IMPROVING THE BUILT ENVIRONMENT TO REDUCE INDOOR HEAT-RELATED ILLNESSES AND DEATHS

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EXECUTIVE SUMMARY

Heat-related illnesses are becoming more common and kill more people than any other type of extreme weather. The Intergovernmental Panel on Climate Change (IPCC) projects with "virtual certainty" that climate change will cause more frequent, more intense, and longer heat waves, much like the 2003 heat wave in France where an estimated 15,000 people died. With rising temperatures, people will be at greater risk of being hospitalized with heat-related illnesses and dying. Bostonians may experience as many as 40 high-heat days over 90°F per year by 2030, and 90 high-heat days per year by 2070. The rising temperatures will be experienced differently across Boston: people living in historically redlined neighborhoods are exposed to higher outdoor temperatures than non-redlined neighborhoods. While the effects of outdoor heat on morbidity and mortality are well understood, heat inside buildings has received minimal consideration. It is important for policymakers to understand the effects of indoor heat because people spend 90% of their time indoors. Moreover, heat exposure and its threat to health is an important environmental justice issue that must be addressed. This paper summarizes the health impacts of extreme heat, explains how buildings can affect exposure to extreme heat, details unequal access to air conditioning and other building cooling measures like tree cover, and suggests policies that will decrease indoor heat-related health risks and address racial-, ethnic-, and income-related disparities in access to cooling.

WHY INDOOR HEAT IS IMPORTANT:

- *People spend 90% of time indoors.*
- *With rising temperatures in Boston, access to cooling in the summer will be as important as access to heating in the winter.*
- *Access to air conditioning is more important to preventing heat-related deaths than access to healthcare.*
- *Low-income households are less likely to have air conditioning or be able to afford to use it.*

The health impacts of extreme heat

The health impacts of extreme outdoor heat are well documented and profound. Increases in outdoor temperature and humidity threaten the health of vulnerable populations, including the elderly, children, pregnant women, outdoor workers, and people with underlying health conditions. Exposure to high temperatures increases the risk of cardiovascular and respiratory-related morbidity and mortality, impairs kidney functioning, and negatively affects pregnancy outcomes and mental health. In Boston, the health impacts of extreme heat are disproportionately borne by environmental justice communities.

Urban heat island effect

Cities are hotter than rural areas. Closely spaced buildings and roads capture and hold heat, increasing the outdoor air temperatures. This phenomenon is called "urban heat island" (UHI). People living in cities are at higher risk of detrimental health effects from high outdoor temperatures. The number of people exposed to these risks is increasing because the population is growing and the proportion of people living in cities in the U.S. is expected to rise from 83% in 2020 to 89% by 2050. The effects of UHIs are greater in historically redlined neighborhoods like Roxbury and Dorchester, where temperatures are on average 6°F warmer than non-redlined neighborhoods in the Greater Boston area. One of the reasons these neighborhoods are hotter is because they have much less tree canopy and green space than their neighbors. Tree canopy can lower surface temperatures and help keep neighborhoods cooler.

Indoor heat

During the summer, when outdoor temperatures rise, so do indoor temperatures. This contrasts with winter outdoor temperatures; when temperatures drop, indoor temperatures stay consistently warm. Vulnerability to heat inside of buildings depends on where people live in the building and their access to cooling. People living on top floors or who lack air conditioning or nearby shade are 2 to 5 times more likely to suffer from heat stroke or die from heat-related illnesses than those living in comparatively lower floors and cooler buildings. Vulnerability to heat-related illnesses is greater if people cannot leave their bed or home, are unable to care for themselves, or do not have access to transportation to move to a cooler building.

Air conditioning protects against heat-related illnesses but there are disparities in access

As the climate warms, air conditioning (AC) will become as essential to Bostonians as heating is in the winter. Access to AC is more important than access to healthcare in preventing heat-related deaths. However, there are disparities in access to AC. In a study of four U.S. cities, white households were twice as likely to have central AC as Black households. Even if households do have AC, they may not be able to use it because they cannot afford higher electricity bills.

