house today; 45% match the energy performance of today's advanced green houses. New and upgraded houses mainly use electric heat pumps for space and water heating.
	By 2050, only 5% of commercial buildings have the energy use profile of a typical commercial building today; 50% match the energy performance of today's advanced green commercial buildings. New and upgraded buildings mainly use electric heat pumps for space and water heating.
	In residential buildings, average square footage per household is about 22% lower in 2050 than today.
Industry	Rising at the same rate as GSP, industrial output in Massachusetts grows to $162 billion (2008$) by 2050.
	Between now and 2050, industrial energy intensity decreases 2.5% per year on average.
Electricity Generation	By 2050, about 80% of the electricity consumed in Massachusetts comes from near zero carbon sources: renewables, pre-2000 nuclear facilities, and a small amount of biomass used in high efficiency combined-heat-and-power applications. The low-carbon power is about five times the amount used in Massachusetts in 2007 (about half the amount of low-carbon power needed in the electrification scenario). The remainder is from natural gas generation.

Scenario Results

In both the electrification and efficiency and conservation scenarios, Massachusetts reaches the 80 percent target by 2050. Given the first two assumptions in Tables 1 and 2 — of rising population and real income — this achievement is remarkable.

Significant changes in infrastructure, technology, and consumer choices pave the way to the 80 percent reduction. Figure 11 depicts projected statewide GHG emissions under the scenarios, as well as historic emissions and a business-as-usual trajectory.

