Assessing the Health Impacts and Benefits of Regional Climate Action Plan Strategies in Western Massachusetts

A COLLABORATIVE ASSESSMENT BY THE MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH, THE PIONEER VALLEY PLANNING COMMISSION, AND THE MUNICIPALITIES OF SPRINGFIELD AND WILLIAMSBURG

Massachusetts Department of Public Health
Bureau of Environmental Health
Bureau of Community Health and Prevention

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EXECUTIVE SUMMARY

Introduction

Health Impact Assessments (HIAs) use data, research, and stakeholder input to assess the likely positive and negative health impacts of a proposed policy, plan, or project before it is implemented. An HIA informs the decision-making process by providing recommendations for changes to a proposal that promote positive health outcomes and minimize negative consequences. A key feature of an HIA is to identify and reduce health inequalities that may arise from a proposal. This HIA — which focused on the communities of Springfield and Williamsburg — explored an overall approach for supplementing climate change action strategies with information on the public health impacts and benefits of these strategies. Due to limited resources and time constraints, this HIA should be viewed as a pilot project for demonstrating the feasibility of using HIAs to evaluate climate action strategies at the local level. A long-term goal of this initial effort is to provide a roadmap for other municipalities and regional agencies to consider health in their climate adaptation planning process.

This HIA represents a collaborative effort by the Massachusetts Department of Public Health (DPH), the Pioneer Valley Planning Commission (PVPC), and the municipalities of Springfield and Williamsburg. The climate action strategies are based on the regional Pioneer Valley Climate Action and Clean Energy Plan (PV Climate Action Plan) completed by the PVPC in 2013. The aim of that plan was to promote greater understanding of the causes and consequences of climate change in PVPC's service region (which includes Springfield and Williamsburg) and to identify a set of actions that local governments and other partners could consider to mitigate and adapt to climate effects.

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An Advisory Committee of stakeholders identified two climate action strategies from the PV Climate Action Plan to be evaluated in the HIA:

(1) Providing cooling centers and other approaches to assist vulnerable populations during heat-related events; and

(2) Implementing energy efficiency measures in municipal buildings.

A summary of the scientific literature, formulation of research questions, pathway diagrams, assessment of the distribution of health impacts and benefits, and the findings and recommendations for each strategy are summarized below.

Highlights of the Literature Review

Below is a brief summary of the literature review for each of the strategies evaluated in this HIA. Additional information and references are provided in the report.

Heat-related Events

According to the National Climate Assessment, the climate in the Northeast is experiencing noticeable changes that are expected to increase in the future. Between 1895 and 2011, temperatures rose by almost 2°F, and projections indicate temperature increases of 4.5°F to 10°F by 2080. As the global climate continues to change, extreme heat events are predicted to occur more frequently and heat-related morbidity and mortality is expected to rise. Extreme heat events account for more fatalities in the U.S. than any other weather hazard. Prolonged exposure to heat can cause dehydration, heat stress, heat exhaustion, and heat stroke. Chronic medical conditions (e.g., diabetes, renal disease, cardiovascular disease, respiratory disease) increase vulnerability to heat, especially among elderly people. Increases in outdoor temperature also influences outdoor air pollutants levels including ozone, aeroallergens, and fine particles.

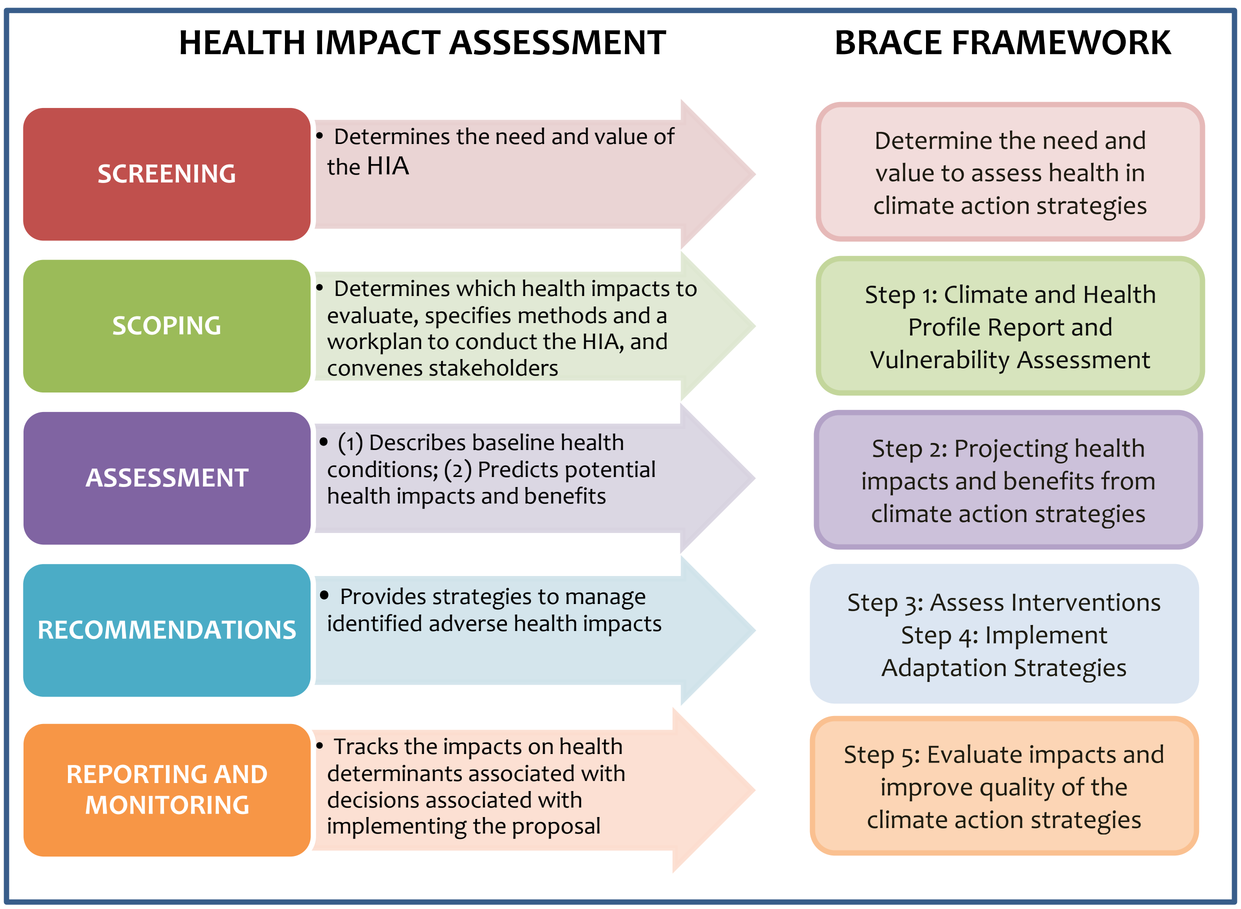
The ability to reduce exposure to heat during extreme events, especially for vulnerable populations, will be an increasingly important health determinant. Elderly people living alone are especially vulnerable. For example, vulnerability factors associated with mortality during the 1995 Chicago heat-related event were elderly living alone, not leaving home daily, lacking access to transportation, and not having an air conditioner. Cooling centers should be located in areas that are accessible to the most vulnerable populations and should be advertised in a way that targets those populations. Coordination between local police and fire departments, human services, the local public health department, emergency medical services, and local hospitals during heat-related events is essential for preventing morbidity and mortality among the most vulnerable populations.

Energy Efficiency

Energy efficiency measures reduce electricity demand by improving end-use technologies in residential, commercial, industrial and manufacturing sectors. In addition to reducing energy consumption and related costs, energy efficiency measures benefit public health by reducing emissions of greenhouse gases and air pollutants, and increasing the reliability of the energy grid. Energy efficiency measures also contribute to energy security by reducing dependence on foreign sources of fuel. According to the US Environmental Protection Agency (US EPA), state and local government agencies across the US spend more than $10 billion a year on energy to provide public services and meet constituent needs, but nearly one-third of the energy used by typical government buildings can be conserved. A 2007 expert report on energy efficiency concluded that strategies emphasizing energy efficiency are the most economically and environmentally sensible ways of providing energy for sustainable development and addressing climate change. Energy efficiency measures that tighten the building envelop also need to ensure adequate ventilation to maintain healthy indoor air quality.

The BRACE framework is a five-step process that allows health officials to develop strategies and programs to help communities prepare for the health effects of climate change. The 5-step process of the BRACE framework incorporates an assessment of climate change impacts and vulnerability (Step 1), assessment of projected health impacts (Step 2), evaluation of evidence-based public health intervention options (Step 3), development and implementation of a climate and health adaptation plan (Step 4), and evaluation of activities in an iterative framework (Step 5). The HIA framework complements the BRACE framework by providing a decision-support tool to assess a wide array of climate-related health impacts and develop health-based intervention and adaptation strategies. Figure 1 illustrates how each step of the BRACE framework was integrated into the assessment phase of this HIA.

Figure 1: Integration of CDC BRACE Framework into HIA Process



Pathway Diagrams

A pathway diagram visually demonstrates the link between the proposal and potential health outcomes. Literature reviews and input from the Advisory Committee informed the development of the pathway diagrams for the climate action strategies evaluated in this HIA.

Figure 2 presents the potential health impacts associated with providing cooling centers and other approaches to assist vulnerable populations during heat-related events. The assessment of this pathway focused on projected increases in the frequency and intensity of heat-related events, characterization of vulnerable populations in each community, evaluation of existing heat response plans in each community, and mapping the location of existing cooling centers.

FIGURE 2: PATHWAY DIAGRAM FOR PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATIONS

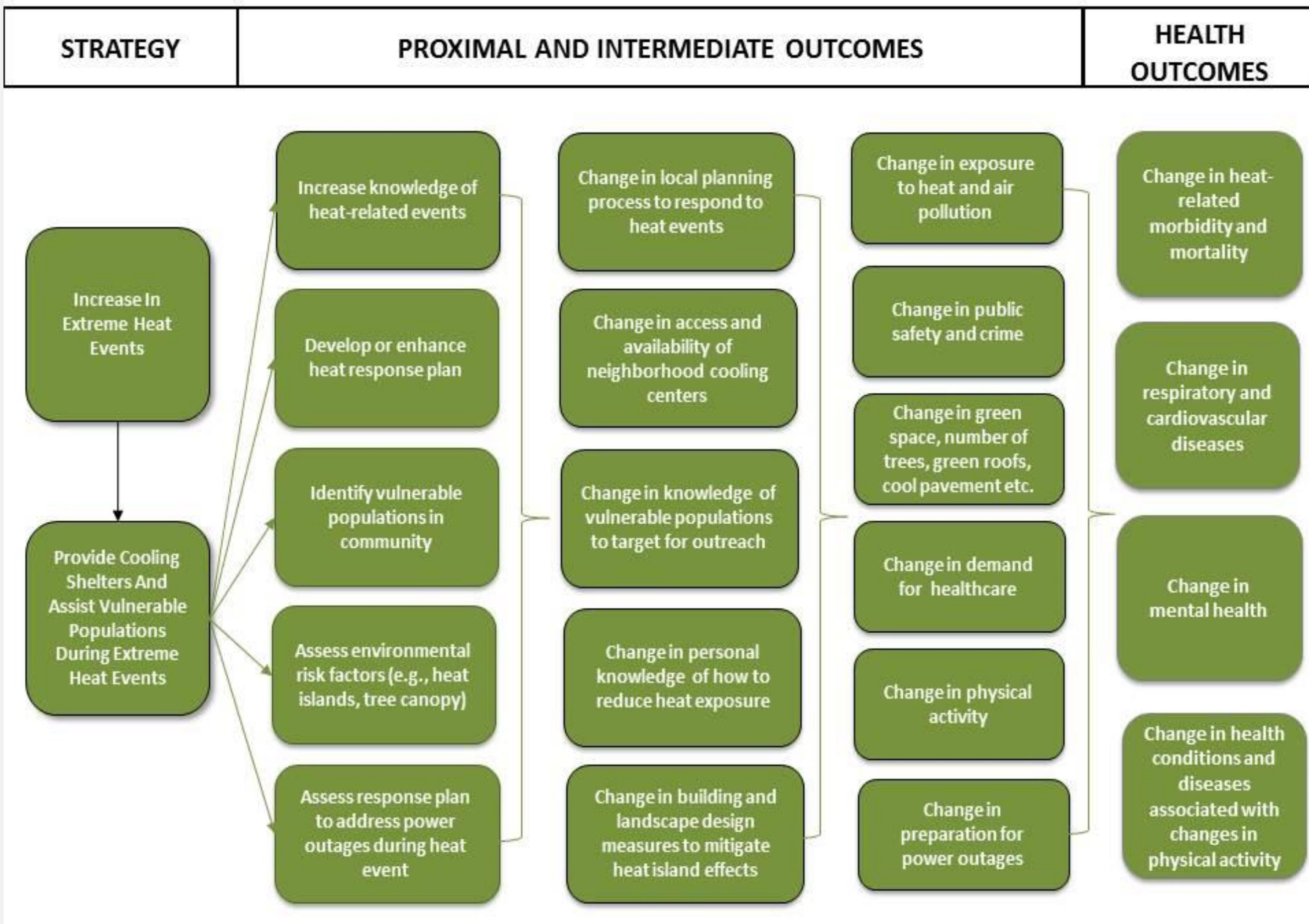


Figure 3 presents the potential health impacts of implementing energy efficiency measures in municipal buildings. In addition to assessing potential climate and vulnerability impacts, the assessment included semi-quantitative analysis of changes in local and regional air pollution emissions from reductions in electricity associated with energy efficiency measures implemented in each community.

FIGURE 3: PATHWAY DIAGRAM FOR IMPLEMENTING ENERGY EFFICIENCY IN MUNICIPAL BUILDINGS

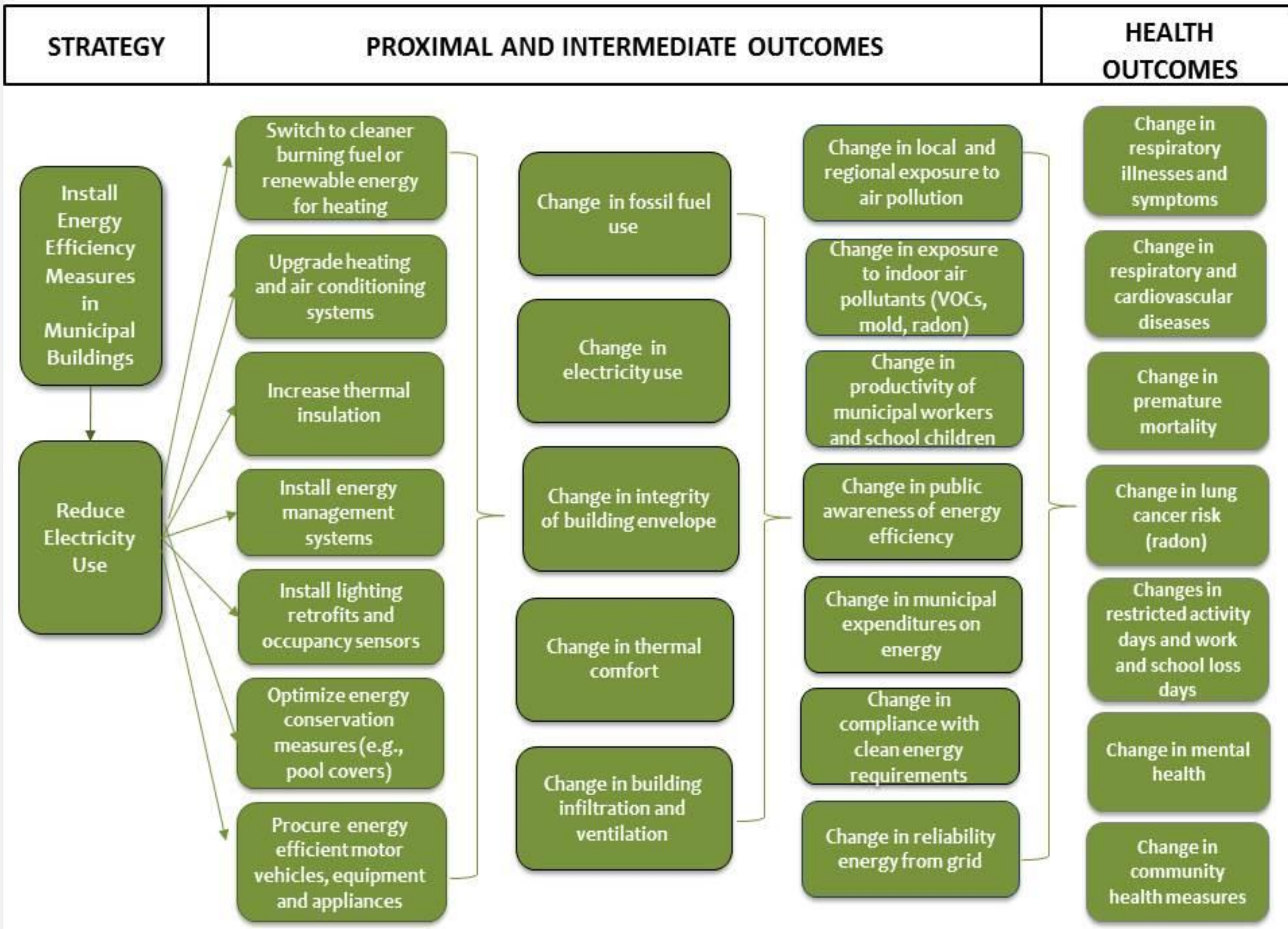


Table 3 and Table 4 provide the overall summary of major impacts, magnitude, severity, strength of causal evidence, assumptions, and limitations/uncertainties of the assessment of climate action strategies evaluated in this HIA using the following criteria:

TABLE 3: OVERALL HEALTH ASSESSMENT FOR PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATIONS DURING HEAT-RELATED EVENTS

<table>
<tr><th colspan="7">PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATION</th></tr>
<tr><th>HEALTH OUTCOMES</th><th>Impact</th><th>Magnitude</th><th>Severity</th><th>Strength of Causal Evidence</th><th>Assumptions</th><th>Limitations / Uncertainties</th></tr>
<tr><td>Change in heat-related morbidity and mortality</td><td>+</td><td>Moderate</td><td>High</td><td>♦♦♦</td><td rowspan="2">Municipalities will develop/enhance and implement a heat response plan that includes planning for vulnerable residents; and expand education and outreach plans on reducing heat exposure during heat events.</td><td rowspan="2">Information on existing use of centers is needed; Impact of power outages during heat-related events is unknown.</td></tr>
<tr><td>Change in respiratory and cardiovascular diseases</td><td>+</td><td>Major</td><td>High</td><td>♦♦♦</td></tr>
<tr><td>Change in mental health</td><td>+</td><td>Unknown</td><td>Unknown</td><td>♦♦</td><td rowspan="2">Municipalities will begin a dialogue about how to address environmental risk factors (e.g., heat island, tree canopy) through changes in building and landscape design measures. Planning and implementation of design measures is required. Increased physical activity is a co-benefit of these actions.</td><td rowspan="2">Insufficient data on mental health effects and future study is recommended.
Insufficient data on changes in physical activity.</td></tr>
<tr><td>Change in health conditions and diseases from increased physical activity</td><td>+</td><td>Unknown</td><td>Unknown</td><td>♦♦♦</td></tr>
</table>

Impact refers to whether the alternative will improve (+), harm (-), or unknown (+/-).

Magnitude reflects a qualitative judgment of the size of the anticipated change in health effect (e.g., the increase in the number of cases of disease). Negligible, Minor, Moderate, and Major.

Severity reflects the nature of the effect on function and life-expectancy and its permanence: High = Intense/severe; Mod = Moderate; Low = Not intense or severe.

Strength of Causal Evidence refers to the strength of the research/evidence showing causal relationship between strategies and the health outcome: ♦ = plausible but insufficient evidence; ♦♦ = likely but more evidence needed; ♦♦♦ = high degree of confidence in causal relationship.

TABLE 4: OVERALL HEALTH ASSESSMENT OF IMPLEMENTING ENERGY EFFICIENCY MEASURES IN MUNICIPAL BUILDINGS

IMPLEMENT ENERGY EFFICIENCY MEASURES IN MUNICIPAL BUILDINGS						
HEALTH OUTCOMES	Impact	Magnitude	Severity	Strength of Causal Evidence	Assumptions	Limitations / Uncertainties
Respiratory illnesses and symptoms	+	Moderate	High	♦♦♦	Improved indoor air quality in schools and municipal buildings including compliance with ventilation guidelines.	The magnitude of the outdoor air quality impact from reduced use of heating oil is uncertain.
Respiratory and cardiovascular diseases	+	Moderate	High	♦♦♦	Reductions in regional air pollution from displaced electricity at electric generating units (EGUs) occur at specified units.	A major limitation of US EPA's model for quantifying benefits of air pollution reductions is that it underestimates total benefits because it only includes secondary formation of $PM_{2.5}$ from NOx and SOx emissions.
Change in premature mortality	+	Major	High	♦♦♦		
Change in lung cancer risk	+/-	Unknown	Unknown	♦♦♦	Indoor radon levels vary across municipalities.	Pre- and post-monitoring is needed. Energy efficiency measures may increase or decrease indoor radon levels.
Restricted activity days and work/school loss days	+	Major	Moderate	♦♦	Increased productivity of workers and students from improvements from energy efficiency measures including improved indoor air quality and lighting.	Surveys are needed. Limited studies from California of post-retrofit benefits in school children; no data on municipal workers.
Change in mental health	+	Unknown	Unknown	♦♦	Improved work/school environment. Public awareness and empowerment to address energy issues and climate change at the local level	Stakeholders provided evidence of positive responses from residents. Further assessment is recommended.
Change in community health measures	+	Unknown	Unknown	♦	Shift in municipal expenditures from energy to other uses; increase market value of municipal buildings	Impact of energy efficient buildings on market value of municipal assets is unknown.

Major Findings of the HIA

- Overall, the HIA found that while designing appropriate research methods for evaluating specific climate action strategies can be challenging, HIAs can be an effective tool to convene municipal stakeholders, evaluate baseline health conditions, and qualitatively assess the health implications of mitigation and adaptation strategies at the local level.

- A key feature of this HIA is the integration of an evidence-based framework developed by CDCs Climate and Health Program (i.e., BRACE framework) to support the advancement of health-based climate change adaptation strategies. Evaluation of the approach for integrating the BRACE framework into the appropriate phases of the HIA found that: (1) the approach addressed one of the goals of the HIA to collect and analyze evidence between climate change planning and health; (2) the approach informed the assessment phase of the HIA by providing evidence-based data on climate impacts, health outcomes of greatest concern, and populations potentially vulnerable to climate impacts; and (3) the findings of the HIA can inform the adaptation planning process.

Heat-related Events

- The climate action strategy to provide cooling centers and other approaches to assist vulnerable populations was found to likely reduce heat-related morbidity and mortality.

- For heat-related impacts, baseline health conditions in Springfield (e.g., higher prevalence of respiratory disease and diabetes in adults, and pediatric asthma) indicate that the health co-benefits of this strategy may be substantial.

- While there are significant differences in the baseline health profile of Springfield compared to Williamsburg in terms of the number of people in poverty, the number of people of race/ethnicity other than white, and population density, the percent of one category of vulnerable residents — elderly living alone (i.e., 1 in 3) — is the same in both communities.

- The common issues and resource constraints shared by both a large urban city and a small rural town in developing and activating a heat response plan, including education and outreach to vulnerable populations, as well as taking steps to mitigate environmental risk factors (e.g., lack of trees and green space, impervious surfaces) through changes in building and landscape design measures may be more effectively addressed through regional efforts.

- Although there is a need to create incentives for people to use their air conditioning during heat waves, this study also identified the need to promote multiple approaches to reduce heat exposure in addition to the use of air conditioning including improving circulation of indoor air using fans, shading windows, applying a cold cloth to neck and wrists, shutting off lights, and staying in cool areas of the home (e.g., basement).

- A key issue raised by stakeholders is the potential loss of power at cooling centers during an extreme heat-related event. Given the regional nature of the electrical grid, this issue should also be considered in future regional planning efforts.

Energy Efficiency

- In addition to cost-savings, energy efficiency programs provide a wide range of health, environmental, and social co-benefits that enhance community resilience.

- Energy efficiency improvements to buildings have positive co-benefits with respect to improving the indoor environment for occupants and reducing outdoor air pollution from emission reductions across the electrical power grid and fuel switching. The monetized regional health benefits from energy efficiency measures implemented in Springfield that reduced air pollution emissions across the Northeast electrical power grid ranged from $760,000-$1,700,000.

- While the overall health impacts from implementing energy efficiency measures in municipal buildings are positive, the need to achieve and maintain adequate ventilation for optimal indoor air quality must also be considered. It is also important to consider the potential increase in indoor radon levels from energy efficiency measures that tighten the building envelope.