Policy Recommendations:

Boston can protect its residents from the health risks of rising temperatures by investing in interventions that cool neighborhoods and buildings to help maintain indoor temperatures below 79°F. We offer six policies to mitigate indoor heat-related mortality and morbidity.

1. Develop policies to preserve and protect existing trees on government and private property. Reinvest in Boston's plan to plant 100,000 trees. Trees provide natural neighborhood cooling. The neighborhoods with the highest temperatures and fewest shade trees and environmental justice communities should be prioritized to receive resources first.

2. Reduce solar heating by installing cooling or reflective components on buildings, roofs, and city surfaces. Dark-colored roofs trap solar heat and increase indoor temperatures. Painting rooftops white is a low-cost intervention that can be implemented on a large scale. Projects to paint rooftops white in several New York City neighborhoods were quite successful in cooling buildings and reducing AC use. Boston should prioritize reducing solar heating in assisted living facilities, nursing homes, public and subsidized housing, municipal buildings, and the hottest neighborhoods.

3. Incentivize "green roofs" in zoning policies. The City of Cambridge provides an incentive to create green roofs and recently passed an ordinance requiring future development and significant rehabilitation of buildings of more than 25,000 square feet to put plants or a blend of plants and solar panels on their rooftops.

4. Advocate for and invest in energy efficiency programs for assisted living facilities, nursing homes, public and subsidized housing, and municipal buildings like Boston schools. The energy efficiency program should include insulation as well as indoor and outdoor shading options, like window coverings, shrubbery, vines, etc. Insulated and shaded buildings are cooler in the summer and cost less to cool.

5. Subsidize the installation and operation of air-source and ground-source heat pumps because they provide more efficient cooling than traditional window AC units. Prioritize assisted living facilities, nursing homes, public and subsidized housing, and municipal buildings like schools.

6. Advocate for and support the expansion of utility-scale, networked ground-source heat pumps, also known as GeoMicroDistricts. The system is made of water loops installed in existing gas utility corridors in the street, replacing gas pipes. Heat pumps in individual buildings transfer thermal energy between a shared district water loop and their own heating and cooling distribution systems. Networked ground-source heat pumps provide the most efficient

mechanism of heating and cooling currently available, as exemplified by Colorado Mesa University. Eversource is piloting this type of system in Massachusetts, and National Grid has requested permission to do so as well. Utility-scale delivery of heating and cooling offers more equitable access than heat-pump adoption alone because the responsibility and cost for installation is transferred from homeowners and building owners to the utilities. Prioritize communities most vulnerable to heat, including the hottest neighborhoods and environmental justice communities.

Conclusion

Access to affordable cooling is as essential to health and well-being as access to adequate heating is in winter. The City should invest in equitable heat resilience solutions to protect Boston's most vulnerable people. It should focus on neighborhood and building cooling efforts, prioritizing neighborhoods with large populations of racial and ethnic minority groups, neighborhoods with the highest summer temperatures, low-income households, senior housing and care facilities, and municipal buildings, like Boston schools. Boston has yet to experience a severe heat wave like the 2003 France heat wave, which killed an estimated 15,000 people. However, the risk of a high fatality heat wave increases every year. City officials must act to ensure that Boston does not suffer a similar catastrophe.

Improving the Built Environment to Reduce Indoor Heat-Related Illnesses and Deaths