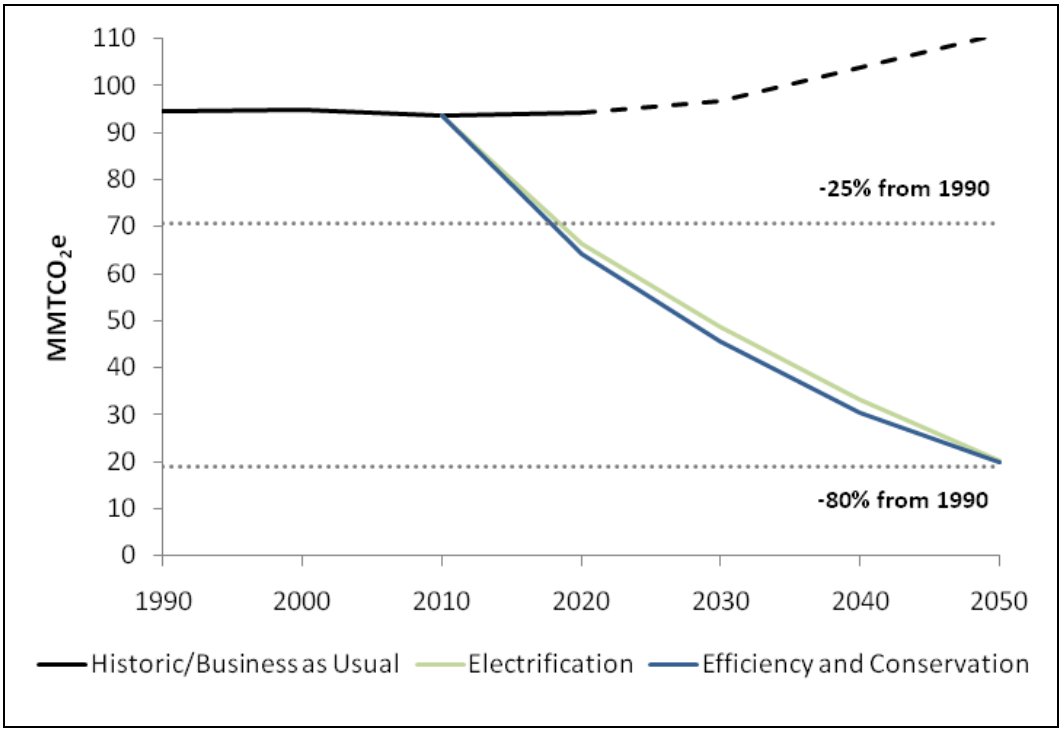

Figure 11. Historic and Projected Massachusetts GHG Emissions

The two scenarios have important commonalities, such as improvements in vehicle and building efficiency, shifts away from fossil fuels in transportation and buildings, and deployment of low carbon electricity generation. But they differ in how they combine demand- and supply-side approaches to reducing GHG emissions from energy use. In the electrification scenario, low-carbon supply rises greatly, to 112 percent of total Massachusetts electric consumption in 2007, or providing nine times the amount of low-carbon supply that Massachusetts consumed in 2007. In the efficiency and conservation scenario, the low-carbon supply only has to rise to about five times the 2007 amount.

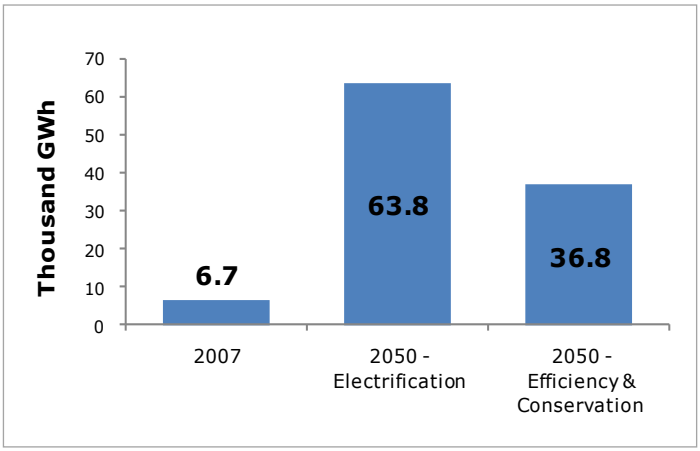

Figure 12. Supply of Near-Zero Carbon Electricity

In the efficiency and conservation scenario, enhanced efficiency measures and consumer choices produce lower transportation and buildings emissions than in the electrification scenario, notwithstanding some continued reliance on fossil fuels. These incremental gains make feasible a somewhat more carbon intensive energy supply. Figure 13 shows that the efficiency and conservation scenario allows for more emissions from electricity generation, whereas more non-emitting electricity sources are needed for the electrification scenario. Both scenarios require dramatic reductions in energy use, but the electrification scenario allows for somewhat greater electricity generation (from clean sources) even compared with today, while the efficiency and conservation scenario requires less energy use (and electricity generation) overall.