- The assessment suggests that energy efficiency measures can increase the productivity of building occupants (e.g., municipal workers and students).

- Energy efficiency activities at the municipal level may also increase public awareness and empowerment to address energy issues and climate change at the local level.

- This HIA demonstrated that although the co-benefits of energy efficiency measures at the municipal level may be relatively small, the total benefits regionally and statewide of such actions are likely to be significant and need to be further assessed.

Recommendations

General Recommendations

- Regions and municipalities statewide without climate action plans should take steps to prepare such plans.

- State, regional, and local agencies should coordinate data and resources to support research and other related activities to improve the understanding of the relationship between climate and health.

- Other climate action strategies recommended in the PV Climate Action Plan should be examined to better understand health impacts and benefits of climate action strategies.

- Tools, innovative methods, and approaches to conduct comprehensive HIAs should be identified to more fully explore health impacts and benefits of adaptation strategies.

Recommendations for Providing Cooling Centers and Other Approaches to Assist Vulnerable Populations During Heat-Related Events

- Develop municipal or regional heat response plans that include information about vulnerable populations (e.g., elderly, elderly living alone, socially isolated, children, people without a car, economically disadvantaged); approaches for locating cooling centers that are accessible to vulnerable populations; and personal strategies and solutions for cooling at home during a heat-related event, especially where air conditioning is not available or when the power goes out.

- Implement community-wide mitigation efforts, such as improving building and landscape design standards, promoting an adequate tree canopy, and minimizing pavement to reduce urban heat islands.

- Promote regional planning efforts that support consistent educational and outreach materials for vulnerable populations, address environmental risk factors (e.g., heat islands, tree canopy), identify critical infrastructure needs, and identify solutions for the potential loss of power at cooling centers during extreme heat-related events.

Recommendations for Implementing Energy Efficiency Measures in Municipal Buildings

- Given that energy efficiency is one of the most practical policy options to mitigate and adapt to climate change impacts, it is important to promote the health co-benefits of energy efficiency at all levels (i.e., individual, municipal, regional and statewide).

- The stakeholder process identified the need to better understand and measure community awareness around climate action and how municipal actions can spur empowerment. Changes in public awareness about the value of municipal energy efficiency programs are the cornerstone of state and local government initiatives such as "Leading By Example." Empowerment is nurtured by a sense of belonging that can occur when energy efficiency measures are implemented across government, businesses, and residences. One option is to encourage such efforts by increasing resources to support additional energy efficiency programs. This recommendation is supported by a large body of work demonstrating the benefits of incentivizing energy efficiency programs.

- Ensure that ventilation systems maintain optimal indoor air quality. Consideration of the Massachusetts Department of Public Health's guideline for indoor air quality will ensure optimal indoor environmental conditions. Specifically, the guideline recommends a ventilation rate of 20 cubic feet per minute (cfm) of fresh air to provide optimal air exchange resulting in carbon dioxide levels at or below 800 ppm.

- Radon testing should occur prior to and before completing the renovation of a building to determine if mitigation measures are warranted and can be incorporated during the renovation. Post-renovation testing should also be conducted to ensure mitigation measures were successful.

- Support municipal efforts to apply for Massachusetts Department of Energy Resources (DOER) Resiliency funding to ensure hospitals and other essential facilities have power during outages.

- Support continued state funding of energy efficiency measures at the local level.

Areas of Future Research

- There was insufficient information to assess the change in physical activity during heat-related events or long-term changes in the community from instituting environmental mitigation measures (e.g., increase in tree canopy) to mitigate rising temperatures. For example, the Michigan Department of Community Health's Climate and Health Adaptation Program conducted a comprehensive HIA

"Expanding the Urban Tree Canopy as a Community Health Climate Adaptation Strategy" in Ann Arbor. The HIA found epidemiological evidence that reduction of heat from an adequate tree canopy has multiple benefits associated decreased heat exposure, decreased air pollution exposure, increase in physical activity. These findings directly benefit the general population and specifically those individuals with pre-existing diseases including diabetes, hypertension, and obesity. Similar methods could be applied to subsequent HIAs to more fully evaluate mitigation measures in Massachusetts.

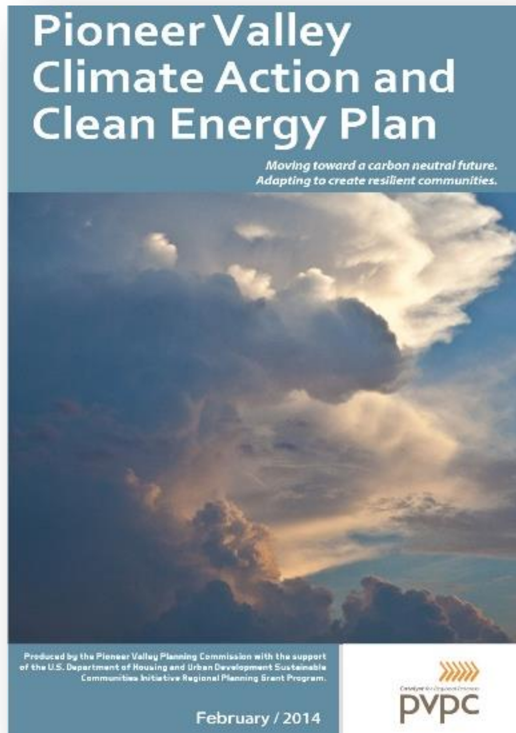
- Improve the understanding of community awareness around climate actions and how municipal actions can spur empowerment for more system-wide change. This may include strategies that educate residents about the problem, provide information on necessary behavioral changes to address the problem, promote transparency about sustainability issues, and facilitate consumer's individual choices toward sustainable consumption patterns.

- Poverty and crime are correlated with excessive morbidity and mortality during heat waves. The percentage and number of people living in poverty are much higher in Springfield than in Williamsburg, indicating that the vulnerable population in Springfield is larger. There is also a significant difference in the number of violent crimes in the two communities. Further examination of the relationship between poverty, crime and successful climate adaptation strategies is needed.

- Power outages were identified as a major concern by municipal officials in Springfield and Williamsburg. Analysis of power outages is conducted by the utility industry and consultants. Given that this information would be useful in the planning process, requests should be made for this information at the regional level.

INTRODUCTION

Health Impact Assessments (HIAs) use data, research, and stakeholder input to assess the likely positive and negative health impacts of a proposed policy, plan, or project before it is implemented. An HIA informs the decision-making process by providing recommendations for changes to a proposal that promote positive health outcomes and minimize negative consequences. A key feature of an HIA is to identify health inequalities that may arise from a proposal.[1] A key feature of an HIA is the identification and assessment of health inequities in the affected community and that may arise from a proposal. Recognizing that climate change impacts will be felt most directly and severely at the local level, the Massachusetts Department of Public Health (DPH) has identified the HIA framework as a tool for integrating health considerations into community-based adaptation planning efforts.



The purpose of this HIA was to work with communities in Western Massachusetts to explore an overall approach for supplementing existing municipal and regional planning efforts (e.g., adaptation planning, emergency preparedness, land-use and master planning, etc.) with information on the public health impacts and benefits of climate change strategies. This HIA represents a collaborative effort by the Massachusetts Department of Public Health, the Pioneer Valley Planning Commission (PVPC), and the municipalities of Springfield and Williamsburg. A long-term goal of this effort is to provide a roadmap for other municipalities and regional agencies to consider health in their climate action planning process.

PVPC is one of 13 regional planning agencies (RPAs) in Massachusetts. For over 50 years, PVPC has supported municipal planning and implementation efforts in 43 cities and towns located in the Pioneer Valley. The Pioneer Valley encompasses the Connecticut River Valley in western Massachusetts. PVPC's service region includes two counties in western Massachusetts (Hampshire and Hampden). The counties include the Commonwealth's third largest city, Springfield (population 153,060) and the Commonwealth's ninth smallest community, Tolland (population 485).

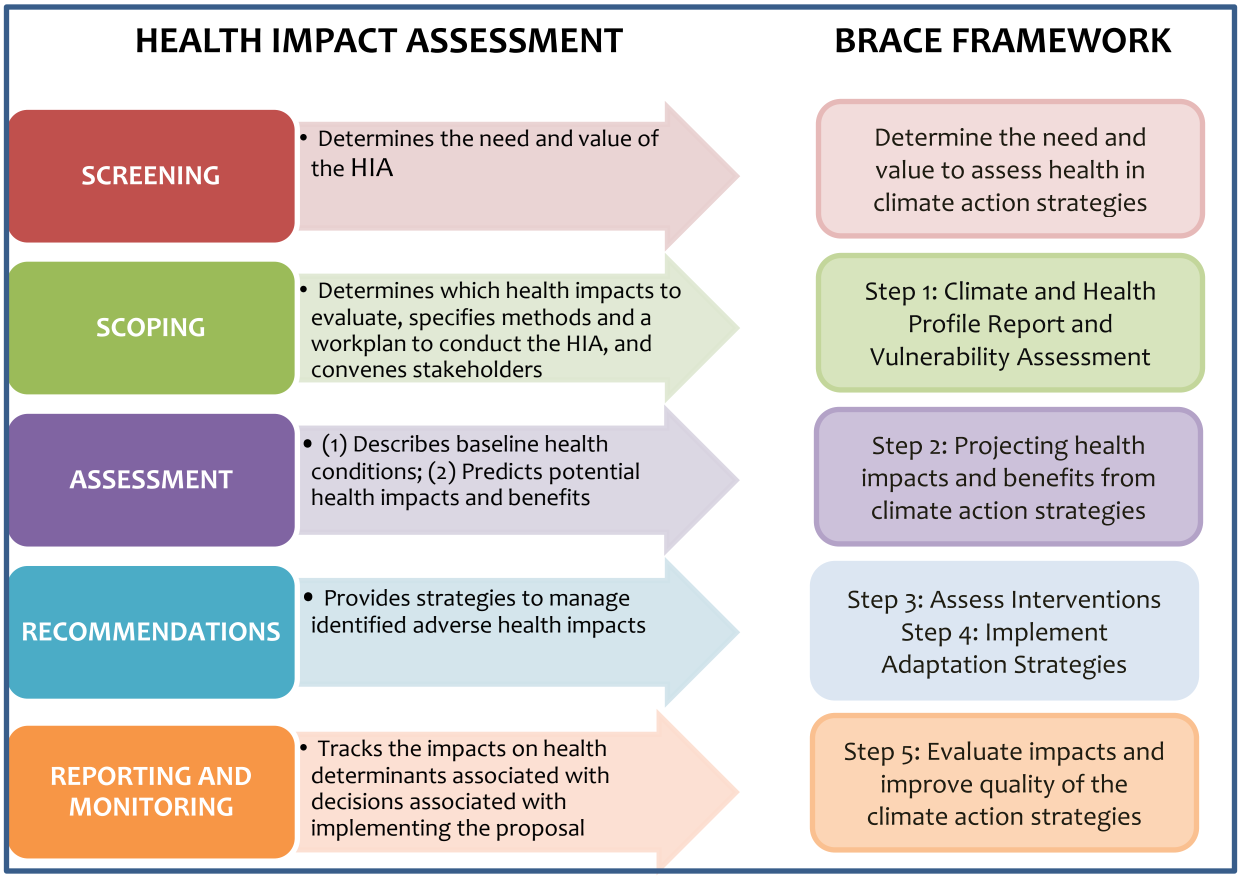
This HIA assessed the regional Pioneer Valley Climate Action and Clean Energy Plan (PV Climate Action Plan), which was completed by the PVPC in 2013. The aim of the PV Climate Action Plan was to promote greater understanding of the causes and consequences of climate change in PVPC's service region and to identify a series of strategies for local and regional partners to mitigate and adapt to climate effects. The Plan specifically identified the need to address the public health impacts of climate change by preparing for climate impacts and increasing the resilience of the region's communities to withstand and recover from extreme weather events. Thus, this HIA provided an opportunity to begin to integrate health considerations into the adaptation planning process at the municipal level.

This HIA was conducted as part of a cooperative agreement with the U.S. Centers for Disease Control and Prevention (CDC) Healthy Community Design Initiative (HCDI) to increase the capacity of public health departments to include health considerations in transportation and land use planning decisions and to expand the scope of health impacts considered when making decisions that impact community design. DPH also received funding from CDCs Climate Ready States and Cities Initiative (CRSCI)[2] to address potential health impacts of climate-related events at the local level.

As part of the CRSCI program, CDC developed an approach for integrating health into the climate adaptation planning process entitled "Building Resilience Against Climate Effects" (BRACE). BRACE is an evidence-based approach developed by CDC for public health agencies to develop health-based climate change adaptation strategies. The 5-step process of the BRACE framework includes assessing climate change impacts and vulnerability assessment (Step 1), modeling of projected health impacts (Step 2), evaluating evidence-based public health intervention options (Step 3), developing and implementing a climate and health adaptation plan (Step 4), and evaluating activities in an iterative framework (Step 5).

The HIA framework complements BRACE by providing an evidence-based systematic approach for assessing the wide array of health impacts associated with climate effects. Figure 1 demonstrates the complementary features between the HIA framework and BRACE including engagement of a wide range of stakeholders in the planning process, assessment of evidence-based climate predictions to quantify public health burdens of climate effects, and development of health-based intervention strategies for reducing climate-related impacts. This HIA evaluated the efficacy of implementing an integrated BRACE/HIA approach to inform the adaptation planning at the local level.

FIGURE 1: INTEGRATION OF CDC BRACE APPROACH INTO THE HIA FRAMEWORK



SCREENING

The purpose of the screening phase of an HIA is to decide whether an HIA is feasible, timely, and would add value to a decision-making process. The North American Minimum Elements and Practice Standards for HIAs[3] include the following three steps in the Screening phase:

1. Determining the topical area of study that would result in substantial effects on public health that stakeholders have expressed concerns about;
2. Identifying an appropriate region of the state and localities that has the potential for unequally distributed impacts; and
3. Identifying active decision making processes that add new information that would be useful to decision-makers and provide recommendations for timely changes to a policy, plan, program, or project.

Each step of the screening process for this HIA is described below:

Determining a Topical Area of Study

DPH has been actively identifying opportunities to explore the use of HIAs in decisions related to health-related climate action planning at the local level. These discussions emanated from work that DPH was engaged in through cooperative agreements with the CDC to explore the use of HIAs as a tool to inform community design decisions and to address potential health impacts of climate-related events at the local level. The HIA framework complements BRACE by providing an evidence-based systematic approach for assessing the wide array of health impacts associated with climate effects (See Figure 1).

The Pioneer Valley Planning Commission (PVPC) had just completed their PV Climate Action Plan and was just beginning to work with municipalities on adopting the municipal strategies in the plan. Evidence indicates that a better understanding of the health implications of climate impacts and actions would enhance the decision-making process to reduce climate-related health impacts and enhance community resilience.[4] Furthermore, the PV Climate Action Plan specifically identified the need to address the public health impacts of climate change by preparing for climate impacts and increasing the resilience of the region's communities to withstand and recover from extreme weather events.[5]

Identifying an Appropriate Region of the State and Localities

The next step in the screening phase involved the selection of municipalities to serve as pilot communities. Together DPH and PVPC staff identified the communities of Springfield and Williamsburg to include in this HIA. These communities were chosen for the following reasons:

- The need for relevancy to other communities across the Commonwealth. Thus, we were specifically interested in working with both an urban and rural community. Springfield, with a population of 153,060 is the third largest city in the Commonwealth and represents larger municipalities. Williamsburg, with a population of 2,482 represents smaller communities. In Massachusetts over one-third of the municipalities have populations under 5,000. These communities represent a wide range of health and social disparities.
- Both municipalities are certified Green Communities. The Green Communities program supports municipalities pursuing energy conservation and renewable energy generation activities; however, the health implications of these activities are not typically evaluated.

  The GCA instituted the 'Green Communities program' to support municipalities pursuing energy conservation and renewable energy generation activities. An analysis of economic impacts to businesses and households found that the first six years of GCA implementation led to $1.2 billion (in 2013 net present value dollars) in net economic benefits to Massachusetts, and more than 16,000 jobs. The $1.2 billion also includes state and local tax revenues of roughly $155 million. These represent only the monetary impacts within Massachusetts and do not consider mitigation of climate change risks, or the costs or benefits associated with health, safety or environmental impacts. Since 2010, the American Council for an Energy Efficient Economy (ACEEE) has ranked Massachusetts as the leading state in advancing energy efficient initiatives, largely due to the Green Communities Act.

- This HIA also recognized communities that participate in DPH's Mass in Motion program. Mass in Motion advances healthy living by promoting policy, systems and environmental strategies that increase access to healthy and affordable food and opportunities for active living (walking, biking, public transit access, etc.). Participation in this program provides an opportunity to highlight important connections between these activities and climate action. Broadly, the strategies that increase walking and biking relate to how land-use decisions (e.g. zoning laws that dictate how, where and what type of new housing is developed) are made and how roadways are constructed and managed to support moving around in a community. One land-use strategy that encourages active living is referred to as "Smart Growth." One of the goals of Smart Growth is to reduce the distance one must travel to access needed and desired goods and services. Smart Growth development has the potential to impact energy use including less dependence on personal vehicles, improved access to public transit, and less energy use per person as people move out of large single family homes. These factors, in turn, reduce energy-generated GHG emissions and improve the overall health and resilience of the community to more effectively respond to climate effects.[6,7]

Identifying Active Decision Making Processes that Add New Information and Provide Timely Recommendations

HIAs can inform the adaptation planning process by providing new information for decision-makers to consider for reducing health impacts of climate effects and improving overall community well-being and resilience. DPH's experience in the use of HIAs to date suggested that the HIA framework could be a useful public engagement and decision-support tool to provide local decision-makers, including municipal officials and the public, with a better understanding of how climate action strategies are likely to positively or adversely influence health. The process of examining the health impacts of climate action recommendations also assists municipal officials in prioritizing which actions they will initially evaluate and implement.

This is the first HIA that we are aware of that is applying the HIA framework to assess climate-related decision-making at the local level in Massachusetts. Given the need to support municipal actions to address climate effects, this effort seeks to bridge the significant work that has been accomplished at the statewide level to inform local decisions related to mitigating and adapting to potential climate impacts. For example, in 2008, significant commitments to climate action and clean energy were made with the passage of five legislative acts signed by the Governor: the Global Warming Solutions Act (GWSA), the Green Communities Act, the Green Jobs Act, the Clean Energy Biofuels Act, and the Oceans Management Act.

The GWSA established the most aggressive set of measures to reduce global warming emissions of any state in the country including a 2020 limit of greenhouse gas (GHG) emissions 25% below 1990 level and a 2050 limit at least 80% below 1990 level. The GWSA also mandated a comprehensive study of adaptation planning strategies across all sectors (Massachusetts Climate Change Adaptation Report) that could increase resilience and preparedness for climate effects in Massachusetts.[8] The 2011 report included a Human Health and Welfare chapter that assessed the primary vulnerabilities and adaptation strategies to protect human health against the impacts of climate change. A key finding of the report with added relevance for the approach taken for this HIA was that climate change impacts will be felt most directly and severely at the local level. Notably, the report recommended that local officials need to better prepare for climate-related impacts.

STAKEHOLDER ENGAGEMENT PROCESS

The next phase of the HIA involved developing plans for stakeholder engagement. Stakeholder engagement is essential to an HIA and provides a source of valuable information and direction to each phase of the HIA. DPH contracted with PVPC to provide overall project management including establishing an advisory committee of representatives from each community, convening stakeholders, and providing expertise in regional climate action plans. PVPC convened meetings between DPH and key municipal officials in the two participating pilot communities to assure their interest in and willingness to participate in this HIA. Officials from Williamsburg and Springfield agreed to participate in the HIA and to appoint representatives to the Advisory Committee. The Advisory Committee met monthly over a 6 month period to identify two climate action strategies to evaluate in the HIA, provide relevant information about municipal activities related to these strategies, provide guidance on the scoping and assessment phases, and provide assistance in the development of HIA recommendations. The Advisory Committee also reviewed and commented on the final draft report and guided the public dissemination process. Additional stakeholders participated as key informants in small group meetings and individual interviews. A list of the Advisory Committee members and other stakeholders is provided below.

Advisory Committee:

Soloe Dennis, Regional Director, Western Regional Health Office, DPH
Donna Salloom, Community Liaison, Division of Prevention and Wellness, DPH
Charlene Nardi, Williamsburg Town Administrator
Donna Gibson, Williamsburg Board of Health
Gerald Mann, Williamsburg Energy Committee
Nicole Bourdon, Springfield Department of Health and Human Services
Michael Gibbons, Springfield Department of Parks, Buildings and Recreation Management

Additional people that provided information included:

Pat Sullivan, Director
Springfield Department of Parks, Buildings and Recreation Management

Phil Dromey, Deputy Director
Springfield Office of Planning and Economic Development

Scott Hanson, Principal Planner
Springfield Office of Planning and Economic Development

Helen Caulton-Harris, Director
Springfield Department of Health and Human Services

Jan Denny, Director
Springfield Office of Elder Affairs

Bob Hassett
Springfield Emergency Management Director

Bettye Anderson-Frederic, Deputy Director
Springfield Department of Health and Human Services

Michaelann Bewsee
Arise for Social Justice and Member, Springfield Green Committee

Mike Kocsmiersky
Spirit Solar and Member, Springfield Green Committee

Katie Stebbins, Chair
Springfield Planning Board

Mike Fenton, President
Springfield City Council and Chair - Springfield Green Committee

Walter Boas
Massachusetts Municipal Wholesale Electric Company (MMWEC) and Chair, Williamsburg Energy Committee

Additional people that provided information included:

Charles Dudek, Member, Williamsburg Energy Committee
Mary Dudek, Member, Williamsburg Energy Committee
Gerry Mann, Member, Williamsburg Energy Committee
Rob Stinson, Member, Williamsburg Energy Committee

SCOPING

Overview of Scoping Process

The Scoping phase of an HIA involves a more focused process of narrowing down the decision points and health determinants to be studied in the HIA. According to the North American Minimum Elements and Practice Standards for HIAs,[9] the Scoping phase of an HIA should include the following factors:

- the decision that will be studied;
- potential health impacts and their pathways (e.g., a logic model);
- research questions for the impact analysis;
- demographic, geographical and temporal boundaries for the impact analysis;
- evidence sources, research methods, and an approach to evaluate the distribution of impacts expected for each research question in impacts analysis;
- the identity of vulnerable subgroups of the affected population roles for experts and key informants;
- the standards or process, if any, that will be used for determining the significance of health impacts;
- a plan for external and public review;
- a plan for dissemination of findings and recommendations.

With the Advisory Committee in place as a result of the stakeholder engagement process, the Scoping phase of the HIA was organized according to the following steps:

(1) Develop goals and objectives for the HIA;

(2) Choose strategies from the PV Climate Action Plan for evaluation in the HIA;

(3) Conduct literature reviews on the chosen strategies;

(4) Identify demographic, geographical and temporal boundaries for the impact analysis;

(5) Develop research questions;

(6) Develop pathway diagrams;

(7) Identify data sources, research methods, and approaches to evaluate the distribution of impacts.

It was evident from the outset of this effort that the limited resources and time constraints would necessitate a focused HIA, typically referred to as a "rapid" HIA. Given the nature and complexity of assessing the health implications of climate change and related multi-sectorial climate action plans, this effort was viewed as an entry point to support more comprehensive HIAs that could be undertaken to inform climate action planning process at the local level.

Goals and Objectives

The overall goal of this effort was to explore the use of HIAs to inform health-based adaptation planning efforts at the local level in Massachusetts. The following specific measurable steps that were taken to meet this goal are:

(1) Work with the Advisory Committee to select two climate action strategies that represent mitigation and adaptation strategies;

(2) Analyze the evidence between climate change planning and health by conducting a literature review of health implications of the selected climate action strategies;

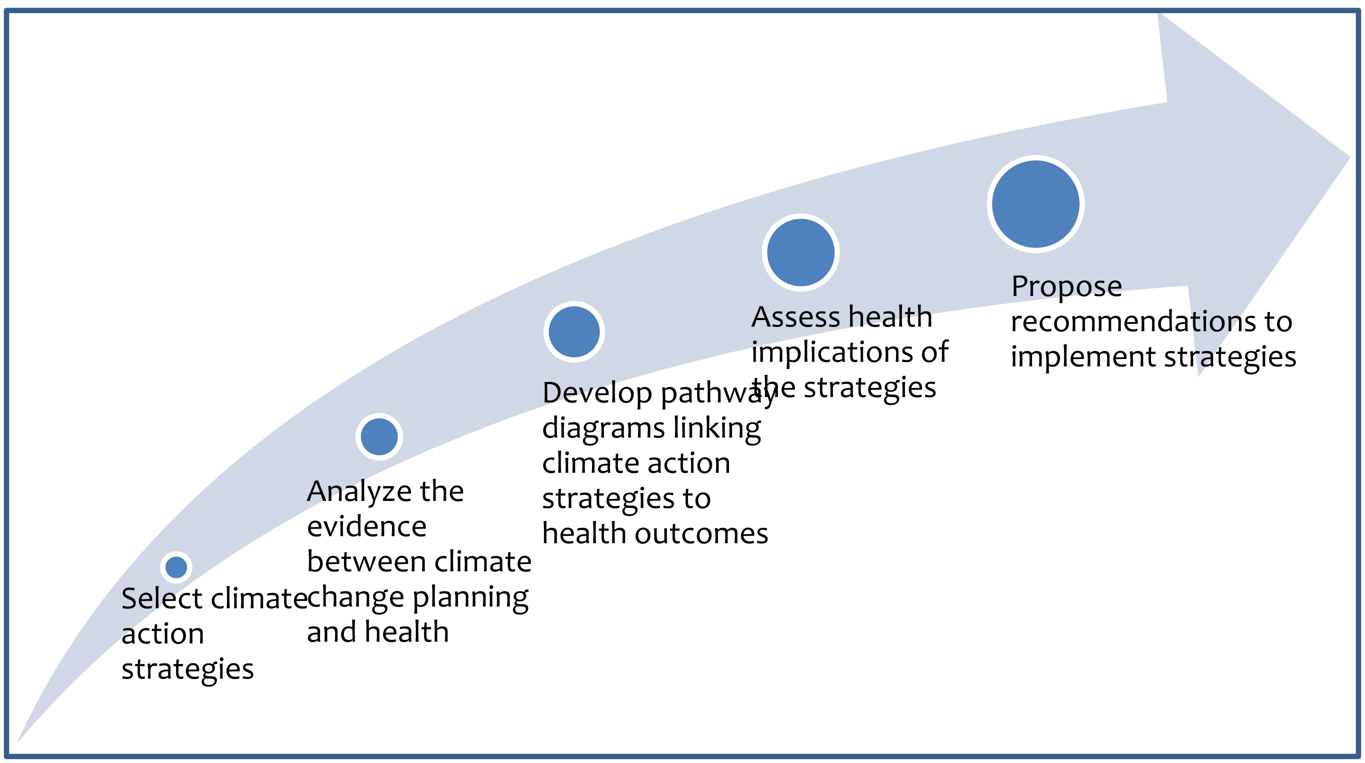
(3) Develop pathway diagrams linking selected climate action strategies to health using the BRACE framework;

(4) Assess the health implications of the two climate action strategies; and

(5) Propose recommendations to move forward with selected strategies at the community level.

The overall approach of this HIA is illustrated in Figure 2.

Figure 2: Objectives of this HIA



Recommended Strategies from the PV Climate Action Plan for the HIA

The Advisory Committee identified two of the 19 municipal climate action recommendations from the PV Climate Action Plan for evaluation in this HIA. These are:

- Provide Cooling Centers and Other Approaches to Assist Vulnerable Populations During Heat-Related Events
- Implement Energy Efficiency Measures in Municipal Buildings

The specific actions recommended in the PV Climate Action Plan for these strategies are as follows:

Provide Cooling Centers and Other Approaches To Assist Vulnerable Populations During Heat-Related Events:

- Make cooling shelters available during hot weather by seeking funding for existing and new cooling shelters at municipal buildings and other appropriate private locations for residents without air conditioning during days of extreme heat.
- Address the emergency needs of the most vulnerable residents in the region. With respect to heat-related concerns, educate residents about heat waves, create a registry of vulnerable populations, support development of a notification network for vulnerable populations, establish neighborhood cooling centers, and promote a "Check your Neighbor" program.
- Improve building and landscape design standards to address the urban heat island effect. This includes educating builders and designers about new technologies and new construction materials and the benefits of green roofs, incentivizing tree planting, educating neighborhoods on street tree care, and working with municipal officials to draft new rules and regulations that require urban heat island mitigation tools.

Implement Energy Efficiency Measures in Municipal Buildings:

- Upgrade energy efficiency in older leaky municipal buildings.
- Partner with an Energy Service Company (ESCO) or the local utility company to complete energy audits of buildings, then use energy savings from proposed improvements to finance the improvements without any out-of-pocket expenses for the municipality.
- Implement energy efficiency strategies including energy efficiency building requirements in new construction by adopting the "Stretch Code" in place of the

State's existing building code. The Green Communities Program requires municipalities to adopt the Stretch Code as part of the eligibility requirements. [10] (See Endnote 10 for a description of the Stretch Code.)

Summary of Literature Review

Literature reviews were prepared to examine the relationship between the climate action strategies and health outcomes. The major findings from the literature review are presented below.

Provide Cooling Centers and Other Approaches to Assist Vulnerable Populations During Heat-Related Events

HEALTH IMPACTS OF HEAT-RELATED EVENTS

- According to the National Climate Assessment, the Northeastern climate is experiencing noticeable changes that are expected to increase in the future. Between 1895 and 2011, temperatures rose by almost 2°F and projections indicate warming of 4.5°F to 10°F by the 2080s. As the global climate continues to change, extreme heat events are predicted to occur more frequently and heat-related morbidity and mortality is expected to rise.[11]

- Heat has a well-documented impact on human health.[12,13,14] Extreme heat events account for more fatalities than any other weather hazard. As the ambient temperature rises, the body employs various mechanisms to stay cool. Sweating contributes to evaporative cooling, while at the same time blood is redirected from the core to the skin to improve radiative and convective cooling. Although these mechanisms are effective at cooling the body for a short time, prolonged exposure to heat can cause dehydration, heat stress, heat exhaustion, and heat stroke.[15] The effects on mortality and morbidity are a significant health concern that will increase as projected increases in the frequency, intensity, and duration of heat-related events occurs.[16]

- Heat stress is defined as a constellation of explicit effects of hot weather on the body. These effects include heat or sun stroke (hyperthermia), heat syncope/collapse, heat exhaustion, heat cramps, heat fatigue, heat edema, and other/unspecified clinical effects attributed to excessive heat exposure. Any individual, regardless of age, sex, or health status can develop heat stress if engaged in intense physical activity and/or exposed to environmental heat (and humidity). However, the very young, the elderly and those with chronic health conditions such as cardiovascular disease, diabetes, or obesity, are more susceptible to the effects of heat.[17]

- Heat stroke is a more serious condition distinguished by nervous system dysfunction, including diminished response time, hallucinations, or bizarre behavior. If treatment is not received quickly after heat stroke develops, mortality can be as high as 70 or 80 percent.[18]

- Increases in outdoor temperature influence outdoor air pollutants levels, including increases in ozone, aeroallergens, and in some cases, fine particles. These increases may, in turn, contribute to poor indoor air quality. Increased temperatures may also increase the risk of food-borne diseases, vector-borne diseases, and exposure to pathogens and algal blooms in recreational water.

- Studies have found that climate change will increase surface ozone levels in polluted areas by 1-10 ppb over the coming decades with the largest effect in urban areas and during pollution episodes.[19] Outdoor air pollutants, in particular, are known to affect human health and contribute to the main causes of illness and death – respiratory and cardiovascular diseases – during a heat wave.[20]

VULNERABILITY TO HEAT IS INFLUENCED BY DEMOGRAPHIC, SOCIO-ECONOMIC, AND BUILT ENVIRONMENT FACTORS

- The ability to reduce exposure to heat during extreme events, especially for vulnerable populations, will be an increasingly important health determinant as temperatures rise. Elderly people living alone are especially vulnerable. Vulnerability factors associated with mortality during the 1995 Chicago heat-related event were elderly living alone, not leaving home daily, lack of access to transportation, and not having an air conditioner.

- Chronic medical conditions (e.g., diabetes; renal disease; cardiovascular disease; respiratory disease; individuals with limited mobility; individuals with mental illness) increase vulnerability to heat, especially among elderly people.[21,22]

- People with low socioeconomic status are vulnerable during heat waves and other extreme weather events.[23,24] A sociological study of the 1995 Chicago heat wave, which killed over 700 people, found that the people most at risk for heat-related mortality had incomes well below the poverty line, and limited access to public transportation.[25]

- The built environment also contributes to higher rates of heat-related morbidity and mortality in urban areas; the lack of vegetation and the nocturnal release of heat from paved surfaces produce an effect known as the urban heat island effect.[26]

SEVERE HEAT-RELATED EVENTS MAY IMPACT PHYSICAL ACTIVITY

- Climate is a feature of the physical environment that may influence the level of physical activity. Excess heat may decrease rates of physical activity.[27,28,29] Conversely, in colder climates, higher average temperatures may extend the warmer season and lead to increased rates of physical activity in the outdoors.

- Physical inactivity is a major public health concern. Inactivity accounts for 9% of global premature mortality, is the 4th leading cause of global death and according to the Centers for Disease Control. Therefore, encouraging physical activity and understanding the conditions that make it easier for people to be physically active is a critical public health priority.[30]

- There are many influences on rates of physical activity. The built environment (e.g., perceived and real safety concerns) represents an important component. The built environment is especially important for encouraging physical activity gained through walking and biking. For example, individuals living in "walkable" neighborhoods are twice as likely to get recommended levels of physical activity as people who do not live in "walkable" neighborhoods.[31]

PLANNING FOR HEAT-RELATED EVENTS CAN BE AN EFFECTIVE WAY TO REDUCE HEAT-RELATED MORBIDITY AND MORTALITY

- Cooling centers should be located in areas that are accessible to the most vulnerable populations and should be advertised in a way that targets those populations.

- Heat warnings via heat health warning systems (HHWS), heat wave early warning systems (HEWS), or very hot weather warnings (VHWW), provide information to municipalities to protect public health during a heat wave. Heat warnings have proven to be very effective at reducing heat-related mortality.[32,33,34,35]

- Municipalities use different indicators and thresholds when determining when to issue a heat warning. For example, a municipality with a normally cool climate may use a lower temperature threshold for declaring a heat warning than a city whose residents are more acclimated to extreme heat, while others may also include such indicators as levels of outdoor air pollution, drought conditions, fire risk, or UV radiation when deciding what kind of warning to issue.[36]

- Coordination between local police and fire departments, human services departments, public health boards, emergency medical services, local health departments, and local hospitals is essential for preventing heat-related health impacts among the most vulnerable populations.

- Local health departments should consider adopting heat response plans to address projected extreme heat conditions.[37]

- Air conditioning is the single most effective intervention to reduce heat-related mortality.[38,39,40]

- Cooling centers should be located in areas that are accessible to the most vulnerable populations and should be advertised in a way that targets those populations.[41]

Implement Energy Efficiency Measures in Municipal Buildings

BACKGROUND ON ENERGY EFFICIENCY MEASURES

- Energy efficiency reduces electricity demand through efficiency improvements in end-use technologies in the residential, commercial, industrial and manufacturing sectors. Such measures reduce electricity consumption, reduce the cost of electricity, reduce air pollution from electricity generating units (EGUs), and increase the reliability of the energy grid. By reducing dependence on foreign and domestic sources of fuel, energy efficiency makes an important contribution to increased energy security.[42]

- An expert report on energy efficiency by the UN Foundation (2007) concluded that a strategy that emphasizes energy efficiency is the most economically and environmentally sensible way of meeting the twin objectives of providing energy for sustainable development and addressing climate change.[43]

- Improving the building envelope is a strategy often used to improve energy efficiency by preventing excess heat from escaping, but the potential negative effects on indoor air quality need to consider adequate ventilation rates.

- The 2014 report by Intergovernmental Panel on Climate Change (IPCC) concluded that: "Efficiency enhancements and behavioral changes, in order to reduce energy demand compared to baseline scenarios without compromising development, are key mitigation strategies in scenarios reaching atmospheric CO2eq concentrations of about 450 or 500 ppm by 2100. Near-term reductions in energy demand are an important element of cost-effective mitigation strategies, provide more flexibility for reducing carbon intensity in the energy supply sector, hedge against related supply-side risks, avoid lock-in to carbon-intensive infrastructures, and are associated with important co-benefits." [44]

- According to the International Energy Agency (IEA), energy efficiency is considered one of the most important near-term strategies to mitigate GHG emissions because many energy efficiency improvements can be made using existing technologies and practices across all end-use sectors.[45]

- The benefits of energy efficiency measures may be reduced by the "rebound effect," which occurs when consumer behavior or producer adjustments offset the intended savings of energy efficiency policies. Although the rebound effect has been identified and can reduce the initial energy savings of efficiency, the IEA suggests that it may be managed by adjusting for rebound to reduce the assumed contributions of energy efficiency to climate change mitigation.[46]

- According to the US EPA, state and local government agencies across the US spend more than $10 billion a year on energy to provide public services and meet constituent needs. Energy used by commercial and industrial buildings in the US is responsible for nearly 50 percent of our national emissions of greenhouse gases (GHGs) that contribute to global climate change. Given budgetary constraints, the potential for one-third of the energy used to run typical government buildings has been a primary consideration for implementing energy efficiency measures at the local level.[47,48]

- Health impact assessment (HIA) is a useful tool for assessing the health effects of climate effects and informs both intervention measures and broader energy and resilience planning projects.[49] HIA provides a systematic framework to evaluate complex pathways of climate policies affecting health including the co-benefits of reduced air pollution and multiple co-benefits of sustainable urban design (see Figure 3).

FIGURE 3: ILLUSTRATION OF MULTIPLE CO-BENEFITS OF ENERGY EFFICIENCY MEASURES

Adapted from IEA, 2012

CO-BENEFITS OF ENERGY EFFICIENCY MEASURES FROM IMPROVEMENT OF OUTDOOR AIR QUALITY

- Although the pollutants that affect air quality are not necessarily the same as those that affect climate change, both air pollutants and GHGs are released by the same processes (e.g., fossil fuel combustion, transportation, agriculture, and industrial processes). Thus, mitigation of GHGs also reduces levels of air pollution, which lead to health co-benefits.[50]

- Efforts to reduce GHGs can also result in reductions in nitrogen oxides (NO_x), volatile organic compounds (VOCs), and sulfur dioxide (SO_2),[51] as well as fine particulate matter ($PM_{2.5}$).[52] These pollutants are linked with adverse health outcomes including respiratory disease, lung cancer, acute respiratory infection, asthma, and heart attacks.[53]

- Some pollutants, including black carbon and ozone degrade air quality while contributing to global warming. Reductions in these pollutants would mitigate global warming and also reduce morbidity and mortality due to exposure to outdoor air pollution.[54]

- A study by Thompson et al. (2014)[55] examined three potential US carbon reduction policies: (1) Clean Energy Standard (CES) to address the electricity generation sector; (2) Transportation (TRN), targeting on-road light duty (passenger) and heavy duty (truck) vehicles; and (3) Cap-and-Trade (CAT). The study found (1) that these GHG reduction strategies also reduce both O_3 and $PM_{2.5}$; (2) population-weighted concentration reductions are largest under TRN, but of similar magnitude across all three policies (0.21-0.99 ppb for O_3 and 0.56-1.16 $\mu g/m^3$ for $PM_{2.5}$; and (3) the monetized human health benefits associated with air quality improvements can offset 26–1,050% of the cost of US carbon policies.

INDOOR AIR QUALITY MAY BE IMPROVED BY EFFORTS TO IMPROVE ENERGY EFFICIENCY

- A UK study found that strategies to improve energy efficiency, including increased insulation, improved ventilation control, fuel switching, and changes in occupant behavior, yielded significant health benefits (measured in avoided Disability-Adjusted Life-Years Lost (DALYs). The factors most affected by these energy saving strategies were concentrations of pollutants such as particulate matter, radon, nitrogen dioxide, and carbon monoxide; dampness and mold; and winter indoor temperatures.[56]

- Several studies have focused on the relationship between effective heating systems and respiratory symptoms, especially pediatric asthma. Efforts to improve insulation and replace polluting heaters (such as un-flued gas heaters or open fires) resulted in improved school attendance and lower hospitalization rates for children with asthma[57] as well as significant energy savings that compensated for the cost of the energy upgrades.[58]

- Improved ventilation and efforts to maintain building HVAC systems for energy efficiency have been shown to improve the health of building occupants, leading to lower rates of worker absenteeism and higher productivity.[59,60,61]

TRADE-OFFS EXIST BETWEEN IMPROVING INDOOR AIR QUALITY AND IMPROVING ENERGY EFFICIENCY

- A 2014 report released by the National House Building Council Foundation cautioned that indoor air quality in new, energy efficient homes may suffer as a result of a tighter building envelope and less ventilation.[62] Improving the building envelope is a strategy often used to improve energy efficiency by preventing excess heat from escaping, but the potential negative effects on indoor air quality need to be considered and mitigated appropriately. However, a 2013 meta-analysis of thirty-six studies found that, on average, household energy efficiency interventions led to a small but significant improvement in the health of residents, particularly in vulnerable groups, including low income residents.[63]

- Increasing natural ventilation may save on air conditioning and reduce symptoms of sick building syndrome,[64] but in some cases this will increase building occupants' exposure to outdoor air pollution, which may aggravate symptoms of asthma or respiratory disease in preschool children.[65] Lack of adequate ventilation may also lead to increased radon exposure, which increases lung cancer risk.[66]

- To determine whether natural or mechanical ventilation is appropriate for a particular building factors that should be considered include presence of mold, radon, and other indoor pollutants; the concentration of outdoor air pollutants in the area surrounding the building; the location and condition of air intakes.[67]

Mental Health Impacts of Climate Change and Climate Action Planning Need to Be Considered

- A full literature review on this topic is beyond the scope of this HIA; however, a limited investigation on the possible mental health related impacts of climate action planning is warranted, specifically to understand how climate actions can impact a sense of control (efficacy), collective action/empowerment, and levels of anxiety.

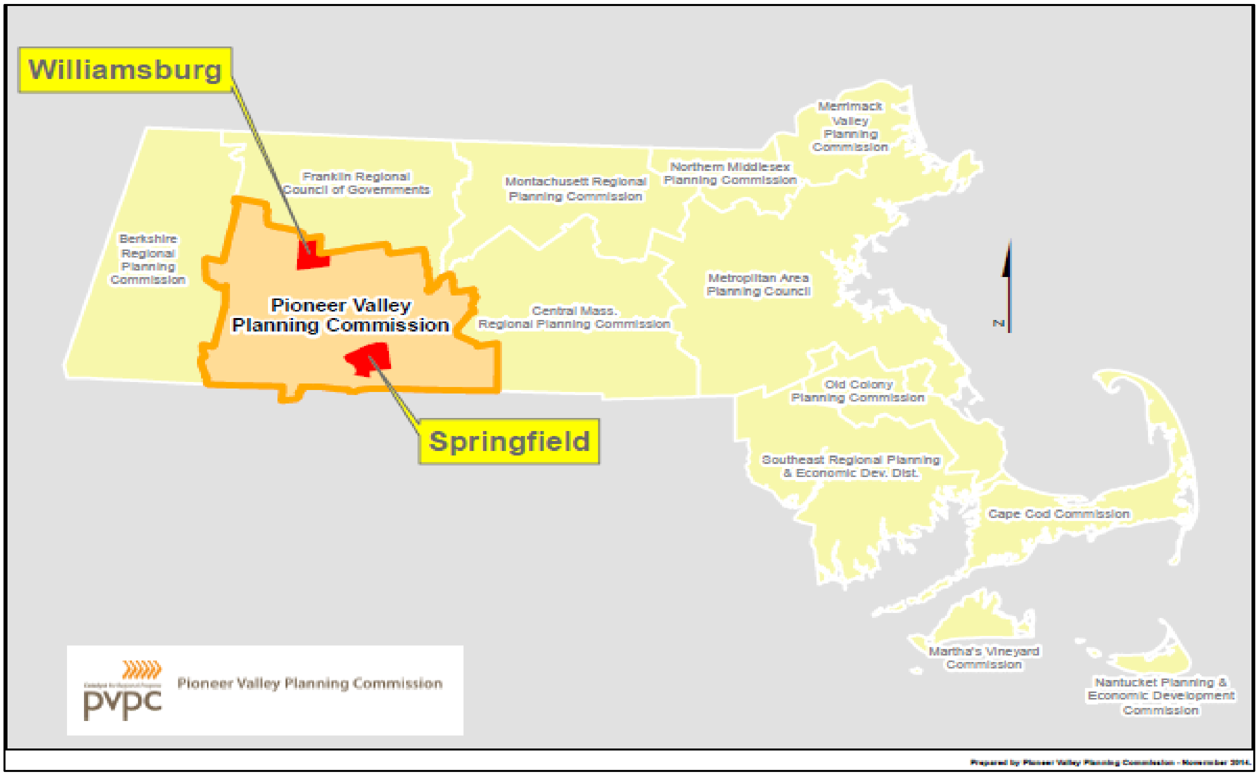
- The mental health impacts of climate change are myriad and complex, ranging from the after effects of weather-related disasters to the anxiety (popularized as "Eco-anxiety") caused by worry over future societal changes caused by climate change.[68] Mental health impacts include increases in the incidence of stress, anxiety, and depression, as well as increases in more severe reactions like post-traumatic stress disorder (PTSD). Research indicates that women, children, and older adults tend to be especially vulnerable to the psychological impacts of climate change, especially those related to stress and anxiety. The irrevocable long-term effects of climate change (e.g., rising temperatures) also may impart a sense of helplessness, fatalism, and resignation.[69]

- While no literature was found specifically linking municipal action on climate change to mental health related impacts, a special issue of the American Psychology on psychology's role in understanding global climate change points to several areas of interest.[70] The studies identified the potential positive mental health impacts that can occur when people take collective responsibility for an issue such as climate change. Taking collective responsibility may lead to positive individual coping mechanisms and positive community level responses.[71] For example, the characteristics of a community can be an important moderator in the chain of inputs that influence adaptation to and coping with climate change. These characteristics include how resilient or vulnerable the community is to climate related impacts.

Demographic, Geographic and Temporal Boundaries of the Impact Analysis

The demographic information for this HIA characterizes the residents of Springfield and Williamsburg (see Figure 4). The geographic boundaries are the jurisdictional boundaries of both communities. The timeframe (temporal boundary) for the assessment of energy efficiency recommendations is related to projecting baseline and future emissions associated with changes in electricity use from implementing energy efficiency measures over a period that results in a 20% reduction in electricity use (Green Communities program reduction goal). For the heat-related assessment, the HIA assessed current plans for cooling centers and current and future projected number of extreme heat days from 2009 to 2080.

FIGURE 4: MAP OF SPRINGFIELD AND WILLIAMSBURG AND REGIONAL PLANNING ASSOCIATIONS IN MASSACHUSETTS



Research Questions for the Impact Analysis

Each of the climate action strategies evaluated in this HIA have specific research questions. In accordance with the overall goal of this HIA, there are also several research questions relating to the broader issue of the connection between climate planning and health.

Provide Cooling Centers and Other Approaches to Assist Vulnerable Populations During Heat-Related Events:

- What are the current activities related to the community's response to heat-related events?
- Are there other approaches to reduce heat exposure?
- What health outcomes need to be considered in the planning process?
- What environmental factors need to be considered to reduce the impacts of heat-related events?
- How do health determinants associated with heat-related events affect health outcomes (e.g., heat-related morbidity and mortality)?

- Who is vulnerable to heat-related events?
- Does the consideration of health outcomes better inform the decision-making process?

Implement Energy Efficiency in Municipal Buildings:

- What are the energy efficiency measures being implementing in Springfield and Williamsburg?
- Do the energy efficiency measures implemented in Springfield and Williamsburg through the Green Communities program have health impacts/benefits?
- What other non-health factors from energy efficiency programs can improve health?
- Are residents more likely to follow suit with energy efficiency improvements if the municipality 'leads by example'?
- Can efforts to achieve greater energy efficiency in the community impact local and regional air quality?
- Does municipal-level action on climate change impact community and individual mental health and sense of empowerment?
- Does the consideration of health outcomes better inform the decision-making process?

Potential Significant Health Impacts and Their Pathways

The goal of a pathway diagram is to visually demonstrate the link between the proposed policy, plan, or project and potential health outcomes. For this HIA, two pathway diagrams were prepared. Figure 5 presents the potential changes in health impacts associated with providing cooling centers and other approaches to assist vulnerable populations during heat-related events. Figure 6 presents the potential change in health impacts from implementing energy efficiency measures in municipal buildings. Literature reviews and input from the Advisory Committee informed the development of the pathway diagrams. The pathway diagrams also illustrate the connection between the HIA framework and Step 1 of CDCs BRACE framework by highlighting the link between climate change, the populations and systems most vulnerable to these changes, and the likely effects on health.[72]

Data Sources, Methods and Approaches for Evaluating the Distribution of Impacts

The following section summarizes the data sources, methods, and approaches for assessing existing conditions (i.e., pre-existing health conditions, health disparities) and assessing potential impacts of the climate action strategies. The full characterization of the baseline health status of the affected community and of the assessment of impacts/benefits of the proposal that takes place during the Assessment phase of the HIA is presented in the next chapter.[73]

Existing Conditions

DEMOGRAPHIC AND SOCIOECONOMIC PROFILE OF EACH COMMUNITY

Determinants of health are factors that contribute to a person's current health status. The World Health Organization (WHO) Commission on Social Determinants reported that 55% of a person's health status is determined by social conditions such as employment, education, housing, and transportation, with genetics (5%), health care (10%), and behavioral factors determining the rest. One of the goals of an HIA is to ensure that health outcomes and health disparities or differences in health status between populations are considered using scientifically valid data.