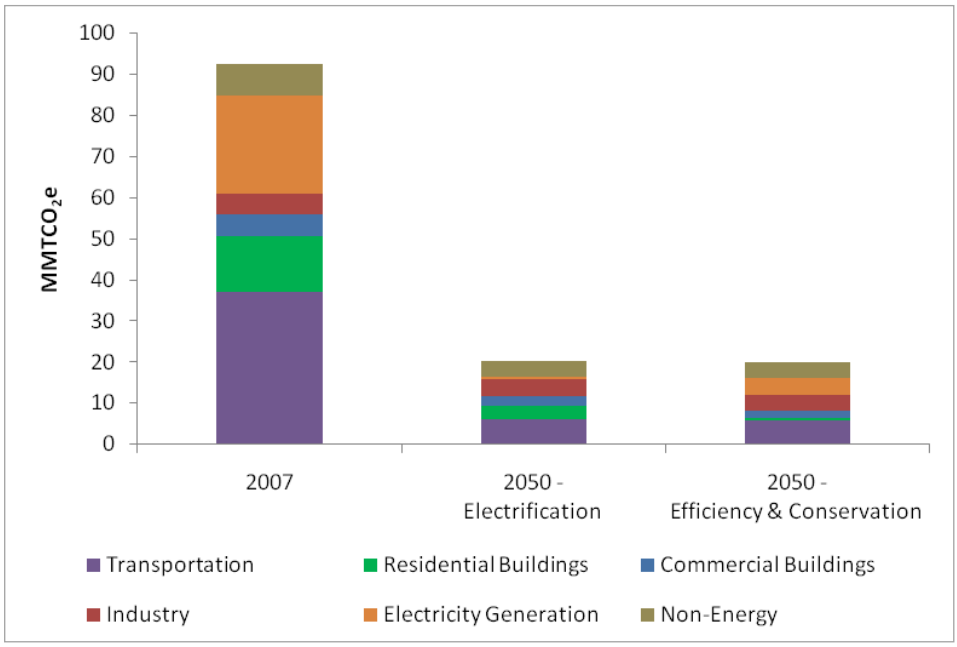

Figure 13. Emissions by sector in two scenarios.

The transportation and buildings sectors are by far the largest end users of energy in Massachusetts. Both scenarios count on considerable gains in building energy efficiency by 2050. These gains go further in the efficiency and conservation scenario, especially for existing houses — more of them are upgraded with energy saving measures and high efficiency mechanical systems. For residential buildings that exist in 2010, the electrification scenario assumes that energy demand per square foot is cut in half by 2050, while in the efficiency and conservation scenario it is cut by two-thirds. Homes that are built between 2010 and 2050 use even less energy, about 50 percent as much per square foot as existing buildings in the efficiency/conservation scenario.

There are three ways that transportation emissions can be reduced — reducing VMT, improving fuel efficiency, and reducing the carbon content of vehicle fuel. To achieve an 80 percent emissions reduction, all of these must achieve large gains relative to Business as Usual (BAU). In the electrification scenario, where vehicles are running almost entirely on low-carbon power, VMT for cars and light trucks is able to grow from 51 billion miles to 58 billion, while in the efficiency and conservation scenario it decreases to 48 billion miles, and the share of light trucks in the fleet drops steeply. Vehicle efficiency improves greatly in both scenarios, but more so in the efficiency and conservation scenario. Conversely, carbon emissions per unit of fuel are only about half as large in the electrification scenario, at 114 grams of CO_2 per kwh of energy input, as they are in the efficiency and conservation scenario (at 217 grams CO_2 per kwh).

Policy Directions to be Developed in Coming Years

As the scenarios show, reducing emissions by 80 percent in 2050 depends on dramatic changes in energy and transportation systems. Some of the policy changes that are critical to reaching the 2050 reduction requirement are included in the 2020 policies discussed earlier in this Plan. But the GHG reductions shown are relatively small, because these policies need long lead times for development and their impacts grow over time, becoming more significant after 2020. In addition, further new policies will be needed that are not necessary to reach the 2020 target, but are essential to reaching the 2050 mandate. Below we briefly review both sets of policy possibilities.

Policies in 2020 Plan that have relatively small impacts in 2020 but are critical for 2050

Buildings — As the scenarios show, on average energy use must drop by at least 42 percent for existing buildings in the electrification scenario and by 69 percent in the efficiency/conservation scenario by 2050. To accomplish this, policies to achieve much deeper reductions in energy use than result from the current utility programs will be needed. For new buildings, this can result largely from code requirements, while for existing buildings it is likely that other forms of incentives and regulatory requirements will be needed. Because buildings are so long-lasting, investments that are made in 2011 and beyond are likely to yield GHG savings for a century or more, while inefficiencies that are not rectified will produce excess emissions for decades. Four of the proposed policies to address this have been discussed in detail earlier in this Plan, but are worth re-emphasizing in their importance for 2050.

Building rating and labeling — At present, the likely energy use of existing buildings, both commercial and residential, is largely unknown to prospective purchasers and tenants. As a result, the built-in efficiency of a building (as distinct from occupant behavior) has little value in the marketplace. Rating the energy performance of buildings relative to an objective standard for others of the same size and type will make it possible for sales and rental prices to take energy use into account, giving owners an incentive to improve performance for resale value. In addition, rating and labeling are prerequisites to instituting performance requirements, which will become necessary over time in order to reduce the average consumption of existing buildings.