Factors related to socioeconomic status (e.g., income, education) are linked to a wide range of health outcomes including higher mortality, cardiovascular disease, hypertension, diabetes, low birthweight, and cancer.[74] For this HIA, the demographic and socioeconomic profile of each community is characterized by age, race, and income distribution in each community. The source of the information is the US Census Bureau's American Community Survey (5-year estimates from 2010-2015).[75]

FIGURE 5: PATHWAY DIAGRAM FOR PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATIONS

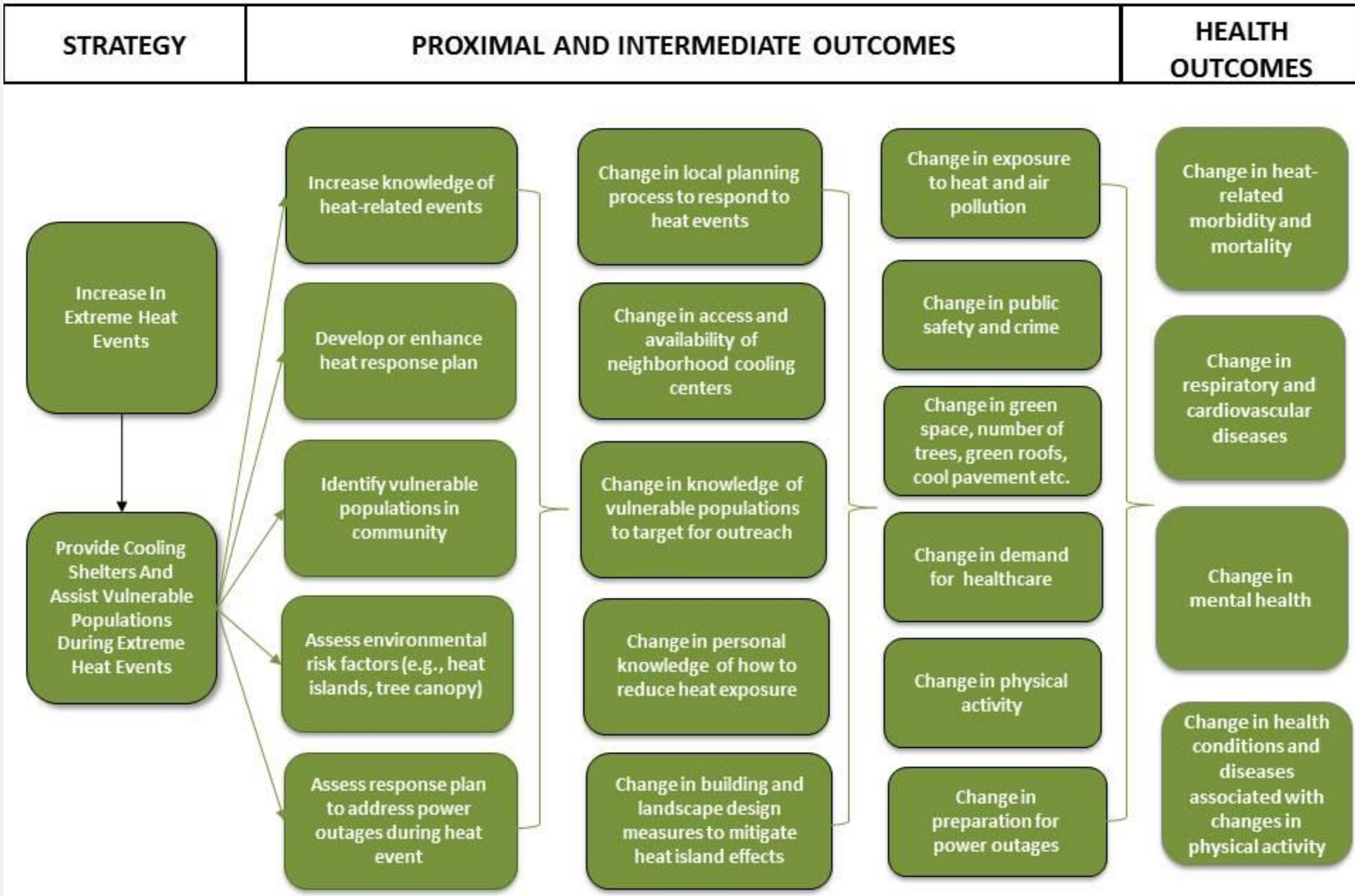
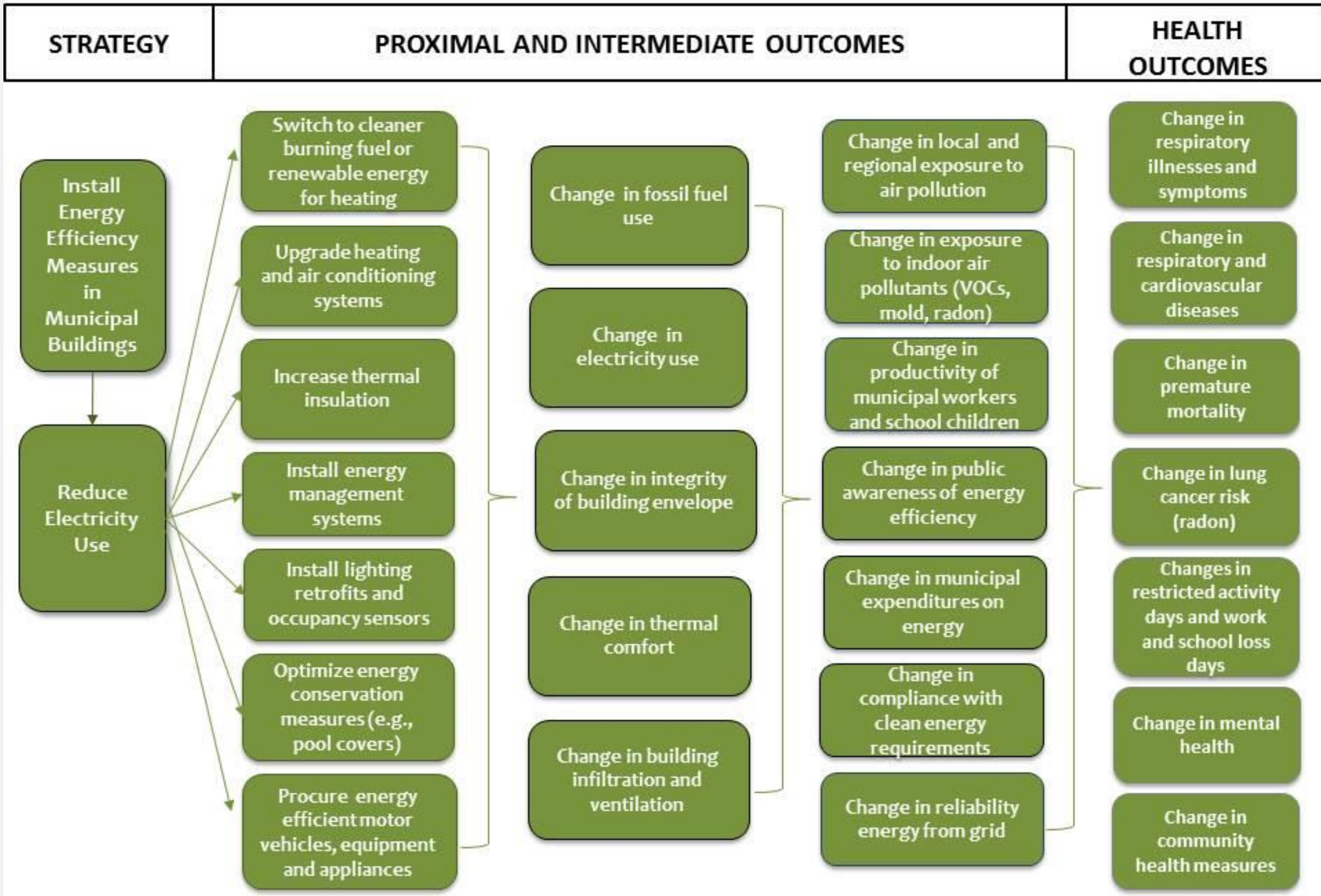


FIGURE 6: PATHWAY DIAGRAM FOR IMPLEMENTING ENERGY EFFICIENCY IN MUNICIPAL BUILDINGS



HEALTH DISPARITIES

In addition to descriptive demographic and socioeconomic data for each community, health disparities may also be characterized by the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) criteria established to identify Environmental Justice (EJ) Income: Median annual household income is at or below 65 percent of the statewide communities.[76] In Massachusetts, a community is recognized as an Environmental Justice community if any of the following criteria are met:

- Block group whose annual median household income is equal to or less than 65 percent of the statewide median ($62,072 in 2010); or
- 25% or more of the residents identifying as minority; or
- 25% or more of households having no one over the age of 14 who speaks English only or very well - Limited English Proficiency (LEP)

The source of the information is the US Census Bureau's American Community Survey (5-year estimates from 2006-2010).

CRIME RATE IN EACH COMMUNITY

Another important indicator of baseline conditions is crime. The violent crime rate is compiled and reported by the Federal Bureau of Investigation.[77]

BASELINE HEALTH CONDITIONS

Baseline health conditions are characterized by surveillance data for Springfield and Williamsburg and summarized in Table 1. The asthma and myocardial infarction hospitalization data are reported on the Massachusetts Department of Public Health's Environmental Public Health Tracking (MA EPHT) portal (matracking.ehs.state.ma.us/). Health data on the MA EPHT portal are available at a variety of geographic levels (e.g., census tract, school, community). It should be noted that a data suppression rule is imposed when case counts are less than 11 in order to protect patient confidentiality for smaller geographic levels (e.g., zip code) or sparsely populated areas.

Health data are also extracted from the Behavioral Risk Factor Surveillance System (BRFSS). BRFSS is an annual telephone survey that collects self-reported data on emerging public health issues, health conditions, risk factors, and behaviors in select communities across Massachusetts. Additional information on each dataset is provided below.

TABLE 1: HEALTH DATA, GEOGRAPHY, DATA SOURCES AND METHODS USED IN HIA

Health Data	Geography	Data Sources	Methods
Asthma and Myocardial infarction	Community	Hospitalization data from MA EPHT Portal (1)	Rate of health outcomes in study area by community for 2010-2012
Pediatric asthma (Grades K-8)	Elementary schools in community	MA EPHT Portal (1)	Prevalence rates in 2009-2010; 2010-2011; 2011-2012.
Lung and bronchus cancer	By census tract and community	DPH EPHT Portal (1) and MA Cancer Registry	SIR (3)
Adult obesity data; Adult hypertension; Adult diabetes; No exercise; Eats 5 fruits and vegetables/day	Community	BRFSS (2)	Varies according to outcome

(1) The MA Environmental Public Health Tracking (EPHT) portal is a web-based portal housed at MPDH/BEH that contains a variety of data including health data, environmental data, and health promotion information (e.g., bike trails, walking trails)
(2) Behavioral Risk Factor Surveillance System is an annual survey of health issues, health conditions, risk factors, and behaviors
(3) Standardized Incidence Ratio (SIR) is the ratio of observed cancer diagnoses in an area to the expected multiplied by 100.

HOSPITALIZATION DATA

The hospitalization data used for this HIA are the most recent hospitalizations data available among Massachusetts residents with an admission date in the years 2010-2012. Using residential address information, hospitalization rates were calculated separately for Springfield and Williamsburg. DPH obtains inpatient, emergency department (ED), and outpatient observation hospitalization data annually from all 80 acute care hospitals in Massachusetts from the Center for Health Information and Analysis or CHIA. CHIA collects inpatient hospital admissions and emergency department data for all visits to Massachusetts acute care hospitals and satellite emergency facilities. The data are based on primary discharge diagnosis codes (ICD9-CM) only. Cases are not included if the condition is listed only as a secondary diagnosis. The rates are based on the age groups most affected by a particular disease. For example, data are restricted to ages 35 and above for rates of myocardial infarction. For asthma, all ages are included.

Population data used in the calculation of age-adjusted incidence rates are from the 2010 US Census. The 2010 US Census provides age-stratified population estimates at the state, city, and zip code tabulation area (ZCTA) level. For asthma and myocardial infarction, rates were age-standardized to the 2010 population distributions of MA and the US into the following 10 age groups (years): 0-4, 5-9, 10-14, 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75+.

As discussed above, a data suppression rule is imposed when case counts are less than 11 in order to protect patient confidentiality for smaller geographic levels (e.g., zip code) or sparsely populated areas. Disease hospitalization rates are based on the residential location of the cases and not necessarily the location of the incident.

BEHAVIORAL RISK FACTOR SURVEILLANCE SYSTEM (BRFSS) DATA

Behavioral Risk Factor Surveillance System (BRFSS) is an annual telephone survey that collects data on emerging public health issues, health conditions, risk factors, and behaviors. The BRFSS was established in 1984 by the U.S. CDC and is the largest, ongoing telephone health survey system, tracking health conditions and risk behaviors in the United States. Currently, data are collected monthly in all 50 states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, and Guam. The DPH Office of Data Management and Outcomes Health Survey Program staff administers the annual survey to selected municipalities and provide annual profile reports.

The BRFSS data are not readily available at the community level because the survey is designed to provide health information statewide or by larger metropolitan areas. Thus, a majority of communities surveyed do not have adequate sample sizes for directly calculating prevalence rates with reasonable precision (Li et al., 2009). The DPH Bureau of Community Health and Prevention has developed a methodology for developing small area estimates when response size in the given locale is adequate.

PEDIATRIC ASTHMA DATA

DPH's Bureau of Environmental Health (DPH/BEH) conducts pediatric asthma surveillance in children who are enrolled in approximately 2,200 public and private schools, grades kindergarten (K) through 8, to monitor the prevalence of pediatric asthma statewide and to evaluate which communities may have higher rates pediatric asthma than the state as a whole. These data are readily available on the DPH Environmental Public Health Tracking Portal (matracking.ehs.state.ma.us/). Information collected as part of this surveillance effort includes the name and address of the school and the number of children with asthma by gender and by grade. The city or town of residence for each child is also collected. Collection of these surveillance data enables DPH/BEH to estimate asthma prevalence by school as well as by municipality of residence. No child-specific information that could identify a particular student is collected.

CANCER INCIDENCE

DPH evaluated lung and bronchus cancer incidence data from 2004–2008 for both communities (Springfield and Williamsburg). Established environmental risk factors for lung and bronchus cancer include smoking, exposure to radon, and occupational contact with the following substances: asbestos, arsenic, beryllium, cadmium, silica, vinyl chloride, nickel and chromium compounds, coal products, mustard gas, chloromethyl ethers, diesel exhaust and radioactive ores. These data are readily available on the DPH Environmental Public Health Tracking Portal (matracking.ehs.state.ma.us/). Cancer incidence data are obtained from the Massachusetts Cancer Registry (MCR) within the MDPH Office of Data Management and Outcomes Assessment. The MCR is a population-based cancer registry that collects information on new diagnoses of cancer in Massachusetts.

The cancer incidence rate is referred to as the Standardized Incidence Ratio or SIR. The SIR is most appropriately used when the population is small, such as that of a community or a census tract. It is used to evaluate whether a community or a census tract's cancer incidence rate differs from that of the state as a whole. Comparison of SIRs between communities or census tracts is an inappropriate use of the statistic. Such comparisons are inappropriate because the age distribution or structure of a community has a strong effect on its cancer rates, and no two communities have the same age distributions within their populations. Comparisons of the SIRs for two communities would be valid only if there were no differences in the age and sex distributions of the two communities' populations.

BASELINE ENVIRONMENTAL CONDITIONS

AIR QUALITY

Studies of exposure to ambient air pollution is linked to an increase in lower respiratory symptoms; reduction in lung function in children and adults; increase in chronic obstructive pulmonary disease; lung cancer; bronchitis; chronic cough; respiratory illness; asthma exacerbation; and premature cardiovascular mortality, non-fatal cardiac events, including myocardial infarction, angina/other ischemic heart disease, and dysrhythmias.

Federal, state, local, and tribal air quality agencies operate and maintain a wide variety of outdoor air monitoring systems across the United States. In Massachusetts, the Massachusetts Department Environmental Protection (MassDEP) Air Assessment Branch (AAB) operates an ambient air quality monitoring network of 24 monitoring stations located in 20 cities and towns in Massachusetts to determine compliance with the NAAQS. The Wampanoag Tribe of Gay Head operates an ozone monitoring site on Martha's Vineyard (Dukes County). U.S. EPA New England also operates a monitoring station at their laboratory in Chelmsford, MA (Middlesex County).

Federal regulations specify network design criteria for ambient air quality monitoring sites. For example, monitoring sites must be capable of providing information about the peak air pollution levels, typical levels in populated areas, air pollution transported into and outside of a city or region, and air pollution levels near specific sources.[78] The baseline air quality data reported in this HIA provides information from the MA EPHT portal on how often people are exposed to unhealthy levels of outdoor air pollution in a given year. Unhealthy levels are determined by comparing the monitored ozone and fine particulates (PM2.5) levels to their respective National Ambient Air Quality Standard (NAAQS). These measures are derived for the purpose of generating Nationally Consistent Data and Measures (NCDMs) for the national Environmental Public Health Tracking program. The data reported in this HIA represent the number of days that the highest levels of ozone and PM2.5 in the county exceed national health-based standards for these pollutants from 2001-2011. In Hampden County (representing Williamsburg), both $PM_{2.5}$ and ozone are measured. In Hampshire County (representing Springfield), the monitoring site is located at the Quabbin Reservoir and measures ozone and PM10, but not PM2.5. The purpose of monitoring sites outside of urban areas, such as Springfield, is to monitor regional background levels of $PM_{2.5}$. Spatial coverage for Hampshire County is provided by three monitoring sites located in Chicopee, Ware (Quabbin Summit) and Greenfield. Therefore, PM2.5 measures are provided only for Hampshire County.

EMISSIONS OF GREENHOUSE GASES (GHG)

PVPC provided the GHG Inventory which quantifies the GHG reductions from energy efficiency programs to the GWSA targets. GHG is any gas that absorbs infrared radiation in the atmosphere. GHG include, but are not limited to, water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), ozone (O3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). A metric measure used to compare the emissions from various GHG based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents (MMTCO2Eq). The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP.

INFORMATION TO EVALUATE CLIMATE ACTION STRATEGIES

To evaluate climate action strategies selected for this HIA, PVPC staff analyzed information reported to municipal reporting systems and information gathered during key informant interviews on climate action strategies associated with heat-related events and energy efficiency. Project staff also reviewed existing municipal planning; Green Communities Action Plans; Hazard Mitigation Plans for any discussion of extreme heat; Comprehensive Emergency Management Plans, and in the case of Springfield, their Extreme Heat Response Plan.

CLIMATE AND HEALTH PROFILE AND VULNERABILITY ASSESSMENT

As discussed above, we developed and evaluated an approach for integrating the BRACE framework into the HIA process in this HIA (see Figure 1). This was accomplished by implementing Step 1 of the BRACE framework (Climate and Health Profile Report and Vulnerability Assessment) for both climate action strategies. For heat-related events, the climate profile included predicted number of days of extreme heat measured from 2009 to 2011 and projected from 2020 to 2080.[79] These data were obtained for each county from the national EPHT portal and were derived from downscaled modeled temperature data for Massachusetts counties (CONUS Daily Downscaled Climate Projections).[80] The climate profile for energy efficiency programs was based on the reduction in emissions of GHG and air pollution from electricity reductions reported from the Green Communities program for Springfield and Williamsburg.

The need to identify vulnerable populations is a critical step in implementing both the BRACE and HIA frameworks. Information on the location and number of potential vulnerable residents and living conditions can assist in more effectively reducing or eliminating climate-related health impacts. Vulnerability indicators evaluated in this HIA are derived from the national EPHT portal.[81] Vulnerability or the degree to which people are susceptible to, or are have limited capacity to cope with the adverse impacts of climate change. Vulnerability indicators include age (e.g., elderly and young who are inherently more vulnerable), socioeconomic factors (e.g., people living in poverty with higher rates of disease and less capacity to adapt to climate impacts), population density (e.g., higher percentage of elderly, people living in poverty, and higher temperatures), and environmental factors (e.g., lack of greenspace, heat island effects).

Summary of Methods and Approaches to Assess Climate Action Strategies

A summary of methods, source of data, and output for assessing existing conditions and the potential impacts and benefits of the climate action strategies in the Assessment phase of this HIA are presented in Tables 2 and 3 below for heat-related events and energy efficiency, respectively.

TABLE 2: METHODS FOR ASSESSING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATIONS DURING HEAT-RELATED EVENTS

	Method	Source of Data	Output
Existing Heat Action Plans	Evaluate existing plans in place to address heat-related events including location and operation of cooling centers.	PVPC conducted interviews with Advisory Committee members, municipal staff and other key stakeholders from each community.	Summary of existing plans in each community.
Identification and Mapping of Vulnerable Populations	Certain populations are more susceptible to increased temperature and may require additional assistance during extreme heat-related events. Two approaches were used: (1) Reported factors that are associated with heat vulnerability indicators on national EPHT portal; and (2) Map with overlay of location of cooling centers and cumulative heat vulnerability index (HVI) map.	For (1) MA EPHT vulnerability mapping tool; for (2) cumulative HVI map from Reid et al., 2009* and location of cooling centers provided by each community.	(1) Percent of population potentially vulnerable to heat-related events and (2) overlay map of cumulative HVI.
* See Endnote 40			

TABLE 3: METHODS FOR ASSESSING ENERGY EFFICIENCY MEASURES IN MUNICIPAL BUILDINGS

	Method	Source of Data	Output
Change in local air quality impacts based on changes in use of heating oil as a result of implementing energy efficiency measures	Energy efficiency measures including replacement of fossil-fuel burning boilers and implementation of energy management systems result in changes to heating oil use and related air pollution emissions from the boilers. The changes in pollutant emissions occur near the municipal buildings and may affect local air quality. Emission factors were applied to fuel usage data for each community to estimate the amount of air pollutant emissions from boilers.	Fuel usage data for each community from the Green Communities program reports Emission factors from EPA's WebFire tables as we discussed (http://cfpub.epa.gov/webfire/	Emission reductions from implementing energy efficiency measures that resulted in fuel switching
Changes in regional air quality impacts from changes in electricity use across the region as a result of implementing energy efficiency measures	One of the primary goals of energy efficiency programs is reduction in electricity use, which in turn reduces regional air pollution, reduces local air pollution around energy generating plants, and reduces demand for energy. Two models were used to estimate health and economic benefits of changes in regional air pollution from reductions in electricity use associated with energy efficiency programs: (1) US EPAs Avoided Emissions and Generation Tool (AVERT) to estimate the amount of emissions reduced from implementing energy efficiency measures in each community and (2) US EPA Co-benefits Risk Assessment (COBRA) Screening model to estimate health* and economic benefits of policies that reduce air pollution.**	Estimated reduction in electricity use from implementing energy efficiency measures reported from Green Communities program.	Estimated reduction in regional air pollutant (NOx and SO_2) emissions (i.e., displaced emissions) from implementing energy efficiency measures and Estimated monetized benefits of avoided health impacts from displaced emissions.

*These health endpoints include: adult and infant mortality; non-fatal heart attacks; respiratory-related and cardiovascular-related hospitalizations; acute bronchitis; upper and lower respiratory symptoms; asthma-related emergency room visits; asthma exacerbations; minor restricted activity days (i.e., days on which activity is reduced, but not severely restricted); and work days lost due to illness
**Model only allows examination of the emission impacts of major fleet adjustments or changes extending further than five years from the baseline year. While Springfield is one of the first communities certified under the Green Communities program, Williamsburg has only recently become certified. As a result, demonstration of this tool is only available for Springfield.

ASSESSMENT

The Assessment phase of an HIA involves a two-step process that first describes the baseline health status of the affected population and then assesses potential impacts and benefits of the proposal evaluated in the HIA. As previously discussed, the Scoping phase of the HIA provided the methods for considering health implications of heat-related events and implementing energy efficiency measures. Stakeholders from Springfield and Williamsburg provided extensive input throughout this process including providing community-specific information on each strategy.