Building codes — To achieve the dramatic reductions in energy use that is needed for new buildings, building additions, and major renovations of existing buildings, continual updating of building codes is the most cost-effective policy. This will require conversion of traditional "prescriptive" codes, which dictate specific measures, to performance-based standards, and tightening over time of the energy requirements. Technological development, experience within the industry, and increases in the real cost of energy, along with an eventual price of carbon, should make such tightening cost effective. Recent trends and projections for the next few years in the IECC and American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) standards show that continual improvement in codes is feasible. Again, because buildings are so long-lasting, it is essential that improvements in the shells of new buildings (insulation and air sealing) be ramped up as quickly as possible.

Deep energy improvements — Today utility-administered efficiency programs provide incentives for "moderate" retrofits of existing buildings, such as installing insulation in attics and in exterior wall cavities, purchasing compact fluorescent light bulbs and high-efficiency commercial light fixtures, and more efficient appliances. Achieving nearly universal adoption of such items should be sufficient to reach the 2020 GHG target, but not for 2050. "Deeper" retrofits, including such items as rigid insulation on the exterior walls of buildings under new siding, triple-glazed windows, LED lighting, and renewable heating systems, will all be needed.

Tree retention and planting — Because trees grow slowly, planting done in the next decade will have small benefits by 2020, but will contribute greatly to the 2050 target by reducing cooling and heating loads in buildings. In addition, though it is not counted in this Plan due to data limitations, planting more trees will result in greater sequestration of GHGs.

Transportation — to reduce transportation emissions on the order of 80 percent, all three of the primary drivers of emissions will have to be addressed — vehicle efficiency (including driving habits), miles driven, and carbon content of vehicle fuel. The measures below are some of the methods for influencing these three areas.

Smart Growth — To achieve the GHG target, VMT for light vehicles (cars and light trucks) must be reduced by 15 percent in the efficiency/conservation scenario versus the business-as-usual scenario. One of the primary influences on VMT is development pattern, with sprawling business and housing development increasing the amount of non-discretionary driving. This impact can be reduced through smart growth, which concentrates development in and around existing cities and in more compact areas with mixed residential, shopping, and employment uses to reduce transportation needs. Because development in Massachusetts is occurring slowly, the savings from smart growth are relatively small in 2020 but will be much greater in 2050. Without new development taking place primarily in smart growth fashion, however, it will not be possible to reach the necessary emissions reduction from transportation.

Low Carbon Fuel Standard (LCFS) — To achieve the 80 percent reduction limit, the average carbon content of vehicle fuel falls by 54 percent in the electrification scenario and by 12 percent in the efficiency / conservation scenario. This will require the conversion of a majority of motor vehicles from petroleum to other fuel sources, such as electricity or biofuels. The 2020 Plan anticipates that introduction of a LCFS will mandate a 5 percent reduction in the average carbon content of light vehicle fuel, contributing modestly to the 2020 limit. But for 2050 the LCFS must become far stricter, and be supported by other policies necessary for the LCFS to succeed (such as development of fueling infrastructure).

Policies not in the 2020 Plan that are needed for 2050

Beyond the measures described above and earlier in this Plan, the 2050 scenarios make clear that additional measures will be necessary to achieve an 80 percent GHG reduction at that time:

Decarbonizing the electricity supply — In both scenarios for 2050, the vast majority of electricity supply must be low-carbon (70 or 80 percent lower than the average emissions from the New England grid at present). Less of this supply is needed in the efficiency/lifestyle scenario than in the electrification scenario. The resources to achieve this shift are theoretically available, if not entirely in Massachusetts (given our small size and limited supply of renewable resources), then in imports from the region and beyond. The current RPS requires that the state's distribution utilities supply 15 percent of their power from qualifying renewable sources by 2020. For 2050 we will need far more resources from both RPS-eligible and non-RPS qualified sources. Part of this we expect will be obtained from offshore wind resources, which are ample in federal waters off Massachusetts. Part will come from non-RPS sources such as Canadian hydro and wind power. To ensure that sufficient supplies are available, new policy mechanisms will need to be developed that go beyond the RPS, such as the Clean Energy Performance Standard discussed earlier in this Plan.

Converting motor vehicles from petroleum to other fuels — The LCFS is the state's primary policy mechanism for encouraging a shift from petroleum to low-carbon vehicle fuels. However, there is evidence that the LCFS may not by itself be sufficient to cause this shift without complementary policies to induce consumers to shift to alternative fuels.[79] At least in part, this result stems from the difficulty in simultaneously developing alternative fuel sources, the infrastructure to distribute the fuels, and the vehicles that can utilize them. For example, converting a substantial portion of vehicle fuel to electricity requires that electric charging stations be installed at homes and businesses and at public locations, that auto manufacturers produce a variety of plug-in hybrid and all-electric vehicles, and that consumers purchase these vehicles in large numbers at a premium to conventional vehicles (at least in the early years). Substantial incentives for fueling infrastructure and for consumers to purchase the vehicles may be necessary.

[79] Based on results of system dynamics modeling conducted by Ventana Systems, Inc. on behalf of the state's CPGEA planning team.

V. Appendix: Methodology for Estimating Policy Impacts on Employment in 2020

State government policies affect employment in several ways. First, employment in a particular industry whose development is affected can be raised or lowered. Second, every industry buys goods and services from other industries, thus "indirectly" creating employment. And third, both employees and owners spend their incomes, creating "induced" employment. The size of employment changes depends greatly on what portion of an industry's income, and of household incomes, are spent within a state (or other geographic area being considered), and the capital- or labor-intensity of an industry, with labor-intensive ones generally yielding larger employment gains.

For purposes of this Plan, we have examined changes in the demand for the products of various industries, mainly those involved in energy production and consumption and in transportation. In general, the Commonwealth's and the federal government's energy and climate policies are designed to shift spending away from fossil fuels and toward energy efficiency and renewable energy, causing shifts in spending among industries. For example, federal fuel efficiency/vehicle CO_2 standards cause an increase in the cost of manufacturing autos, but the reduction in spending on gasoline and diesel fuel is several times larger than the higher manufacturing costs. Incomes of Massachusetts households rise by the difference between their savings on fuel and their extra spending on new vehicles, and, when they spend this money in Massachusetts, employment in Massachusetts rises. Income for auto manufacturers rises, but, since there are no auto plants in Massachusetts, almost all of this goes out of state, except for the small fraction gained by auto dealers. Income to the petroleum industry falls greatly, but this impact is primarily felt out of the state and out of the country, except for the reduced income to retailers. On balance, we estimate that in 2020 federal efficiency standards for light, medium, and heavy-duty vehicles will raise employment in Massachusetts by 7,000 jobs, driven by fuel savings that no longer go outside the Commonwealth, but that can now be spent in Massachusetts.

A similar procedure has been used for most of the major policies included in this Plan, wherever it was possible to make reliable estimates of the impact of a policy on energy production and consumption, and, as a result, on the incomes and expenses of various industries and on households. The first step in each case is to estimate the dollar value of changes in energy usage, and the amounts of higher or lower spending that will occur in each industry. To convert these to employment changes, several different models can be used; we have utilized the RIMS (Regional Input-Output Multiplier System) of the Bureau of Economic Analysis (BEA) in the U.S. Department of Commerce. Specifically, the RIMS Type II multipliers provide an estimate of the number of jobs in Massachusetts that result from an increase in spending of $1 million on an industry located in the Commonwealth — due to "direct" jobs within the industry itself, "indirect" jobs at suppliers to the industry, and "induced" jobs from spending by employees of the industry. The multipliers must be adjusted for the degree to which spending on an industry, or by an industry, goes out of the state — such as purchases of fuel or equipment from outside the Commonwealth.