Assessment of Existing Conditions

Demographic and Socioeconomic Profiles of Springfield and Williamsburg

Springfield is the third largest city in the state, while Williamsburg is a small, rural 'hill town.' The 2015 American Community Survey estimates the population of Springfield is over 153,060, while the population of Williamsburg is 2,482. Williamsburg is 96.9 percent white, while Springfield is 55.5 percent white, 21.1% Black or African American and 42.2% Hispanic or Latino. In Springfield, the median household income is $34,728, or about one-half the statewide median income. In Williamsburg, the median household income is about $65,885, or within 10 percent of the statewide median income. Per capita personal income follows a similar pattern; residents of Williamsburg make more than the statewide average per capita personal income, while residents of Springfield make less than one-half the state per capita personal income average. These data are summarized in Table 4.

TABLE 4: DEMOGRAPHIC CHARACTERISTICS OF WILLIAMSBURG AND SPRINGFIELD

	Springfield	Williamsburg	Massachusetts
Total Population	153,060	2,482	6,705,586
Percent White	55.5	96.9	79.6
Percent Black or African American	21.1	0.3	7.1
Percent Hispanic or Latino (of any race)	42.2	2.0	10.6
Median household income	34,728	65,855	68,563
Per capita personal income	18,553	35,597	36,895

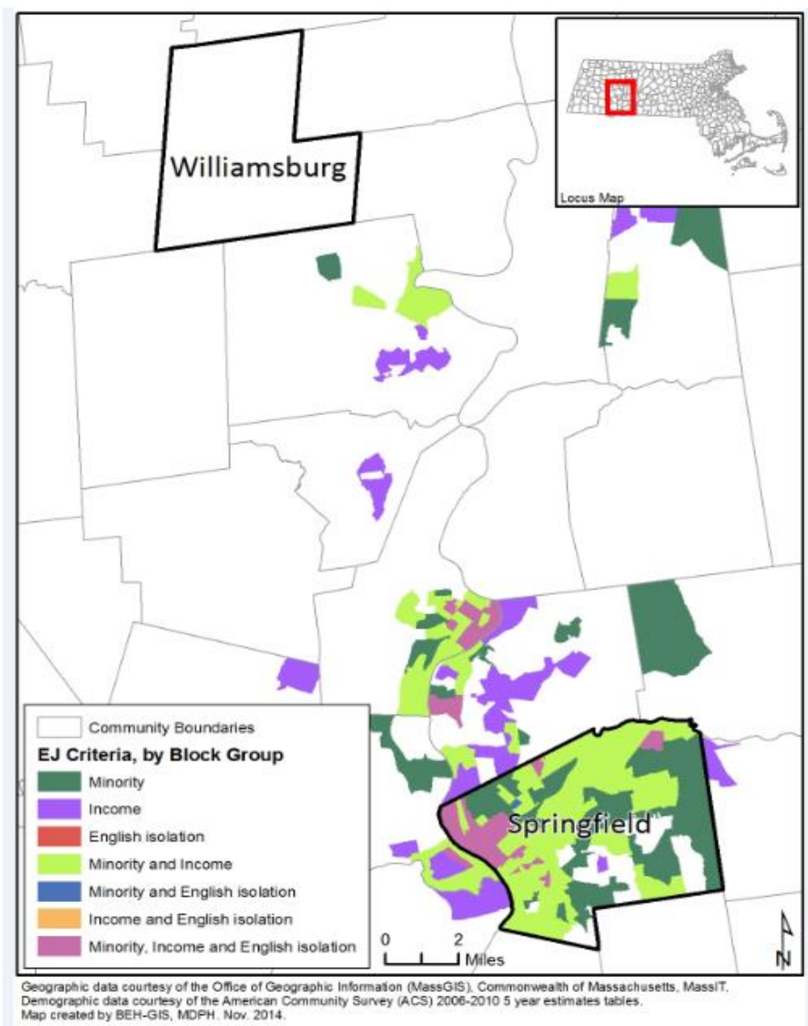
Source: 2011-2015 American Community Survey 5-Year Estimates

Another important indicator of baseline conditions is crime. Springfield's 2011 violent crime rate (per 1,000 people) is 10.3 compared to the overall statewide rate of 4.06. There is no violent crime reported in Williamsburg.

Environmental Justice Populations

Figure 7 is a map of the Environmental Justice (EJ) populations in Springfield using 2010 Census Block groups. The Commonwealth's Executive Office of Energy and Environmental Affairs (EEA) established an Environmental Justice Policy to help address the disproportionate share of environmental burdens experienced by lower-income people and communities of color who, at the same time, often lack environmental assets in their neighborhoods. According to the Massachusetts Environmental Justice Policy, EJ is based on the principle that all people have a right to be protected from environmental pollution, and to live in and enjoy a clean and healthful environment. The EJ criteria are as follows: (1) median annual household income is at or below 65 percent of the statewide median income for Massachusetts; or (2) 25 percent of the residents are minority; or (3) 25 percent of the residents are lacking English language proficiency (English Isolation). The map illustrates that most of the census blocks in Springfield are characterized by one of more EJ criteria. There are no EJ populations in Williamsburg.

FIGURE 7: MAP OF ENVIRONMENTAL JUSTICE POPULATIONS IN SPRINGFIELD



Baseline Health Profiles of Springfield and Williamsburg

Selected Hospitalization and Emergency Department Utilization Data

Table 5 presents the rates of hospitalization for primary diagnoses of asthma and myocardial infarction (heart attack) in Springfield, Williamsburg and the state as a whole for 2010-2012. To address the fact that health outcomes vary across age groups, a statistical method was applied to the rates of a disease in a population that allows comparison among populations with different age distributions. In this case, rates are age-standardized to the age distribution of the state of Massachusetts based on data from the 2010 US Census.

Inpatient hospitalizations for asthma can primarily be thought of as the subset of asthma Emergency Department (ED) visits that resulted in an overnight admission since the large majority of hospital admissions for asthma originated in the ED and are included in the ED rate. Springfield has statistically significantly higher rates of asthma hospitalizations compared to the state. Note that statistical significance indicates that the rates are different from the state prevalence and the difference is unlikely due to chance. Williamsburg rates are not shown due to small numbers. These data are suppressed for confidentiality reasons. A data suppression rule is imposed when case counts are less than 11 in order to protect patient confidentiality for smaller geographic levels (e.g., zip code) or sparsely populated areas.

TABLE 5: ASTHMA HOSPITALIZATIONS PER 10,000 PEOPLE IN SPRINGFIELD AND WILLIAMSBURG (2010-2012)

	Year	Age Adjusted Rate	95 % Confidence Intervals	Statistical Significance of Difference from State Prevalence
Springfield	2010	25.7	23.1 - 28.3	Statistically significantly higher
	2011	19.4	17.2 - 21.6	Statistically significantly higher
	2012	23.9	21.4 - 26.3	Statistically significantly higher
Williamsburg	2010	NS	NS	NS
	2011	NS	NS	NS
	2012	NS	NS	NS
Statewide	2010	15.6	15.3 - 15.9	
	2011	15.1	14.8 - 15.4	
	2012	13.3	13.0 - 13.6	

NS indicates number/ rate not shown due to small numbers. These data are suppressed for confidentiality reasons.

Table 6 presents the rates of asthma emergency department (ED) visits in Springfield, Williamsburg and the state as a whole for 2010-1012. Rates of ED visits in Springfield are statistically significantly higher compared to the statewide rates whereas the rates in Williamsburg or lower (2011) are not statistically significantly higher.

TABLE 6: ASTHMA EMERGENCY DEPARTMENT VISITS PER 10,000 PEOPLE IN SPRINGFIELD AND WILLIAMSBURG (2010-2012)

	Year	Age Adjusted Rate	95% Confidence Intervals	Statistical Significance of Difference from State Prevalence
Springfield	2010	184.6	177.7 - 191.4	Statistically significantly higher
	2011	178.9	172.2 - 185.6	Statistically significantly higher
	2012	177.7	171.1 - 184.3	Statistically significantly higher
Williamsburg	2010	63.4	31.3 - 95.5	Not statistically significant
	2011	34.6	14.1 - 55.0	Statistically significantly lower
	2012	49.0	20.0 - 78.0	Not statistically significant
Massachusetts	2010	70.2	69.5 - 70.8	
	2011	72.0	71.3 - 72.7	
	2012	73.5	72.8 - 74.1	

Rates of myocardial infarction for people 35 years and older (Table 7) are statistically significantly elevated in Springfield in 2011 and 2012 but not elevated in 2010 compared to the state as a whole. The rates for myocardial infarction are not reported for Williamsburg because of small numbers.

TABLE 7: RATES OF MYOCARDIAL INFARCTION PER 10,000 PEOPLE AGE 35 YEARS AND OLDER IN SPRINGFIELD AND WILLIAMSBURG (2010-2012)

	Year	Age Adjusted Rate	95% Confidence Intervals	Statistical Significance of Difference from State Prevalence
Springfield	2010	36.2	31.9 - 40.6	Not statistically significantly different
	2011	38.0	33.5 - 42.4	Statistically significantly higher
	2012	34.9	34.9	Statistically significantly higher
Williamsburg	2010	NS	NS	NS
	2011	NS	NS	NS
	2012	NS	NS	NS
Massachusetts	2010	33.0	32.4 - 33.5	
	2011	30.4	29.9 - 31.0	
	2012	9.5	29.0 - 30.0	
NS indicates number/ rate not shown due to small numbers. These data are suppressed for confidentiality reasons.				

Behavioral Risk Factor Surveillance System (BRFSS) Data

Table 8 and Table 9 provide the BRFSS estimated prevalence of lifetime and current asthma, diabetes, and mental health disorders (i.e., depression, anxiety and depressive disorders) for Springfield, Williamsburg, and the state as a whole. Note that to provide municipal level information for the indicators presented below, multiple years of BRFSS data are combined to allow for small area estimations. Springfield residents reported statistically significant higher rates of asthma (both current and ever), diabetes, more days of poor mental health, less reported days of good or excellent health and less physical activity.

BRFSS data are consistent with the overall summary of hospitalizations and ED visits for asthma and myocardial infarction presented for Springfield above, which demonstrate higher rates of health-related outcomes and behaviors compared with the state as a whole. Conversely, residents of Williamsburg reported better or otherwise statistically insignificant differences compared to the state. BRFSS data for current depression, anxiety and depressive disorders presented in Table 9 continues the same trend with Springfield residents reporting more mental health issues than the state as whole. For these indicators it was not possible to generate small area estimates for Williamsburg.

TABLE 8: BRFSS SURVEY DATA FOR SPRINGFIELD AND WILLIAMSBURG

Outcome	Community	Percent	95% Confidence Intervals
Ever Asthma	Springfield	21	18.9 - 23.2
	Williamsburg	14.7	12.1 - 17.8
	Massachusetts	15.4	14.8 - 15.9
Current Asthma	Springfield	14.7	12.9 - 16.6
	Williamsburg*	9.5	7.7 - 11.7
	Massachusetts	10.3	9.9 - 10.8
Diabetes	Springfield	11.5	10.2 - 13.1
	Williamsburg	NA	NA - NA
	Massachusetts	7.5	7.2 - 7.8
15+ days poor mental health (2007, 2008, 2009, 2010, 2011)	Springfield	15.3	13.9 - 16.9
	Williamsburg*	7.3	5.2 - 10.1
	Massachusetts	9.9	8.0 - 12.3
3-years average prevalence of good to excellent health among adults (2008, 2009, 2010)	Springfield	76.9	74.7 - 78.9
	Williamsburg	NA	NA - NA
	Massachusetts	87.5	83.7 - 90.3
5-year average prevalence of lack of regular physical activity among adults (2001, 2003, 2005, 2007, 2009)	Springfield	55.7	53.3 - 58.1
	Williamsburg	NA	NA - NA
	Massachusetts	47.3	42.0 - 52.7

Data source: BRFSS. Note that multiple years of BRFSS data listed are combined to allow for small area estimations. *In order to provide data for more MA communities, town level estimates that may be based on relatively few respondents or have standard errors that are larger than average. The confidence interval for this community is wider than the normal limits set by DPH. Therefore, the estimate for this community is wider than the normal limits set by DPH.

TABLE 9: BRFSS SURVEY DATA FOR DEPRESSION, ANXIETY DISORDER, AND DEPRESSIVE DISORDER

Outcome	Community	Percent	95% Confidence Intervals
Current Depression	Springfield*	15.4	12.1 - 19.3
	Williamsburg	NA	NA - NA
	Massachusetts	7.4	6.7 - 8.2
Anxiety Disorder	Springfield*	18.3	15.1 - 22
	Williamsburg	NA	NA - NA
	Massachusetts	13.8	12.9 - 14.7
Depressive Disorder	Springfield*	23	19.8 - 26.6
	Williamsburg	NA	NA - NA
	Massachusetts	16.1	15.2 - 17

Data source: CY2006, 2008, 2010 BRFSS. *To provide data for more Massachusetts communities, town level estimates that may be based on relatively few respondents or have standard errors that are larger than average. The confidence interval for this community is wider than the normal limits set by DPH. Therefore, the estimate for this town should be interpreted with caution.

Lung and Bronchus Cancer

Table 10 contains lung and bronchus cancer incidence data for the communities of Springfield and Williamsburg. These data are based on new diagnoses of invasive lung and bronchus cancer reported to the Massachusetts Cancer Registry (MCR), a population-based statewide surveillance system. These data cover the five-year period 2005 through 2009. Table 10 presents the observed number of diagnoses in the community and the number of expected diagnoses based on the statewide cancer experience, a statistic referred to as a standardized incidence ratio (SIR), and the 95% confidence interval for the SIR (a measure of the SIR's stability). The SIR is the ratio of the observed number of cancer diagnoses in an area to the expected number of diagnoses multiplied by 100.

For Springfield, the citywide incidence of lung and bronchus cancer was about as expected for females. Two hundred and sixty two diagnoses were observed among Springfield females while approximately 269 diagnoses would be expected. Among Springfield's 35 census tracts, a statistically significant elevation was noted in females in one census tract (8002.02). For Springfield males, a statistically significant elevation was seen with 270 diagnoses observed and approximately 238 diagnoses expected; this elevation was of borderline statistical significance. As was true with females, only one census tract had a statistically significant elevation in males – census tract 8001.

For Williamsburg, the incidence of lung and bronchus cancer for this time period was about as expected for females and lower as expected for males. For females, five diagnoses were observed while approximately five diagnoses were expected. For males, two diagnoses were observed while approximately six diagnoses were expected.

Established risk factors for lung and bronchus cancer include smoking, exposure to radon, and occupational contact with the following substances: asbestos, arsenic, beryllium, cadmium, silica, vinyl chloride, nickel and chromium compounds, coal products, mustard gas, chloromethyl ethers, diesel exhaust and radioactive ores.

Of the males diagnosed with lung and bronchus cancer in Springfield, information on tobacco use was provided to the MCR for 238 of the 270 men. Of these, 227 (95.4%) reported current or former tobacco use. In census tract 8001, where a statistically significant elevation was seen in males, 22 of the 22 men (100%) reported current or former tobacco use. Among the female diagnoses, information on tobacco use was provided to the MCR for 232 of the 262 women. Of these, 205 (88.4%) reported current or former tobacco use. In census tract 8002.02, where a statistically significant elevation was seen in females, 6 of the 7 women (85.7%) reported current or former tobacco use.

TABLE 10: CANCER INCIDENCE IN SPRINGFIELD AND WILLIAMSBURG

	Males					Females				
	Obs	Exp	SIR		95% CI	Obs	Exp	SIR		95% CI
Springfield	270	238.4	113	*	100 -128	262	269.4	97		86-110
Williamsburg	2	5.6	NC		NC-NC	5	5.2	96		31-224

Obs = Observed number of diagnoses	95% CI = 95% Confidence Interval
Exp = Expected number of diagnoses	NC = Not calculated
SIR = Standardized Incidence Ratio	* = Statistical significance

The source of the cancer data is the Massachusetts Cancer Registry, Bureau of Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health. SIRs are calculated based on the exact number of expected diagnoses. Expected numbers of diagnoses presented are rounded to the nearest tenth. SIRs and 95% CIs are not calculated when the observed number is < 5.

Pediatric Asthma

DPH/BEH routinely conducts statewide pediatric asthma surveillance as reported by school nurses and/or administrative staff at public and private schools serving students from kindergarten (K) through 8 grades. School-based asthma data have been shown to closely reflect doctor-diagnosed asthma, as demonstrated in a study carried out by DPH/BEH in the Merrimack Valley region of the state, which showed 96 percent agreement between the two sources.[82] Data reported by school nurses includes the city or town of residence for each child with asthma, which also enables estimates of pediatric asthma prevalence by city/town of residence.

Pediatric asthma prevalence data per 100 students are presented in Springfield, Williamsburg and the state as a whole in Table 11. For Springfield, the pediatric asthma prevalence was statistically significantly higher for the most recent three school years examined. In Williamsburg, a statistically significant elevation compared to the state was observed only in the 2009-2010 school year; the remaining years were not statistically significant. Note that statistical significance indicates that prevalence is different from the state prevalence and the difference is unlikely due to chance.

TABLE 11: PEDIATRIC ASTHMA PREVALENCE IN SPRINGFIELD AND WILLIAMSBURG

School Year	Student Case Count	Prevalence Per 100 Students	95% Confidence Interval	Statistical Significance
Springfield				
2009 - 2010	3,682	17.7	17.1 - 18.3	Statistically significantly higher
2010 - 2011	3,833	18.5	17.9 - 19.1	Statistically significantly higher
2011 - 2012	3,498	16.8	16.2 - 17.4	Statistically significantly higher
Williamsburg				
2009 - 2010	32	15.2	9.9 – 20.4	Statistically significantly higher
2010 - 2011	28	13.7	8.6 – 18.8	Not Statistically significantly higher
2011 - 2012	31	13.9	9.0 – 18.8	Not Statistically significantly higher
Statewide				
2009 - 2010	80,602	11.6	11.5 - 11.7	
2010 - 2011	81,234	11.7	11.6 - 11.8	
2011 - 2012	82,553	11.9	11.8 - 12.0	

Baseline Environmental Conditions in Springfield and Williamsburg

As described in the Methods section, the baseline environmental conditions for Springfield and Williamsburg are characterized by air quality conditions and the change in GHG emissions for each community.

Air Quality

Figure 8 shows the percent of days in Hampden County exceeding the daily $PM_{2.5}$ NAAQS from 2001-2011. (Note: There were no exceedances in 2009 or 2011.) The monitored concentration used to compare to the NAAQS reflects the highest concentration of $PM_{2.5}$ measured on a daily basis. The daily $PM_{2.5}$ NAAQS is 35 $\mu g/m^3$.

FIGURE 8: PERCENT OF DAYS EXCEEDING $PM_{2.5}$ NAAQS IN HAMPDEN COUNTY

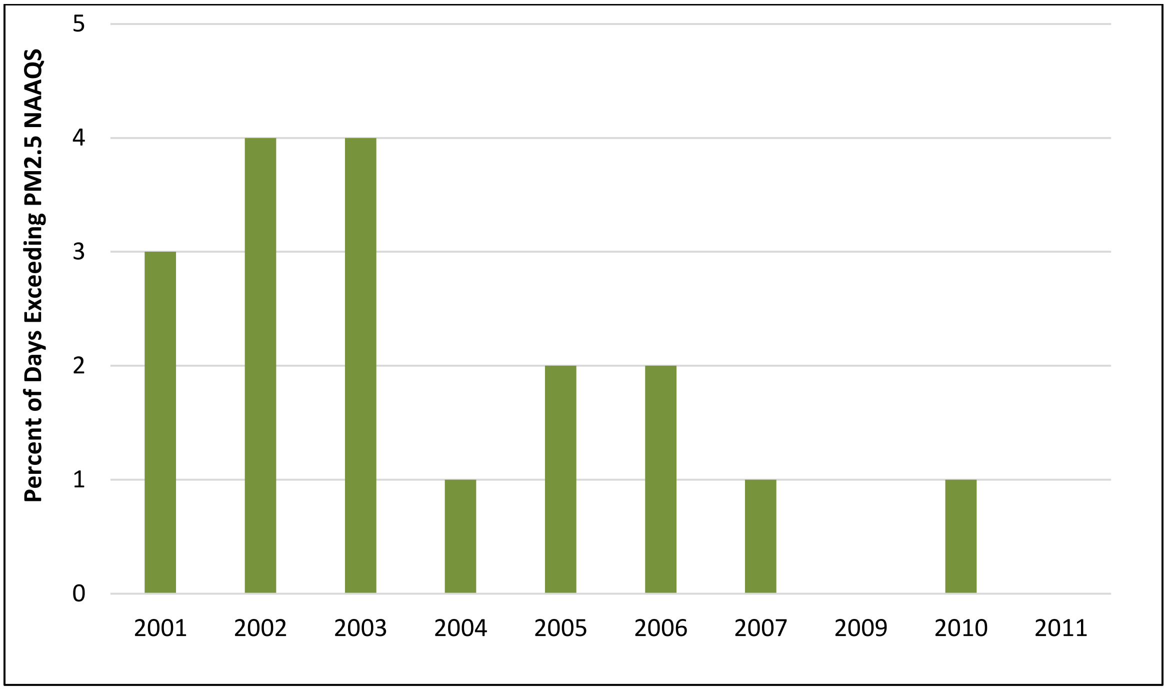


Figure 9 and Figure 10 present the number of days exceeding the ozone NAAQS in Hampden and Hampshire counties, respectively. The ozone measure is based on the highest daily maximum 8-hour ozone concentration measured in the county. The daily ozone National Ambient Air Quality Standard (NAAQS) is 0.075 ppm.

FIGURE 9: NUMBER OF DAYS EXCEEDING OZONE NAAQS IN HAMDEN COUNTY

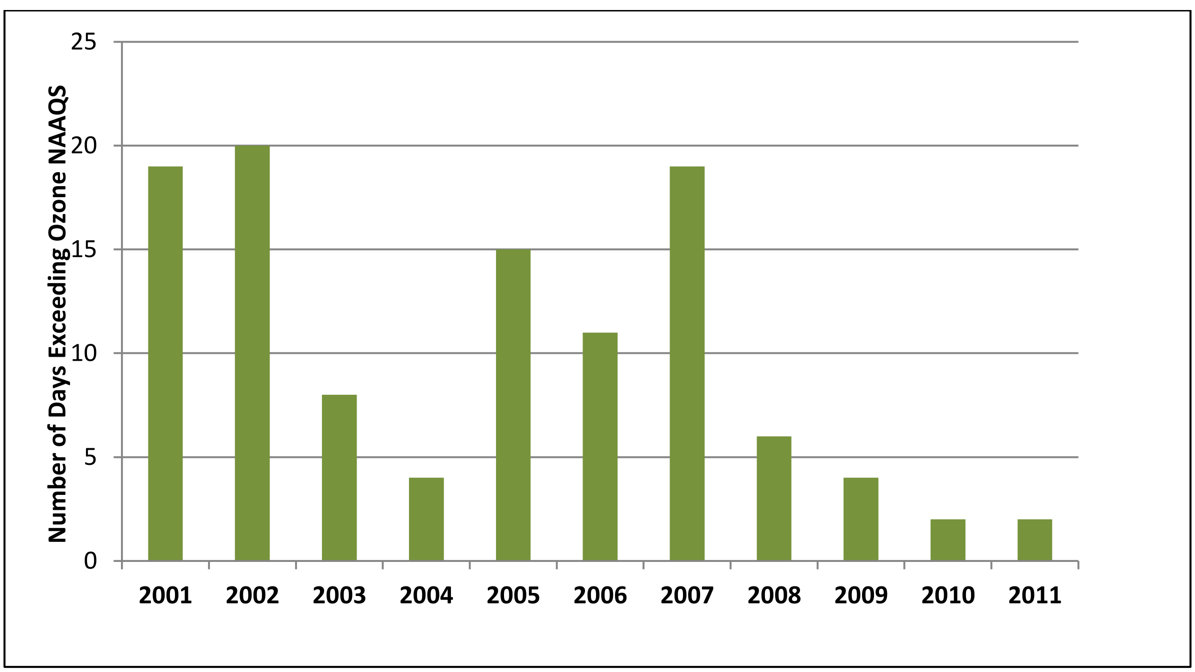
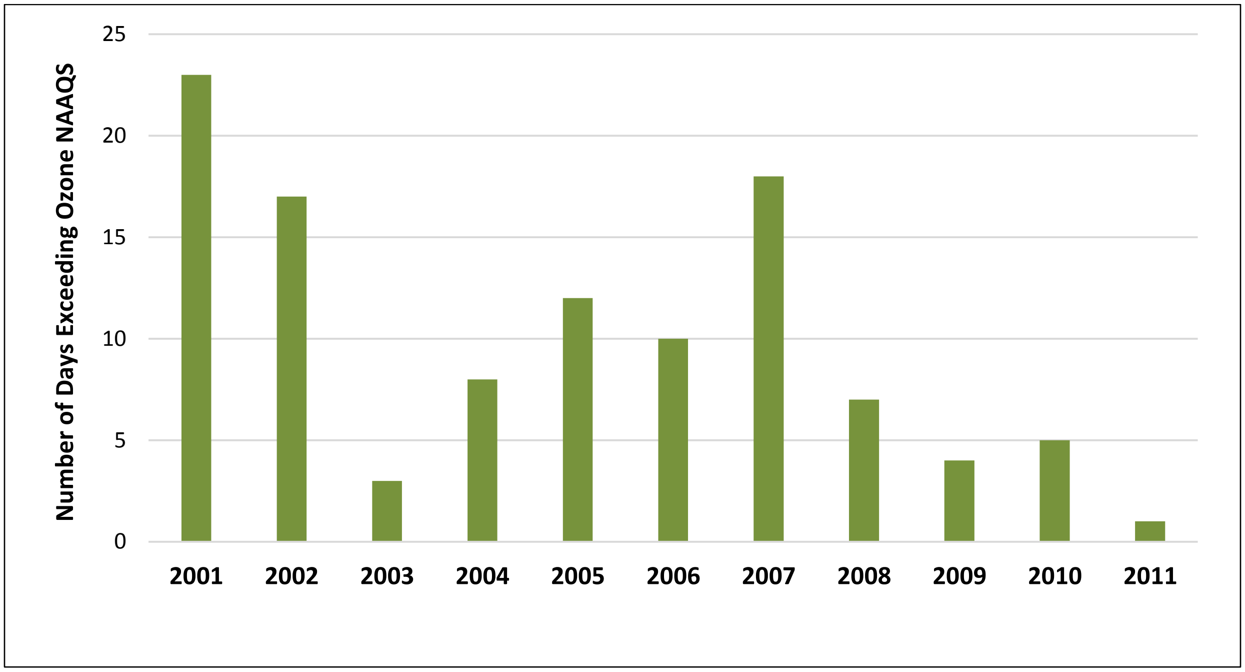


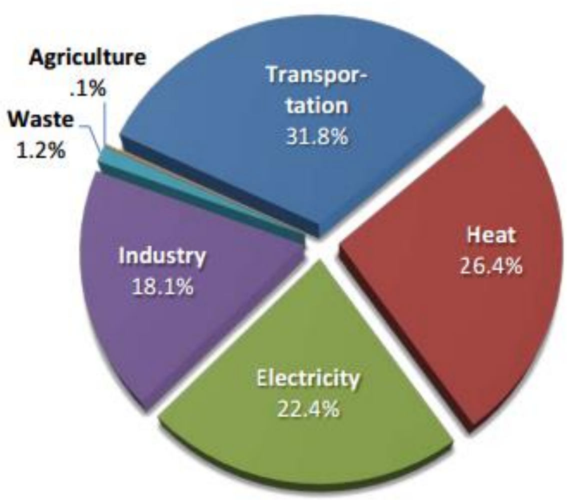
FIGURE 10: NUMBER OF DAYS EXCEEDING OZONE NAAQS IN HAMPSHIRE COUNTY



Greenhouse Gas Emissions

According to the 2014 PV Climate Action Plan, a regional GHG inventory was completed for the Pioneer Valley region, which showed that the region produced 9.2 million metric tons of CO_2 equivalents or MTCO2e (Figure 11). The region's largest sources of GHGs were transportation, followed by heat for buildings and electricity consumption.

FIGURE 11: GHG EMISSIONS INVENTORY FOR THE PIONEER VALLEY REGION[83]



Sector	$MTCO_2e$
Transportation	2,922,382
Heat for buildings	2,428,076
Electricity consumption	2,064,432
Industry	1,663,689
Waste	110,547
Agriculture	12,806
TOTAL	**9,201,933**

One of the primary goals of energy efficiency programs is reduction in electricity use, which in turn reduces regional air pollution, reduces local air pollution around energy generating plants, and reduces demand for energy. The GHG inventory for the Pioneer Valley estimated that 22.4% of the total $MMTCO_2e$ is emitted from electricity generating units serving the Pioneer Valley region.

GHG emission per capita in Springfield ranges from 3.3 to 4.9 million metric tons and 0.3-2.7 million metric tons for Williamsburg.

Over a period from 2008-1013, Massachusetts initiated a variety of legislative actions, executive orders, and new regulations to address climate change and promote clean energy, including the Green Communities Act. The GHG emissions from the use of electricity fell from 28 million MMTCO2e in 1990 to 17 MMTCO2e in 2011. Statewide GHG emissions in 2010 were 84 MMTCO2e, or an 11% reduction below 1990 levels.

Assessment of Potential Health Impacts and Benefits of Climate Action Strategies Evaluated in this HIA

The following section provides an assessment of the potential health impacts and benefits associated with the two climate action strategies evaluated in this HIA. For heat-related events, the assessment presents a summary of current plans to address heat and a map of vulnerable populations relative to the location of cooling centers in each community. The assessment of energy efficiency measures focused on health impacts associated with changes in air quality from implementing energy efficiency measures in municipal buildings. As previously discussed, an important feature of this HIA is the integration of the BRACE framework (i.e., climate and health profile and vulnerability assessment) into the assessment phase of the HIA.

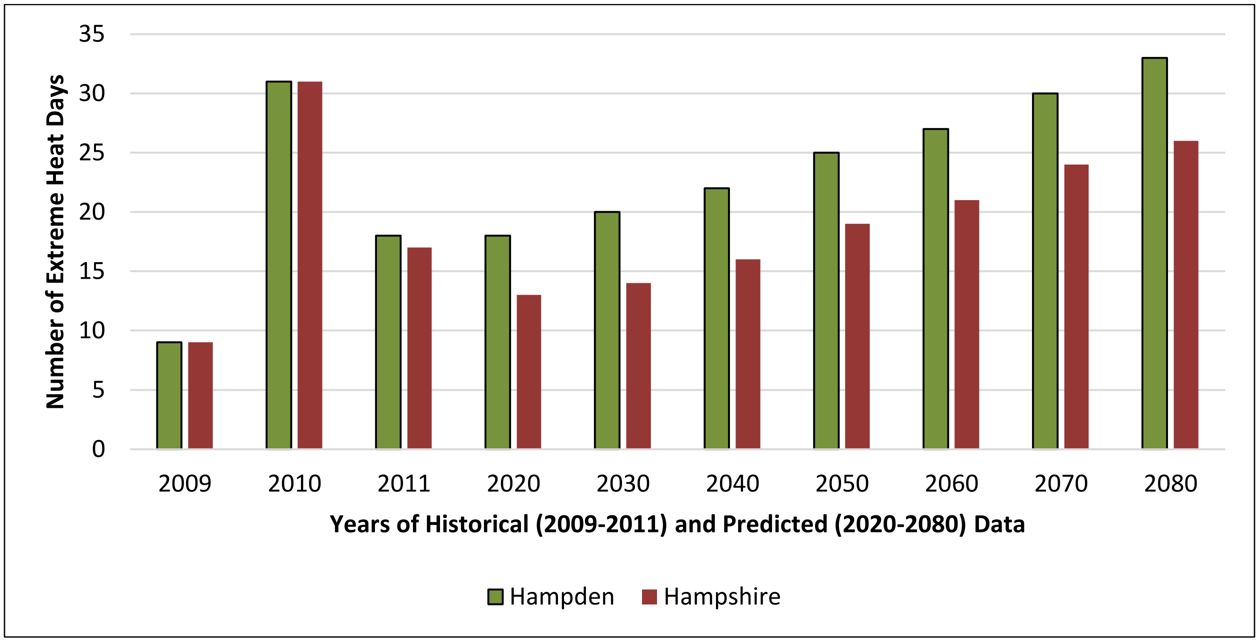
Assessing the Need to Provide Cooling Shelters and Assist Vulnerable Populations During Heat Waves

Climate and Health Profile for Heat-Related Events

PROJECTED CHANGES IN EXPOSURE TO HEAT-RELATED EVENTS

Heat-related events, which are projected to increase in frequency, intensity, and duration are predicted to increase heat-related morbidity and mortality.[84] In Massachusetts, annual temperatures have increased at an average rate of 0.26 degree C (0.5 degrees F) per decade since 1970. Winter temperatures have been rising faster at a rate of 0.7 degrees C (1.3 degrees F).[85] Figure 12 presents the historical and predicted climate modeling data of the projected number of extreme heat days (98th percentile) in Hamden and Hampshire Counties.

FIGURE 12: NUMBER OF HISTORICAL AND PREDICTED EXTREME HEAT DAYS (98TH PERCENTILE) IN HAMPDEN AND HAMPSHIRE COUNTIES



HEALTH OUTCOMES OF CONCERN

The health outcomes of concern identified in the pathway diagrams that may be influenced by adaptation strategies to address heat-related events include heat-related impacts, respiratory and cardiovascular diseases, mental health and changes in physical activity.

VULNERABILITY INDICATORS

Table 13 presents the vulnerability indicators for Springfield and Williamsburg. Many of these indicators overlap with Environmental Justice criteria and can be applied more generally to overall vulnerability of human health to climate change.

TABLE 12: VULNERABILITY INDICATORS ASSOCIATED WITH HEAT-RELATED EVENTS IN SPRINGFIELD AND WILLIAMSBURG

Demographic Factors		Springfield	Williamsburg
Age	Percent 5 and under	7.6	4.4
	Percent under age of 10	14.6	9.2
	Percent older than 65	11.0	12.4
	Percent older 65 living alone	36.9	35.8
	Percent living alone	4.0	4.4
Income	Percent below poverty	27.6	6.7
Race	Percent of a race/ethnicity than white	45.8	1.3
Population density	Population density (per square mile)	4,771.2	96.6
Environmental factors	Percent Green Space	24.4	91.9
	Green Space (acres)	5,170.4	15,122.7

Although there are substantial differences in demographics, population density, and availability of green space between the two communities, Williamsburg and Springfield face similar challenges when it comes to vulnerable populations. Both communities have elderly populations that comprise about 11-12 percent of the total population, and of that elderly population, about 36-37 percent live alone. This is notable given that the poverty rate in Springfield is 21 percentage points higher than that of Williamsburg. Thus, the elderly will likely be disproportionately affected by heat-related events in both communities, especially those living in poverty or without access to transportation to cooling centers.

Current Local Planning Process to Address Heat-Related Events

SPRINGFIELD

Springfield has a robust plan and approach to addressing health concerns related to extreme heat. Since 1996, Springfield has had an Extreme Heat Plan and Policy, updated in 1997 and again in 2012. The Springfield Department of Health and Human Services coordinates the city's response to extreme heat by collaborating with a Task Force comprised of representatives from Emergency Management, Elder Affairs, Police, Senior Services, the Springfield Regional Chamber and the Visitor's Center. City officials monitor weather for "Heat Advisory", "Heat Watch" and "Heat Emergency". The city opens cooling centers following a process described in the city's Heat Emergency Response plan.

Springfield uses traditional media releases, issued by the Mayor's office to area newspapers, TV and radio stations. The overall message is to stay cool in place and drink plenty of water. Because these releases go out from the Mayor's communications staff, they are generally reported by the local media. In addition, city libraries and Senior Centers are open to the public and they are air conditioned and have cool water available.

Springfield focuses on elders and other vulnerable populations, which is why they target both libraries Senior Centers and as cooling centers. Springfield alerts the public in the event of a "Heat Watch"—90-104 degrees for 3 consecutive days and/or a "Heat Emergency"—over 105. These definitions are understood by city officials to be national standard definitions. City officials do not conduct surveillance during extreme heat events, but they are concerned that their efforts may not reach ably challenged individuals, who may not be able to easily leave their homes and individuals with chronic disease who are not mobile. They are also concerned about homeless individuals because shelters for homeless usually close during the day, so homeless people may be outside during heat-related events.

WILLIAMSBURG

Williamsburg has a much less formal response to extreme heat. While there is no existing plan to respond to extreme heat events, information about emergency preparedness is available on their municipal webpage. They also participate in regional sheltering planning with the Western Region Homeland Security Advisory Council (as does Springfield). The emergency preparedness information on the website does not highlight extreme heat, but it does discuss the town's participation in the Mohawk area public health coalition. In past extreme heat events, town officials have opened the Town Hall to residents as a cooling center during normal office hours. The town reports responding to an estimated 1-2 heat-related public health emergencies in the last five years and also does not conduct surveillance during heat-related events.

Like Springfield, Williamsburg is primarily concerned about older residents and economically disadvantaged residents, and takes a coordinated approach to addressing heat-related events by including the Council on Aging, the Emergency Management Director, Police and Fire departments, and the Board of Health. Unlike Springfield, Williamsburg officials do use their reverse 911 calling capacity to alert residents to the availability of Town Hall as a cooling center and unlike Springfield, town officials report feeling unprepared to adequately respond to an extreme heat event that resulted in 3+ days of 90+ temperatures.

Mapping Vulnerable Populations and Location of Cooling Centers to Heat to Inform Planning Process

To better assess the impacts associated with predicted increases in heat-related events, stakeholders recommended that a map be developed that identifies the potential vulnerabilities to heat and the current location of cooling centers in Springfield and Williamsburg.

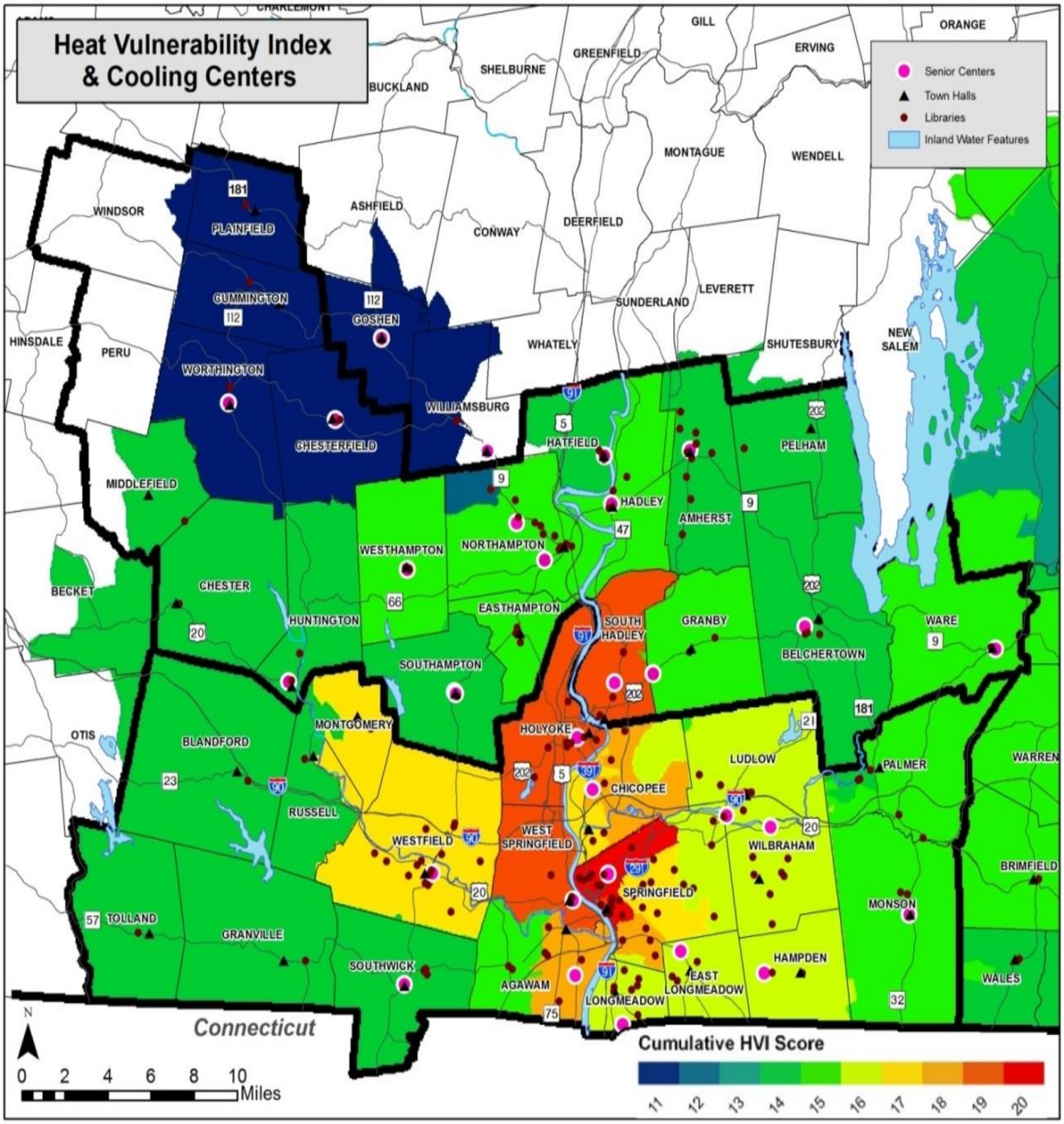
We selected the cumulative heat vulnerability index (HVI) map developed by Reid et al. (2009) to identify areas and population that are more vulnerable to heat because it was developed to focus interventions on the prevention of heat-related morbidity and mortality. PVPC geocoded and overlaid a map of the location of cooling centers in both communities (Figure 13).

The factors that are considered in the cumulative HVI are: social/environmental vulnerability (i.e., percent below poverty, percent with less than high school education, percent of race other than white, and percent green space); social isolation (i.e., percent population living alone); percent of households without air conditioning; and percent elderly/with diabetes (i.e., population 65+years of age; diabetes prevalence). The cumulative HVI is calculated by assigning values to categories that correspond to less than 1, 1-2, or greater than 2 standard deviations from the mean for each factor and summing the values for each census tract. Figure 13 indicates that there are a large number of cooling centers in areas with the highest cumulative HVI values in Springfield.

As expected, the cumulative HVI in Williamsburg is lower than Springfield; however, heat vulnerability is possible in any smaller areas with a high concentration of impervious surface and sparse vegetation.

There are several important findings from the Reid et al. study that are relevant to this HIA. Within-city variability of heat vulnerability, as observed in Springfield, indicates the importance of evaluating heat vulnerability at the census tract or zip code level. The Reid et al., study also identified the importance of household air conditioning as one of many strategies to address heat; however, key informant interviews also identified the need to promote multiple approaches to reduce heat exposure in addition to air conditioning including improving circulation of indoor air using fans, shading windows, applying a cold cloth to neck and wrists, shutting off lights, and staying in cool areas of the home (e.g., basement).

FIGURE 13: MAP OF THE HEAT VULNERABILITY INDEX (HVI) AND LOCATIONS OF COOLING CENTERS IN SPRINGFIELD AND WILLIAMSBURG



Assessing Energy Efficiency Measures in Municipal Buildings

Climate and Health Profile for Energy Efficiency Measures

The climate and health profile for assessing energy efficiency measures in municipal buildings focused on the climate impacts, health outcomes, and vulnerability indicators associated with reductions in GHG emissions and air pollution from such measures. One of the primary goals of energy efficiency programs is reduction in electricity use, which, in turn, reduces emissions of GHG and air pollution. Over a period from 2008-2013, Massachusetts initiated a variety of legislative actions, executive orders, and new regulations to address climate change and promote clean energy. These programs included promotion of energy efficiency programs, renewable energy programs, and reductions in power plant emissions. In addition, statewide limits of GHG emissions from 10-25 percent below 1990 levels were established. The baseline environmental assessment provided information on GHG inventory in Springfield and Williamsburg. Overall, statewide GHG emissions in 2010 were 84 $MMTCO_2e$, or an 11% reduction below 1990 levels.

PROJECTED CHANGES FROM INCREASING GHG EMISSIONS

It is widely accepted that the increased amount of GHG emissions is contributing to climate change.[47] These changes are currently causing, and are predicted to continue to cause, significant widespread impacts in Massachusetts. According to the Massachusetts Climate Change Adaptation Report, the impacts include:

- Higher temperatures contribute to complications or exacerbation of conditions associated with respiratory illnesses and cardiovascular disease;
- Increased ozone and particulate matter production, coupled with higher temperatures, results in poor air quality, and increases risk to conditions associated with preexisting respiratory and cardiovascular diseases;
- Increased plant pollen production and more allergenic pollen content, may aggravate and exacerbate allergies, asthma and other respiratory illnesses;
- Shift in disease patterns and a possible increase of vector-borne diseases (including Lyme disease, Eastern Equine Encephalitis and West Nile Virus) as ticks and mosquitoes adapt to changing conditions;
- Increased potential for water-borne disease outbreaks during and after flooding events;
- Degraded surface water quality from sediments, pathogens, nutrients, and pesticides in storm water and agricultural runoff;
- Shifts in shellfish pathogens, with possible increasing contamination and closure of shellfish beds;

- Extreme weather events, such as ice storms, heat waves, and more powerful storms that disrupt power and sanitary services, health care services, and access to safe and nutritious food, and which cause damage to homes and property;

- Increased mental and physical health burdens from the need to cope with more extreme weather, disaster response, and uncertainty;

- The potential for stressing each component of the public health infrastructure. Public and private health care systems will need to respond to increased occurrences and demand for treatment of acute and chronic diseases and ailments such as heat stress, exacerbation of pre-existing asthma, new diseases, mental health effects such as anxiety resulting from displacement under emergency circumstances, and physical trauma from flooding.

HEALTH OUTCOMES OF CONCERN

The pathway diagram for energy efficiency measures identified a wide range of factors that directly and indirectly influence health. For example, energy efficiency measures may change the quality of the indoor environment (air quality, thermal comfort, and lighting) that, in turn, may change such factors as the productivity of occupants, municipal expenditures for energy, and the market value of upgraded municipal assets. The health outcomes of concern associated with this strategy are respiratory illnesses, respiratory and cardiovascular diseases, premature mortality, lung cancer, restricted activity days, mental health, and community health.

VULNERABILITY INDICATORS

Vulnerable populations include municipal workers, school children and other occupants of municipal buildings with sensitivities to changes to the indoor environment (e.g., thermal comfort, lighting) and those with pre-existing respiratory or cardiovascular disease that may be adversely affected by factors related to poor indoor and outdoor air quality. In addition, there are potentially a substantial number of people that may be affected by changes in regional air pollutants from reduction in electricity use from energy efficiency measures. Changes in heating oil use may also impact populations living near municipal buildings.

Current Activities to Reduce GHG Emissions

The literature review provided several examples of how energy efficiency plays a duel role in supporting both carbon mitigation and adaptation strategies by reducing energy demand and increasing the efficiency of energy use by both electric generators and end-users of electricity (e.g., energy management systems). The following section provides an overview of specific activities associated with the Green Community program that were undertaken in Springfield and Williamsburg to implement energy efficiency measures in their communities. Additional details related to these activities are provided in Appendix A.

To be designated a Green Community in Massachusetts, a municipality must meet the following criteria:

Criterion 1: Provide as-of-right siting in designated locations for renewable/alternative energy generation, research & development, or manufacturing facilities.
Criterion 2: Adopt an expedited application and permit process for as-of-right energy facilities.
Criterion 3: Establish an energy use baseline and develop a plan to reduce energy use by twenty percent (20%) within five (5) years.
Criterion 4: Purchase only fuel-efficient vehicles.
Criterion 5: Set requirements to minimize life-cycle energy costs for new construction (e.g., adopt the new Board of Building Regulations and Standards (BBRS) Stretch Code).

SPRINGFIELD

In 2010 Springfield became one of the first certified Green Communities in Massachusetts. The 20% reduction plan in Springfield associated with Criterion 3 above spans the years from 2007 to 2012 during which time the city achieved a 21% reduction in energy use. This is summarized in Table 15.

TABLE 13: BASELINE ENERGY USE AND PROJECTED ENERGY SAVINGS FROM SPRINGFIELD'S 20 PERCENT REDUCTION PLAN (2011)

	MMBTu
Completed Work	54,603.1
Work In Progress	3,243.2
Future Work	38,003.7
Street Lights	5,050.1
Gasoline Reduction	746.0
TOTAL Projected Savings	101,646.0
Total usage baseline FY07	470,587.5
Total Percent Reduction	21.6%

MMBTu – Million British Thermal Units (BTU)

Springfield has over five years of data and can show significant reductions in municipal electricity use as well as other fuels used for heating and cooling. As part of their Green Communities certification, the city also adopted the Stretch Energy code, which requires all new construction to be built to a higher energy efficient standard than the baseline Building code and the city also adopted a fuel efficient vehicle policy.

Energy efficiency work accomplished in Springfield includes: replacing and upgrading boilers, water heaters and lighting fixtures; installation of web-based energy management systems; installation of variable frequency drives and high efficiency motors; insulation of buildings and other improvements to the building envelope; replacement of windows; and roof upgrades. In addition, the city committed to review all future construction, renovations and equipment replacement and repairs for energy efficiency.