When energy costs, such as electricity bills, fall, this is a gain to the incomes of both

households and businesses. To estimate the resulting employment changes, we need to know how much of the savings goes to households and to each type of business, and how each spend their money. The split between households and businesses can be obtained from the state's electric utilities. Then, for households, we have used the Consumer Expenditure Survey of the U.S. Bureau of Labor Statistics as the basis for how families will spend their energy savings. Combining this with the employment multipliers for each industry, we have constructed an employment multiplier for household spending. For businesses, we have used BEA data on the share of Massachusetts Gross Domestic Product coming from each industry, in combination with BEA multiplier data that shows the percentage of each industry's spending that goes to utility costs. These two data sources, then combined with the overall employment multipliers for each industry, give us an estimate of what the employment change will be in Massachusetts for a change of $1 million in business spending on electricity bills.

This procedure was used for those policies where the dominant change was a reduction in fossil fuel spending, and the changes to other industries in Massachusetts could be predicted with some reliability — which includes federal and state vehicle efficiency policies, policies to affect vehicle miles traveled, utility-administered buildings efficiency policies, building codes, and federal appliance/product efficiency standards. However, for renewable energy policies, more of the employment impact comes from growth in the renewable energy industries themselves, including equipment and fuel supplies. For these, we lack Massachusetts-specific studies on the likely development of relevant businesses within the Commonwealth by 2020 — such as manufacturing of solar photovoltaic panels or wind turbines, or conversion of biomass into cellulosic biofuels. We have therefore utilized national-level studies of employment changes due to increased reliance on renewable energy (primarily electricity), some of which have provided state-by-state estimates. However, such studies have not, in general, predicted the degree to which renewable energy industries will develop to differing degrees within different states. These studies usually provide results based either on the current status of the industries by state, or simply based on the overall size of a state's economy. For this reason, in our results shown in this Plan, we have given a broad range for possible employment in 2020 from renewable energy industries.

In most cases, policies as they existed prior to 2008 are considered part of the BAU trend for GHG emissions — for example a portion of savings from building codes and federal appliance standards. Only the post-2008 expansion of programs or creation of new programs are counted as causing reductions from the BAU in GHG. Consequently, energy savings, and the resulting jobs, deriving from pre-2008 policies have in most cases not been counted here. However, the Massachusetts DPU requires DOER to report on the impacts of all efficiency spending, including the level that existed prior to 2008. In order to be consistent with the figures reported to the DPU, the employment figures shown here are based on all efficiency spending.

Sources for transportation and buildings efficiency estimates: RIMS II multipliers for Massachusetts, Bureau of Economic Analysis, U.S. Department of Commerce, December 2010; Consumer Expenditure Survey 2009, Northeast states, U.S. Bureau of Labor Statistics; Gross Domestic Product by Industry for Massachusetts 2009, Bureau of Economic Analysis, U.S. Department of Commerce.

Sources for renewable energy estimates: "Economic Impacts of Extending Federal Solar Tax Credits," Navigant Consulting, Burlington, MA, Sept. 15, 2008; "Wind Turbine Development: Location of Manufacturing Activity," George Sterzinger and Matt Svrcek, Renewable Energy Policy Project, Sept. 2004; "Solar PV Development: Location of Economic Activity," George Sterzinger and Matt Svrcek, Renewable Energy Policy Project, January 2005; "The Economic Benefits of Investing in Clean Energy," Robert Pollin et al, Political Economy Research Institute and Center for American Progress, June 2009; "Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?," Daniel M. Kammen et al, Renewable and Appropriate Energy Laboratory, Goldman School of Public Policy, University of California - Berkeley, April 13, 2004 (corrected 1/31/2006).

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