WILLIAMSBURG

The town of Williamsburg was certified as a Green Community in 2014. Prior to this formal recognition of the Town's efforts to reduce energy use, Williamsburg had already formed an energy committee in 2007, collaborated with the Pioneer Valley Planning Commission on a regional energy services company (ESCO) project in 2008-2010, and received state and federal funding for energy efficiency. While Williamsburg did not move forward with the ESCO to comprehensively address the recommended energy efficiency improvements (in part because a 20-year loan for a relatively small amount of work did not make financial sense given the interest rates at the time), the town did use the information from the project to work aggressively with their utility company to reduce energy use. This information is summarized in the Table 16.

TABLE 14: BASELINE ENERGY USE AND PROJECTED SAVINGS FROM 20% ENERGY REDUCTION PLAN IN WILLIAMSBURG (2013)

	MMBtu Used In Baseline Year (2011)	Percent Of Total Baseline Energy Consumption	Projected Planned Savings	Savings As A Percent Of Baseline
Buildings	5417	73	774	14
Vehicles	1537	21	17	1
Street/Traffic Lights	171	2	0	0
Water/Sewer/Pumping	292	4	0	0
Open Space	5	0	0	0
Total (MMBtu)	7422	100%	791	15%

MMBTu – Million British Thermal Units (BTU)

Previous energy efficiency initiatives in Williamsburg include: a boiler retrofit at the Haydenville Police and Fire (Public Safety) Building; use of ARRA funding for efficiency improvements (insulation, weatherization and heating controls) at the Town Offices and the Highway Department building in FY 2011; and utility-sponsored direct installation of lighting retrofits. In addition to projects that installed more efficient operating equipment, the Water Department initiated operation and maintenance practices, starting in FY2010, which have resulted in a reduction of 48% in water pumping electrical usage through FY 2013. The Town has reduced its weather normalized energy use by 17% from FY 2011 base year and reduced its usage by an additional 1% in FY 2013.

Williamsburg is presently in an evolving building use situation due to the replacement of Dunphy School with a new building which will not only be more energy efficient, but eliminate the need for another building - the Helen E. James School. The energy efficiency of this building will far surpass that of either of the two existing school buildings and will be a main driver in achieving the community's 20% reduction in energy use. As part of their Green Communities certification, the town also adopted the Stretch Energy code, which requires all new construction to be built to a higher energy efficient standard than the baseline Building code and the town also adopted a fuel efficient vehicle policy. The Town has reduced its energy use by 18% from the baseline year of FY 2011 through FY 2013.

Reductions in Air Pollution Emissions from Energy Efficiency Measures

The health impacts of energy efficiency measures were assessed in the following three scenarios: (1) reduction of air pollution emissions from reduced electricity use due to energy efficiency measures; and (2) reduction of air pollution from the replacement of fossil-fuel burning boilers emissions at municipal buildings. (See Methods section for more details.)

Energy efficiency measures reduce the amount of electricity generated from the power grid. Measures to reduce electricity use from fossil fuel electric generating power plants also reduce air pollution emissions (e.g., GHGs and air pollutants) from these power plants. A large number of studies have demonstrated that air pollution emissions are associated with a broad range of respiratory and cardiovascular health impacts including mortality, hospitalizations for asthma and heart attacks, restricted activity days and work loss days. The health impacts also have health care-related costs associated with them. The costs associated with environmental exposures are typically associated with individual cases of illness from onset through recovery or death. For example, the costs are estimates of how much people are willing to pay for small reductions in their risk of dying from adverse health conditions that may be caused by environmental pollution.[86] The co-benefits of air pollution reductions from energy efficiency measures were evaluated in this HIA by using two US EPA screening models that quantify the co-benefits of air pollution reductions associated with energy efficiency measures, and monetize the economic benefits of reductions in utility-related air pollution emissions.[87]

The US EPA models are:

- The Avoided Emissions and Generating Tool (AVERT) model quantifies the displaced emissions of sulfur dioxide (SO_2), nitrogen oxides (NOx), and carbon dioxide (CO_2) from energy efficiency and renewable energy policies and programs. "Displaced Generation" is the total electrical energy output, measured in kilowatt-hours (kWh), from conventional electricity sources that is either "displaced" or "avoided" altogether through the implementation of energy efficiency measures. The model quantifies displaced emissions by capturing the actual historical behavior of electric generating units (EGUs) operation on an hourly basis to predict how EGUs will operate when additional energy efficiency or renewable energy policies are operationalized.

- A companion model, the Co-benefit Risk Assessment Screening Model (COBRA), was used to estimate the air quality, human health, and related economic benefits (excluding energy cost savings) of energy efficiency programs and policies. COBRA contains detailed emission estimates of fine particles ($PM_{2.5}$), So_2, NO_X, and volatile organic compounds (VOCs) for the year 2017. The reduction in emissions from energy efficiency programs are specified as decreases to the baseline emission estimates from the AVERT output. A screening air quality model (the Source-Receptor (S–R) Matrix) estimates the effects of emission changes on ambient particulate matter (PM), which are translated to estimates of avoided health impacts and monetized benefits using standard US EPA methods. For additional information see Appendix B.

For Springfield, AVERT modeled the reductions in electricity use under the Green Communities program spanning from 2007 to 2012, which resulted in a total savings of 101,646.0 MMBtu compared to a baseline of 470,587.5 MMBtu. While there were measureable reductions in energy use in Williamsburg, the projected savings of 791 MMBtu compared to a baseline of 7422 MMBtu were below the de minimus level for the AVERT model. Thus, Table 16 presents a summary of the amount of electric utility emissions that were displaced by energy efficiency measures only in Springfield.

TABLE 15: MODELED CHANGE IN ELECTRIC UTILITY EMISSIONS FROM ENERGY EFFICIENCY MEASURES (EEM) IMPLEMENTED IN SPRINGFIELD

Statewide	Original	Post-EEM	Impacts
Generation (MWh)	118,386,500	118,356,600	29,800
Total Emissions			
SO_2 (lbs)	70,078,900	70,050,400	28,400
NO_x (lbs)	63,532,900	63,510,800	22,100
CO_2 (tons)	64,050,700	64,034,100	16,600
Emission Rates			
SO_2 (lbs/MWh)	0.592	0.592	
NO_x (lbs/MWh)	0.537	0.537	
CO_2 (tons/MWh)	0.541	0.541	

Table 17 presents the annual displaced generation in electricity and air pollutant reductions annually and during the ozone season from energy efficiency measures implemented in Springfield. The spatial distribution of air pollution emissions from EGUs in the Northeast, the air quality model predicts benefits across several states. (See Appendix D for details.)

TABLE 16: AIR POLLUTION EMISSION REDUCTIONS FROM UTILITIES FROM ENERGY EFFICIENCY MEASURES IMPLEMENTED IN SPRINGFIELD

State	Annual Displaced Generation (MWh)	Annual Displaced SO_2 (lbs)	Annual Displaced NO_x (lbs)	Annual Displaced CO_2 (tons)	O_3 Season Displaced SO_2 (lbs)	Ozone Season Displaced NO_x (lbs)
Connecticut	-3100	-1100	-1800	-1700	-400	-700
Massachusetts	-5700	-8600	-3200	-3600	-2600	-1200
Maine	-1200	-1100	-300	-500	-500	-100
New Hampshire	-1900	-3200	-2000	-1400	-1200	-800
New Jersey	-500	–	–	-200	–	–
New York	-15900	-14400	-14100	-8200	-5900	-6100
Rhode Island	-1400	0	-300	-900	0	-100
Vermont	–	–	–	-100	–	–
Negative numbers indicate displaced generation and emissions. All results are rounded to the nearest hundred. A dash ("—") indicates a result greater than zero, but lower than the level of reportable significance.						

COBRA estimated the monetized benefits of the avoided health impacts of displaced emissions from energy efficiency measures in Springfield ranged from $759,945 to $1,717,057.[88] It should be noted that these benefits are based only on secondary formation of particles from SO_2 and NOx reductions and not reductions of other pollutants. Modeling the reductions of these other pollutants, particularly primary emissions of $PM_{2.5}$ from EGUs would likely significantly increase these monetized benefits.

To provide context for the contribution of energy efficiency measures implemented in Springfield and Williamsburg, an analysis of the reductions in emissions from the aggregated reduction in electricity use from all municipalities and two regional entities participating in the Green Communities program was performed. There are currently 123 Green Communities, representing 48% of the Massachusetts population.[89] Over a three year period from 2010-2012, municipal and regional entities saved more than 135,000 MWh of electricity. Table 18 presents the total emissions displaced from the Green Communities program during this time period.

TABLE 17: MODELED CHANGE IN ELECTRIC UTILITY EMISSIONS FROM ENERGY EFFICIENCY MEASURES (EEM) IMPLEMENTED THROUGHOUT MASSACHUSETTS

Statewide	Original	Post-EEM	Impacts
Generation (MWh)	118,386,500	118,251,300	135,100
Total Emissions			
SO_2 (lbs)	70,078,900	69,950,500	128,300
NO_x (lbs)	63,532,900	63,432,800	100,100
CO_2 (tons)	64,050,700	63,975,700	75,000
Emission Rates			
SO_2 (lbs/MWh)	0.592	0.592	
NO_x (lbs/MWh)	0.537	0.536	
CO_2 (tons/MWh)	0.541	0.541	

Table 19 presents the annual displaced generation in electricity and air pollutant reductions annually from energy efficiency measures implemented statewide.

TABLE 18: AIR POLLUTION EMISSION REDUCTIONS FROM UTILITIES FROM ENERGY EFFICIENCY MEASURES IMPLEMENTED IN SPRINGFIELD

State	Annual Displaced Generation (MWh)	Annual Displaced SO_2 (lbs)	Annual Displaced NO_x (lbs)	Annual Displaced CO_2 (tons)
Connecticut	-14500	-5100	-8700	-7700
Massachusetts	-25700	-38600	-14400	-15700
Maine	-5700	-5000	-1600	-2600
New Hampshire	-8200	-14300	-9000	-6000
New Jersey	-2200	–	-200	-800
New York	-66600	-64900	-60600	-1600
Rhode Island	-5500	-100	-1400	-3400
Vermont	-200	–	-200	
Negative numbers indicate displaced generation and emissions. All results are rounded to the nearest hundred. A dash ("—") indicates a result greater than zero, but lower than the level of reportable significance.				

COBRA estimated the monetized benefits of the avoided health impacts of displaced emissions from energy efficiency measures ranged from $2,008,777 to $4,538,588 statewide. As noted above, these benefits are based only on secondary formation of particles from SO_2 and NOx reductions. Modeling the reductions of these other pollutants, particularly primary emissions of $PM_{2.5}$ from EGUs would likely significantly increase these monetized benefits.

Reductions in Local Air Pollutants from Changes in Heating Oil Use

Energy efficiency measures undertaken in Springfield and Williamsburg described above including replacement of fossil-fuel burning boilers and implementation of energy management systems resulted in changes to heating oil use and, in turn, reductions in air pollution emissions from the boilers. Heating oil burners emit particulate matter (PM), oxides of nitrogen (NOx), sulfur dioxide (SO_2), mercury (Hg), carbon dioxide (CO_2) and other pollutants. Collectively, these pollutants have direct health impacts, as well as contribute to the formation of ozone and secondary formation of fine particulate matter.

Emissions from heating oil boilers are generally considered "local" sources of air pollution that affect local air quality and are influenced by such factors as stack height, location of adjacent buildings, and rooftop structure.[90] The combustion of heating oil is a significant source of SO_2 emissions in the Northeast region – second only to electric power plants. The burning of heating oil also produces approximately 10 percent of total CO_2 emissions in the Northeast.[91]

Table 20 provides a summary of heating oil use in Springfield (2007-2013) and Williamsburg (2009-2013). Table 21 provides the estimates of air pollutant emissions reduction from decreased use of heating fuel oil in Springfield and Williamsburg, respectively.

TABLE 19: HEATING FUEL OIL USE IN SPRINGFIELD AND WILLIAMSBURG

Springfield			
Heating Fuel Oil		FY2007	FY2013
	Location	Gallons	Gallons
	School Buildings	533,655.6	44,736.3
	Municipal Buildings	88,544.3	26,402.9
	Totals	622,199.9	71,139.2
Williamsburg			
Heating Fuel Oil		FY2009	FY2013
	Location	Gallons	Gallons
	School Buildings	19,124.0	14,690.0
	Municipal Buildings	14,888.0	12,197.0

Table 20: Estimate of Emission Reductions from Energy Efficiency Measures Associated Heating in Springfield and Williamsburg

Springfield			
	School Buildings	Municipal Buildings	Pounds
$PM_{2.5}$	1041.4	132.4	1173.8
PM_{10}	1163.6	147.9	1311.5
CO	2444.6	310.7	2755.3
NOx	11734.1	1491.4	13225.5
Williamsburg			
	School Buildings	Municipal Buildings	Pounds
$PM_{2.5}$	9.4	5.7	15.2
PM_{10}	10.6	6.4	17.0
CO	22.2	13.5	35.6
NOx	106.4	64.6	171.0

FINDINGS AND RECOMMENDATIONS

Summary of Overall Assessment

Table 23 and Table 24 provide the overall qualitative assessment of the climate action strategies evaluated in this HIA. This step of the HIA supports Steps 3 and 4 of the BRACE framework by informing interventions and the adaptation planning process. The following provides the criteria developed by Human Impact Partners (2011) to qualitatively summarize the health impacts and strength of evidence of the health assessment for each strategy:

- ***Impact*** refers to whether the alternative will improve (+), harm (-), or unknown (+/-).
- ***Magnitude*** reflects a qualitative judgment of the size of the anticipated change in health effect (e.g., the increase in the number of cases of disease, injury, adverse events): Negligible, Minor, Moderate, and Major.
- ***Severity*** reflects the nature of the effect on function and life-expectancy and its permanence: High = Intense/severe; Mod = Moderate; Low = Not intense or severe.
- ***Strength of Causal Evidence*** refers to the strength of the research/evidence showing causal relationship between mobility and the health outcome: ♦ = plausible but insufficient evidence; ♦ ♦ = likely but more evidence needed; ♦ ♦ ♦ = high degree of confidence in causal relationship. A causal effect means that the effect is likely to occur, irrespective of the magnitude and severity.

Summary of Overall Assessment of Providing Cooling Centers and Other Approaches to Assist Vulnerable Populations During Heat-Related Events

Overall, this HIA found that providing cooling centers and other approaches to assist vulnerable populations during heat-related events will have positive health impacts for Springfield and Williamsburg residents. The implementation of the existing heat response plan in Springfield is important given the statistically significantly higher prevalence of baseline respiratory disease and diabetes in adults, pediatric asthma in children, and large vulnerable population. Studies have demonstrated that neighborhood-level factors including poverty, poor housing conditions, lack of access to air conditioning increase the risk of death[92] and hospitalizations during heat-related events.[93] Although Williamsburg has a less formal heat response plan, it is important to note that the percentage of elderly living alone in Springfield (37%) and Williamsburg (36%) is about the same.

Interviews with stakeholders and municipal officials in both communities during the course of this HIA indicated that they are aware of many of the issues reported in the literature related to expanding education and outreach plans during heat-related events particularly to vulnerable populations. Studies have also identified such factors as the need to ensure safe and secure cooling centers, the need for consistent promotional material, and the importance of creating incentives to use air conditioning, and promoting alternative strategies to motivate people to reduce heat exposure or go to cooling centers during a heat-related event. There was a general view that such activities would benefit from regional planning efforts. A key issue raised during this project is the potential loss of power at cooling shelters during an extreme heat event. Given the regional nature of the electrical grid, this issue should also be considering in future regional planning efforts.

TABLE 21: OVERALL HEALTH ASSESSMENT FOR PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATIONS DURING HEAT-RELATED EVENTS

PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATION						
HEALTH OUTCOMES	Impact	Magnitude	Severity	Strength of Causal Evidence	Assumptions	Limitations / Uncertainties
Change in heat-related morbidity and mortality	+	Moderate	High	♦♦♦	Municipalities will develop/enhance and implement a heat response plan that includes planning for vulnerable residents; and expand education and outreach plans on reducing heat exposure during heat events.	Information on existing use of centers is needed; Impact of power outages during heat-related events is unknown.
Change in respiratory and cardiovascular diseases	+	Major	High	♦♦♦		
Change in mental health	+	Unknown	Unknown	♦♦	Municipalities will begin a dialogue about how to address environmental risk factors (e.g., heat island, tree canopy) through changes in building and landscape design measures. Planning and implementation of design measures is required. Increased physical activity is a co-benefit of these actions.	Insufficient data on mental health effects and future study is recommended.
Change in health conditions and diseases from increased physical activity	+	Unknown	Unknown	♦♦♦		Insufficient data on changes in physical activity.

Summary of Overall Assessment of Implementing Energy Efficiency Measures in Municipal Buildings

Overall, this HIA found positive health impacts from implementing energy efficiency measures in municipal buildings. These findings are based, in part, on the environmental co-benefits associated with improved indoor air quality in schools and municipal buildings and reductions in local (from reduced use of heating oil) and regional air pollution (from Electricity Generating Units, EGUs). The HIA demonstrated that although the co-benefits at the municipal level may be relatively small, the total benefits statewide of such actions are likely significant and need to be further assessed. With respect to changes in indoor air quality from potential increases in air pollution and mold associated with improvements of the building envelope, stakeholders from both Springfield and Williamsburg indicated that occupancy permits required after any renovation that may include energy efficiency measures requires compliance with ventilation standards that maintain indoor air quality. Consideration of the Massachusetts Department of Public Health guideline for indoor air quality will ensure optimal indoor environmental conditions. Specifically, the guideline recommends a ventilation rate of 20 cubic feet per minute (cfm) of fresh air to provide optimal air exchange resulting in carbon dioxide levels at or below 800 ppm.

While there is no definitive information regarding increased risk of lung cancer from increased exposure to radon from energy efficiency measures, one study found that increasing the tightness of the building envelope increased the levels of radon by over 50 percent.[94] Consultation with the expert on radon at DPH recommended that radon testing should occur prior to and after renovations of a building to determine if mitigation measures are warranted and can be incorporated during the renovation.[95] Additional testing after renovations should then be conducted to ensure mitigation measures were successful.

Key informant interviews also provided information on the positive view of the co-benefits associated with improved thermal comfort and lighting and increased public awareness of energy efficiency programs. The assessment also suggests that energy efficiency measures can increase productivity of building occupants (e.g., municipal workers and students). These activities also increase public awareness and empowerment to address energy issues and climate change at the local level.

TABLE 22: OVERALL ASSESSMENT OF IMPLEMENTING ENERGY EFFICIENCY MEASURES IN MUNICIPAL BUILDINGS

IMPLEMENT ENERGY EFFICIENCY MEASURES IN MUNICIPAL BUILDINGS						
HEALTH OUTCOMES	Impact	Magnitude	Severity	Strength of Causal Evidence	Assumptions	Limitations / Uncertainties
Respiratory illnesses and symptoms	+	Moderate	High	♦♦♦	Improved indoor air quality in schools and municipal buildings including compliance with ventilation guidelines.	The magnitude of the outdoor air quality impact from reduced use of heating oil is uncertain.
Respiratory and cardiovascular diseases	+	Moderate	High	♦♦♦	Reductions in regional air pollution from displaced electricity at electric generating units (EGUs) occur at specified units.	A major limitation of US EPA's model for quantifying benefits of air pollution reductions is that it underestimates total benefits because it only includes secondary formation of $PM_{2.5}$ from NOx and SOx emissions.
Change in premature mortality	+	Major	High	♦♦♦		
Change in lung cancer risk	+/-	Unknown	Unknown	♦♦♦	Indoor radon levels vary across municipalities.	Pre- and post-monitoring is needed. Energy efficiency measures may increase or decrease indoor radon levels.
Restricted activity days and work/school loss days	+	Major	Moderate	♦♦	Increased productivity of workers and students from improvements from energy efficiency measures including improved indoor air quality and lighting.	Surveys are needed. Limited studies from California of post-retrofit benefits in school children; no data on municipal workers.
Change in mental health	+	Unknown	Unknown	♦♦	Improved work/school environment. Public awareness and empowerment to address energy issues and climate change at the local level	Stakeholders provided evidence of positive responses from residents. Further assessment is recommended.
Change in community health measures	+	Unknown	Unknown	♦	Shift in municipal expenditures from energy to other uses; increase market value of municipal buildings	Impact of energy efficient buildings on market value of municipal assets is unknown.

Major Findings of the HIA

- Overall, the HIA found that while designing appropriate research methods for evaluating specific climate action strategies can be challenging, HIAs can be an effective tool to convene municipal stakeholders, evaluate baseline health conditions, and qualitatively assess the health implications of mitigation and adaptation strategies at the local level.

- A key feature of this HIA is the integration of an evidence-based framework developed by CDCs Climate and Health Program (i.e., BRACE framework) to support the advancement of health-based climate change adaptation strategies. Evaluation of the approach for integrating the BRACE framework into the appropriate phases of the HIA found that: (1) the approach addressed one of the goals of the HIA to collect and analyze evidence between climate change planning and health; (2) the approach informed the assessment phase of the HIA by providing evidence-based data on climate impacts, health outcomes of greatest concern, and populations potentially vulnerable to climate impacts; and (3) the findings of the HIA can inform the adaptation planning process.

Heat-related Events

- The climate action strategy to provide cooling centers and other approaches to assist vulnerable populations was found to likely reduce heat-related morbidity and mortality.

- For heat-related impacts, baseline health conditions in Springfield (e.g., higher prevalence of respiratory disease and diabetes in adults, and pediatric asthma) indicate that the health co-benefits of this strategy may be substantial.

- While there are significant differences in the baseline health profile of Springfield compared to Williamsburg in terms of the number of people in poverty, the number of people of race/ethnicity other than white, and population density, the percent of one category of vulnerable residents — elderly living alone (i.e., 1 in 3) — is the same in both communities.

- The common issues and resource constraints shared by both a large urban city and a small rural town in developing and activating a heat response plan, including education and outreach to vulnerable populations, as well as taking steps to mitigate environmental risk factors (e.g., lack of trees and green space, impervious surfaces) through changes in building and landscape design measures may be more effectively addressed through regional efforts.

- Although there is a need to create incentives for people to use their air conditioning during heat waves, this study also identified the need to promote multiple approaches to reduce heat exposure in addition to the use of air conditioning including improving circulation of indoor air using fans, shading windows, applying a cold cloth to neck and wrists, shutting off lights, and staying in cool areas of the home (e.g., basement).

- A key issue raised by stakeholders is the potential loss of power at cooling centers during an extreme heat-related event. Given the regional nature of the electrical grid, this issue should also be considered in future regional planning efforts.

Energy Efficiency

- In addition to cost-savings, energy efficiency programs provide a wide range of health, environmental, and social co-benefits that enhance community resilience.

- Energy efficiency improvements to buildings have positive co-benefits with respect to improving the indoor environment for occupants and reducing outdoor air pollution from reductions in electricity generated across the electrical power grid and fuel switching from oil to natural gas. For example, using a US EPA model, the monetized benefits of avoided health impacts from air pollution reductions from energy efficiency measures across the electrical grid implemented in Springfield ranged from $760,000-$1,700,000.

- While the overall health impacts from implementing energy efficiency measures in municipal buildings are positive, the need to achieve and maintain adequate ventilation for acceptable indoor air quality must also be considered. It is also important to consider the potential increase in indoor radon levels from energy efficiency measures.

- The assessment suggests that energy efficiency measures can increase the productivity of building occupants (e.g., municipal workers and students).

- Energy efficiency activities at the municipal level may also increase public awareness and empowerment to address energy issues and climate change at the local level.

- This HIA demonstrated that although the co-benefits of energy efficiency measures at the municipal level may be relatively small, the total benefits regionally and statewide of such actions are likely to be significant and need to be further assessed.

Recommendations

General Recommendations

- Regions and municipalities statewide without climate action plans should take steps to prepare such plans.

- State, regional, and local agencies should coordinate data and resources to support research and other related activities to improve the understanding of the relationship between climate and health.

- Other climate action strategies recommended in the Pioneer Valley Action and Clean Energy Plan should be examined to better understand health impacts and benefits of climate action strategies.

- Tools, innovative methods, and approaches to conduct comprehensive HIAs should be identified to more fully explore health impacts and benefits of adaptation strategies.

Recommendations for Providing Cooling Centers and Other Approaches to Assist Vulnerable Populations During Heat-Related Events

- Develop municipal or regional heat response plans that include information about vulnerable populations (e.g., elderly, elderly living alone, socially isolated, children, people without a car, economically disadvantaged); approaches for locating cooling centers that are accessible to vulnerable populations; and personal strategies and solutions for cooling at home during a heat-related event, especially where air conditioning is not available or when the power goes out.

- Implement community-wide mitigation efforts, such as improving building and landscape design standards, promoting an adequate tree canopy, and minimizing pavement to reduce urban heat islands.

- Promote regional planning efforts that support consistent educational and outreach materials for vulnerable populations, address environmental risk factors (e.g., heat islands, tree canopy), identify critical infrastructure needs, and identify solutions for the potential loss of power at cooling centers during extreme heat-related events.

Recommendations for Implementing Energy Efficiency Measures in Municipal Buildings

- Given that energy efficiency is the most practical policy option to mitigate and adapt to climate change impacts, it is important to promote health co-benefits of energy efficiency at all levels (i.e., individual, municipal, regional and statewide).

- The stakeholder process identified the need to better understand and measure community awareness around climate action and how municipal actions can spur empowerment. Changes in public awareness about the value of municipal energy efficiency programs are the cornerstone of state and local government initiatives such as "Leading By Example." Empowerment is nurtured by a sense of belonging that can occur when energy efficiency measures are implemented across government, businesses, and residences. One option is to encourage such efforts by increasing resources to support additional energy efficiency programs. This recommendation is supported by a large body of work demonstrating the benefits of incentivizing energy efficiency programs.

- Ensure that ventilation systems maintain good air quality. Consideration of the Massachusetts Department of Public Health's guideline for indoor air quality will ensure optimal indoor environmental conditions. Specifically, the guideline recommends a ventilation rate of 20 cubic feet per minute (cfm) of fresh air to provide optimal air exchange resulting in carbon dioxide levels at or below 800 ppm.

- Radon testing should occur prior to and after renovating a building to determine if mitigation measures are warranted and can be incorporated during the renovation. Post-renovation testing should be conducted to ensure mitigation measures were successful.

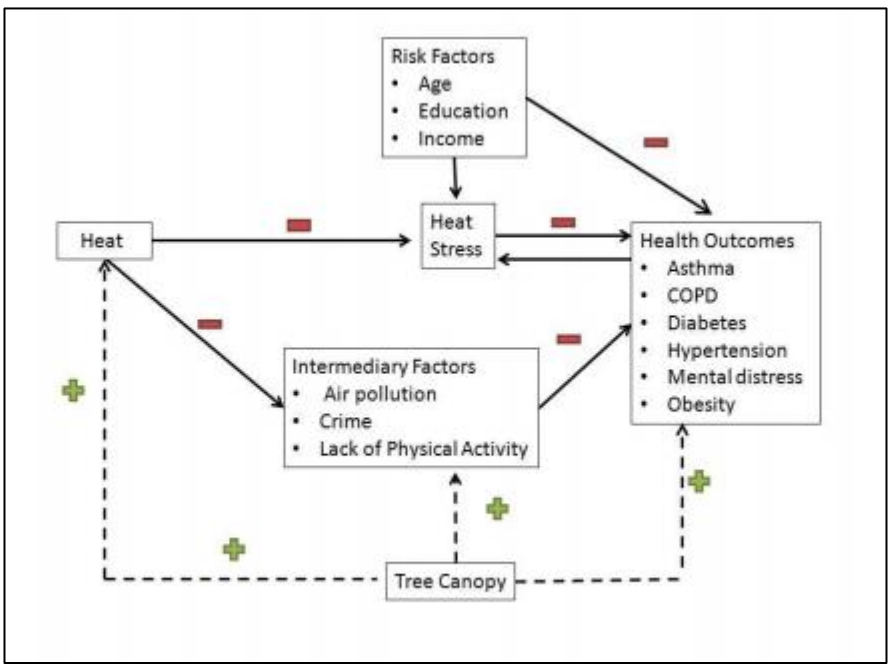
- Support municipal efforts to apply for Massachusetts Department of Energy Resources (DOER) Resiliency funding to ensure hospitals and other essential facilities have power during outages.

- Support continued state funding of energy efficiency measures at the local level.

Areas of Future Research

The following areas of future research were identified over the course of this HIA.

1. There was insufficient information to assess the change in physical activity during heat-related events or long-term changes in the community from instituting environmental mitigation measures (e.g., increase in tree canopy) to mitigate rising temperatures. For example, the Michigan Department of Community Health's Climate and Health Adaptation Program conducted a comprehensive HIA "Expanding the Urban Tree Canopy as a Community Health Climate Adaptation Strategy" in Ann Arbor.[96] The pathway diagram below illustrates the relationship of heat, tree canopy, and related population risk factors. The HIA found epidemiological evidence that reduction of heat from an adequate tree canopy has multiple benefits associated decreased heat exposure, decreased air pollution exposure, increase in physical activity, which directly benefits those individuals with pre-existing diseases including diabetes, hypertension, and obesity. Similar methods could be applied to subsequent HIAs to more fully evaluate mitigation measures in Massachusetts.



2. The stakeholder process identified the need to better understand and measure community awareness around climate action and how municipal actions can spur empowerment. There is large body of work demonstrating the benefits of incentivizing energy efficiency programs. Changes in awareness and sense of empowerment across municipal workforce and community residents of the value of municipal energy efficiency programs is the cornerstone of programs of state and local government initiatives such as Leading By Example. Understanding the

relationship between municipal actions and other types of incentive programs will likely require primary data collection (e.g., surveying community members).

3. Additional research is needed to support sustainability strategies at the local and regional level. Research suggests that joint efforts where both governments and businesses participate in sustainable consumption patterns may be "indispensable" to empowering consumers to implement an overall strategy of sustainability.[97] Education about the nature of energy problems, information on behavioral changes to address these problems, transparency about sustainability issues, and facilitating consumer's individual choices toward sustainable patterns are important considerations. Empowerment is also nurtured by a sense of belonging that can occur when, for example, energy efficiency measures are implemented concurrently by government, businesses and residences.

4. Poverty and crime have both been shown to be correlated with excessive morbidity and mortality during heat waves. Both the percentage and the number of people living in poverty are much higher in Springfield than in Williamsburg, indicating that the vulnerable population is larger. There is also a significant difference in the number of violent crimes in the two communities. Thus, further examination of this issue is needed.

5. In addition to the cost-saving, there was insufficient data to quantify the health impacts of the co-benefits of energy efficiency programs. For example, the health and performance benefits of lighting retrofits for both school children and municipal workers was recognized; however, there was limited information on the health impacts of such retrofits. Post-occupancy surveys may be useful to more fully understand the extent of these benefits. Such an analysis would also need to consider the environmental health benefits of removing PCB fluorescent light ballasts.

APPENDICES

ata on statewide emissions from electric generation facilities is available from the EPA's E-Grid archive. Consumption patterns have tapered since 2005, with a notable decrease in 2009. Although this slightly rose the following year, it is anticipated to remain stagnant given the increasing number of coal-burning plants being taken offline, either due to their conversion to allow for the burning of natural gas, or due to the lack of financial viability many of them face due to aging infrastructure. As presented below, less than one-half of the annual MWh generation occurs during peak season. This time is also when a staggering rate of NO_2 emissions occurs. Overall, emissions rates in all categories have steadily declined since 2005.

MASSACHUSETTS ELECTRICAL GENERATION FACILITY EMISSIONS

	Annual Generation (MWh)	Ozone Season Generation (MWh)	NO_2 Rate (lb./MWh	Ozone Season NO_2 Rate (lb./MWh)	SO_2 Rate (lb./MWh)	CO_2 Rate (lb./MWh)
2010	43,991,075.50	20,554,469.90	0.76	0.51	2	1,602.10
2009	39,036,133.80	16,149,553.50	0.8	0.5	2.1	1,113.50
2007	47,048,509.50	21,205,032.05	1.02	0.86	3.7	1,199.10
2005	47,494,728.00	20,239,850.00	1.11	0.98	3.5	1,762.90

Electricity Reduction from Energy Efficiency Measures in Springfield:

In 2010 Springfield became one of the first certified Green Communities in Massachusetts. Before the Commonwealth of Massachusetts created the Green Communities certification program, many cities and towns across the Commonwealth, including Springfield, had been taking action to reduce their municipal energy use, often times as a money saving initiative. The Springfield has a long history of action to reduce municipal energy use. Their 20% reduction plan spans the years from 2007 to 2012 during which time the city achieved the following energy use reductions summarized in the table below.

PROJECTED SAVINGS FROM SPRINGFIELD'S 20 PERCENT REDUCTION PLAN (2011)

Completed Work	54,603.1 MMBTu
Work In Progress	3,243.2
Future Work	38,003.7
Street Lights	5,050.1
Gasoline Reduction	746.0
TOTAL Projected Savings	101,646.0
Total usage baseline FY07	470,587.5
TOTAL % REDUCTION	21.6%

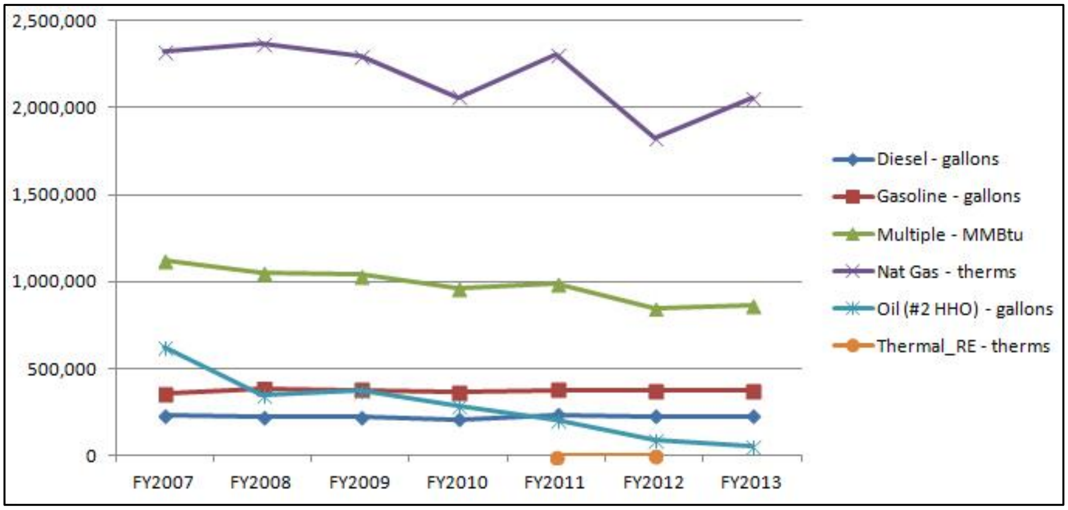
Beginning in State Fiscal Year (SFY) 2007, Springfield contracted with and completed the first phase of an Energy Services Contractor (ESCO) project which identified 138 energy conservation measures in 28 facilities at an estimated cost of $15.1 million. In addition to the work completed with the ESCO, the city completed improvements and renovations at 23 sites. The city also hired an Energy Conservation Manager and worked to install solar panels at municipal facilities. Springfield was also one of the first communities in the country to be awarded a Climate Showcase Communities grant from the US EPA. The city funded four positions which completed preventative maintenance and energy audits in all remaining city facilities.

Energy efficiency work accomplished includes:

- replacing and upgrading boilers, water heaters and lighting fixtures
- installation of web-based energy management systems
- installation of variable frequency drives and high efficiency motors
- insulation of buildings and other improvements to the building envelope
- replacement of windows
- roof upgrades.

In addition, the city committed to review all future construction, renovations and equipment replacement and repairs for energy efficiency. Springfield has over five years of data and can show significant reductions in municipal electricity use as well as other fuels used for heating and cooling (see figure below).

ENERGY USE IN SPRINGFIELD FROM 2007-2013



As part of their Green Communities certification, the city also adopted the Stretch Energy code, which requires all new construction to be built to a higher energy efficient standard than the baseline Building code and the city also adopted a fuel efficient vehicle policy.

Electricity Reductions from Energy Efficiency Measures in Williamsburg:

The town of Williamsburg was certified as a Green Community in 2014. Prior to this formal recognition of the Town's efforts to reduce energy use, Williamsburg had already formed an energy committee in 2007, collaborated with the Pioneer Valley Planning Commission on a regional ESCO project in 2008-2010, and received state and federal funding for energy efficiency. While Williamsburg did not move forward with the energy services company to comprehensively address the recommended energy efficiency improvements (in part because a 20-year loan for a relatively small amount of work did not make financial sense given the interest rates at the time), the town did use the information documented to work aggressively with their utility company to reduce energy use. This information is summarized in the table below

BASELINE ENERGY USE AND PROJECTED SAVINGS FROM 20% ENERGY REDUCTION PLAN IN WILLIAMSBURG (2013)

	MMBtu used in baseline year (2011)	% of total MMBtu baseline energy consumption	Projected planned MMBtu savings	Savings as % of MMBtu baseline
Buildings	5417	73	774	14
Vehicles	1537	21	17	1
Street/Traffic Lights	171	2	0	0
Water/Sewer/Pumping	292	4	0	0
Open Space	5	0	0	0
Total	7422 MMBtu	100%	791 MMBtu	15%

Previous energy efficiency initiatives in Williamsburg include: a boiler retrofit at the Haydenville Police and Fire (Public Safety) Building and use of ARRA funding for efficiency improvements (insulation, weatherization and heating controls) at the Town Offices and the Highway Department building in FY 2011, as well as utility sponsored direct install lighting retrofits which installed energy efficient T-8 fluorescent lamps and electronic ballasts in FY 2009. National Grid provided the Town with LED light bulbs to replace existing incandescent or CFL lights. In addition to projects that installed more efficient operating equipment, the Water Department initiated operation and maintenance practices, starting in FY2010, which have resulted in a reduction of 48% in water pumping electrical usage through FY 2013. The Town has reduced its weather normalized energy use by 17% from FY 2011 base year and reduced its usage by an additional 1% in FY 2013.

Williamsburg is presently in an evolving building use situation due to the replacement of Dunphy
School with a new building which will not only be more energy efficient, but eliminate the need for another building - the Helen E. James School. In addition, Williamsburg is following up with the 2010 Building Needs Assessment report which detailed the present condition of all Town buildings and provided recommendations to address structural, operational and mechanical deficiencies. A Building Use committee has been authorized to implement the recommendations contained in the needs assessment and with the Energy committee will play a significant role in meeting the 20% energy reduction goal mandated as part of the Town's Green Community designation.

The Dunphy School has been the Town's largest oil using building for many years and comprised 39% of the total FY 2011 oil use. It used 42% more oil in FY 2011 than the James School, a building built in 1910 with approximately the same building area, (22,449 sq ft vs 22,274 sq ft). The primary reason for this difference is the James School has a newer, more efficient boiler than the Dunphy School's fifty plus year old boiler. The new school building will open in 2014 and be 38,000 square feet in area and will be a Mass CHPS certified building. The energy efficiency of this building will far surpass that of either of the two existing school buildings and will be a main driver in achieving the community's 20% reduction in energy use.

The Town Library is one of the larger energy users and has an insulation improvement project approved for installation. The Haydenville Library is not a high priority due to its intermittent use and low potential for significant energy saving but potential low-cost measures such as, retrofitting existing incandescent or compact fluorescent building with LED and a night setback thermostat will be investigated and implemented.

The current Town Office building, built as a school in 1860, has significant potential for efficiency improvements primarily with its steam heating system. It is presently unknown if this building will continue in use long enough to make investing in a heating system retrofit cost effective. Insulation and heating measures identified in the ECIP audits were installed with ARRA funds in FY2010-2011 in the Town Offices which has saved 1,577 gallons from FY 2011 through FY 2013 as documented in MEI data. This represents a 219 MMBtu reduction or a 3% reduction from the base year total MMBtu.

The Public Safety building which currently houses the Police and Fire headquarters, as well as fire engines in a bay added onto the existing building sometime in the 1960's may also not be in use within the five years of this plan. Its heating system was upgraded in 2009. Lighting and lighting controls could be upgraded and attic insulation added. The Williamsburg Fire Station may also not be in use within the five years of this plan if a new centralized fire or public safety building is constructed. This project is currently in the Town's five year capital budget plan.

The potential to retrofit the current high pressure sodium street light fixtures to LED offers significant savings potential of fifty percent or more from current usage. The economics of an LED retrofit project depends upon the cost of LED fixtures, which is significant but with product costs declining and the potential to coordinate a joint purchase with other towns or utility rebate this project could be cost effective. There are 132, 70-watt high pressure sodium street lights which used 46,911 kWh in 2011 and cost $6,479. A fifty percent reduction in usage due to a wholesale LED retrofit would result in a savings of over $4,000 annually at current electricity prices. The Town will consider implementation of this project since it offers significant savings potential. Further research on LED technology and project cost is needed before proceeding.
As part of their Green Communities certification, the town also adopted the Stretch Energy code, which requires all new construction to be built to a higher energy efficient standard than the baseline Building code and the town also adopted a fuel efficient vehicle policy. The Town has reduced its energy use by 18% from the baseline year of FY 2011 through FY 2013.

APPENDIX B: DESCRIPTION OF US EPA'S AVERT AND COBRA MODELS

Avoided Emissions and Generation Tool (AVERT) is a model developed by US EPA that is designed to evaluate reductions in county, state and regional air pollution emissions at electric power plants by energy efficiency or renewable energy (EE/RE) projects. The model only allows examination of the emission impacts of major fleet adjustments or changes extending further than five years from the baseline year.

According to US EPA, AVERT is a screening model that represents the dynamics of electricity dispatch based on the historical patterns of actual generation in one selected year. Currently, AVERT has data for 2007-2013. AVERT's Statistical Module uses hourly "prepackaged" data from EPA's Air Markets Program Data (AMPD) to perform statistical analysis on actual behavior of past generation, heat input, SO2, NOx, and CO2 emissions data given various regional demand levels. (AVERT's Statistical Module can also analyze user-modified data created in the AVERT's Excel-based Future-Year Scenario Template). The AVERT Main Module performs the emissions displacement calculations based on the hourly electric generating unit information in the regional data files and the displaced electricity from EE/RE impacts entered into the tool. The input for the model is the reportable reductions in electricity use from energy efficiency measures from Green Communities projects. For more information and to download the model for free, go to: http://epa.gov/avert/.

According to US EPA, the Co-Benefits Risk Assessment (COBRA) is a screening model evaluates the health and economic benefits of policies that affect air pollution. In this application, the reduction in air pollution emissions estimated from AVERT are used as input to COBRA. The model assesses health outcomes of clean energy policies that change emissions of particulate matter ($PM_{2.5}$), sulfur dioxide (So_2), nitrogen oxides (NO_X), ammonia (NH_3), and volatile organic compounds (VOCs) at the county, state, regional, or national level. For example, exposure to air pollution from fossil fuel-based energy can exacerbate respiratory diseases, like bronchitis and asthma, and cause heart attacks and premature death. Beyond the physical health effects, pollution-related illnesses impose other 'costs' on people, such as lost wages or productivity when someone has to miss work or school, the costs of medical treatment and outdoor activity restrictions when air quality is poor.

COBRA contains detailed emission estimates of PM2.5, S02, NOX, NH3, and VOCs for the year 2017 as developed by the U.S. EPA. Users create their own scenario by specifying increases or decreases to the baseline emission estimates. Emission changes were entered for each state that supplied electricity.

COBRA uses a reduced form air quality model, the Source-Receptor (S–R) Matrix, to estimate the effects of emission changes on ambient PM. Using an approach to estimating avoided health impacts and monetized benefits that is generally consistent with EPA practice, the model translates the ambient PM changes into human health effects and monetizes them.

According to US EPA, COBRA users can create their own new scenarios by specifying increases or reductions to the emissions estimates for the analysis year (i.e., 2017). Emissions changes can be entered at the county, state, or national level. COBRA then generates changes in PM 2.5 concentrations between the baseline scenario (the "business-as-usual" estimates for the analysis year) and the control scenario (the analysis year modified by the user's emissions changes). A source-receptor matrix translates the air pollution emissions changes into changes in ambient PM2.5. Using a range of health impact functions, COBRA then translates the ambient PM 2.5 changes into changes in the incidence of human health effects. Finally, the model places a dollar value on these health effects. 6 COBRA estimates the change in air pollution-related health impacts, and estimates the economic value of these impacts, using an approach that is generally consistent with EPA Regulatory Impact Analyses. These analyses reflect the current state of the science regarding the relationship between particulate matter and adverse human health.

Health outcomes can be modeled nationwide or for smaller geographic areas. Results include changes in ambient PM2.5 concentrations, and changes in the number of cases of a variety of health endpoints that have been associated with PM2.5 exposures. These health endpoints include: Adult and infant mortality; Non-fatal heart attacks; Respiratory-related and cardiovascular-related hospitalizations;
Acute bronchitis; Upper and lower respiratory symptoms; Asthma-related emergency room visits;
Asthma exacerbations; Minor restricted activity days (i.e., days on which activity is reduced, but not severely restricted); and Work days lost due to illness.

OUTPUT AND DESCRIPTION FROM AVERT

State	County	Annual Displaced Generation (MWh)	Annual Displaced SO_2 (lbs)	Annual Displaced NO_x (lbs)	Annual Displaced CO_2 (tons)	Ozone Season Displaced SO_2 (lbs)	Ozone Season Displaced NO_x (lbs)
CT	Fairfield	-700	-700	-500	-500	-300	-200
CT	Hartford	–	–	–	–	–	–
CT	Middlesex	-700	-200	-200	-300	-100	-200
CT	New Haven	-900	-200	-1,100	-400	–	-300
CT	New London	–	–	–	–	–	–
CT	Windham	-800	–	–	-500	–	–
MA	Barnstable	-100	-100	-100	–	–	–
MA	Berkshire	-100	–	–	-100	–	–
MA	Bristol	-1,700	-5,200	-1,700	-1,400	-1,600	-600
MA	Essex	-200	-1,700	-300	-200	-600	-100
MA	Hampden	-500	-200	-300	-300	-100	-100
MA	Middlesex	-1,800	-1,300	-400	-800	-300	-200
MA	Norfolk	-1,000	-100	-200	-500	–	-100
MA	Suffolk	–	–	–	–	–	–
MA	Worcester	-300	–	-200	-200	–	-100
ME	Cumberland	-900	-1,100	-300	-400	-500	-100
ME	Franklin	–	–	–	–	–	–
ME	Hancock	-100	–	–	–	–	–
ME	Oxford	-100	–	–	–	–	–
ME	Penobscot	-100	–	–	-100	–	–
NH	Merrimack	-600	-1,300	-1,500	-600	-400	-600
NH	Rockingham	-1,300	-1,900	-500	-800	-800	-200
NJ	Union	-500	–	–	-200	–	–
NY	Albany	-1,100	–	-800	-600	–	-200
NY	Bronx	-100	–	-100	–	–	–
NY	Cattaraugus	-100	–	–	–	–	–
NY	Chautauqua	-100	-400	-200	-100	-200	-100
NY	Clinton	-200	–	–	-100	–	–
NY	Erie	-300	-1,600	-500	-300	-700	-200

State	County	Annual Displaced Generation (MWh)	Annual Displaced SO_2 (lbs)	Annual Displaced NO_x (lbs)	Annual Displaced CO_2 (tons)	Ozone Season Displaced SO_2 (lbs)	Ozone Season Displaced NO_x (lbs)
NY	Genesee	–	–	–	–	–	–
NY	Greene	-1,000	–	-100	-400	–	–
NY	Jefferson	–	–	–	–	–	–
NY	Kings	-300	–	-900	-100	–	-500
NY	Lewis	–	–	–	–	–	–
NY	Nassau	-900	-100	-900	-500	100	-400
NY	New York	-300	–	–	-100	–	–
NY	Niagara	-1,200	-4,900	-3,900	-1,100	-1,900	-1,300
NY	Oneida	–	–	–	–	–	–
NY	Onondaga	–	–	–	–	–	–
NY	Orange	-200	-400	-300	-200	-200	-200
NY	Oswego	-1,600	-600	-300	-600	-400	-200
NY	Queens	-3,900	-600	-1,700	-1,500	-300	-1,000
NY	Rensselaer	-900	–	–	-400	–	–
NY	Richmond	-500	–	-300	-200	–	-200
NY	Rockland	-700	-100	-1,100	-400	–	-400
NY	St Lawrence	–	–	–	–	–	–
NY	Saratoga	-100	–	–	-100	–	–
NY	Suffolk	-2,000	-3,000	-2,000	-1,200	-1,600	-1,100
NY	Tompkins	-400	-2,600	-1,000	-300	-700	-300
NY	Wyoming	–	–	–	–	–	–
RI	Newport	-200	–	–	-100	–	–
RI	Providence	-1,200	–	-300	-800	–	-100
VT	Chittenden	–	–	–	-100	–	–

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[10]The purpose of the Stretch Energy Code (780 CMR 115.AA), an appendix to the MA State Building Code, is to provide a more energy efficient alternative to the Base Energy Code for new and existing buildings. A municipality seeking to ensure that construction within its boundaries is designed and built above the energy efficiency requirements of 780 CMR (i.e., the “Base” Energy Code) may mandate adherence to the Stretch Energy Code. The stretch code appendix offers a streamlined and cost effective route to achieving approximately 20% better energy efficiency in new residential and commercial buildings than is required by the Base Energy Code. This is largely achieved by moving to a performance-based code, where developers are required to design buildings so as to reduce energy use by a given percentage below base code, rather than being required to install specific efficiency measures.

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