Introduction

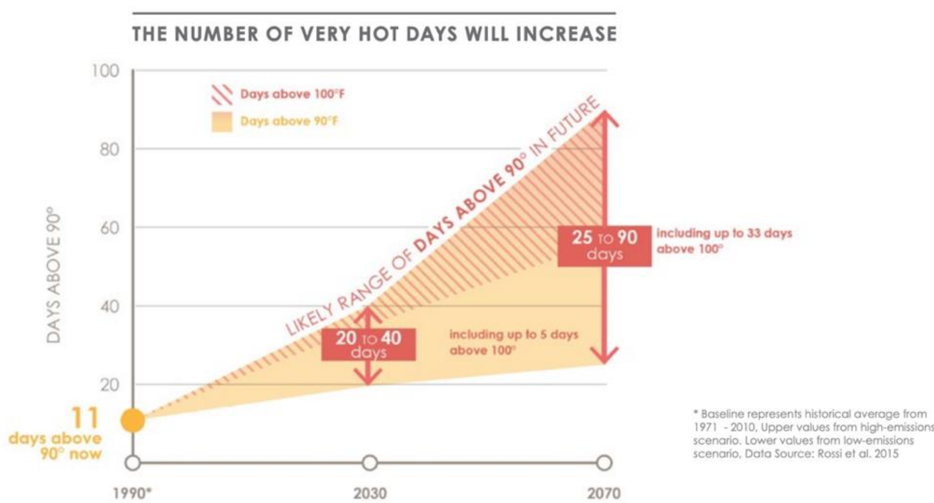
Heat-related illnesses are becoming more common and kill more people than any other type of extreme weather.[1] The Intergovernmental Panel on Climate Change (IPCC) projects with "virtual certainty" that climate change will cause more frequent, more intense, and longer heat waves, much like the 2003 heat wave in France, where 15,000 people died. With rising temperatures, people will be at greater risk of being hospitalized or dying from heat-related illnesses. Bostonians may experience as many as 40 high-temperature days over 90°F per year by 2030, and 90 high-temperature days per year by 2070. The rising temperatures will be experienced differently across Boston: people living in historically redlined neighborhoods are exposed to higher outdoor temperatures than non-redlined neighborhoods.

While the effects of outdoor heat – also called ambient heat – on morbidity and mortality are well understood, the health impacts of heat inside buildings have not been as thoroughly studied. It is important for policymakers to understand the effects of indoor heat because people spend 90% of their time indoors.[2] Heat exposure and its threat to health is an important environmental justice issue that must be addressed. This paper summarizes the health impacts of extreme heat, explains how buildings can affect exposure to extreme heat, details unequal access to air conditioning and other building cooling measures like tree cover, and suggests policies that will decrease indoor heat-related health risks and address racial-, ethnic-, and income-related disparities in access to cooling.

Number of very hot days in Boston on the rise

The Centers for Disease Control and Prevention defines extreme heat as “summertime temperatures that are substantially hotter and/or more humid than average for that location at that time of year.”[3] In the Northeast a heat wave is defined as three or more days of 90°F or higher. The International Panel on Climate Change (IPCC) predicts that temperatures will increase 2.5° to 10°F over the course of the next 100 years.[4] In 2020, Bostonians experienced the hottest summer on record with 14 days over 90°F,[5] and in the next few decades if greenhouse gasses continue to increase, Boston may record as many as 40 high-heat days over 90°F per year by 2030, and 90 high-heat days per year by 2070. In 2070, up to 33 days each summer could reach 100°F or more.[6]

Figure 1: Screenshot from *Climate Ready Boston*[7]



Heat increases the risk of illness and death

Over the last 30 years, exposure to extreme heat was the top cause of weather-related deaths in the United States.[8] In Boston, over 50 people die each year due to heat-related illnesses,[9] and this is likely an undercount[10] since there are no widely accepted criteria for determining heat-related mortality. In addition to illnesses directly caused by heat exposure, there are a variety of heat-related impacts on people's health.

Heat stroke is the most serious acute heat-related illness and the most likely to result in death or other serious medical conditions if not treated. It occurs when the core body temperature reaches 105°F or higher.[11] The initial symptoms (headache, nausea, vomiting, excessive sweating, muscle cramps, fatigue, etc.) are often signs of heat exhaustion, and progress to heat stroke with more acute symptoms such as neurological impairment, lack of sweating, loss of consciousness, and rapid pulse.[12]

HEAT-RELATED ILLNESSES

Exposure to extreme heat increases the risk of cardiovascular- and respiratory-related mortality. It also reduces kidney function, increasing the risk of kidney stones, kidney disease, and chronic kidney failure. Furthermore, it negatively affects people's sleep patterns and mental health.

Cardiorespiratory: High outdoor temperatures can cause severe cardiorespiratory problems, particularly among the elderly. When body temperature rises, blood flow is shunted away from vital organs, limiting vasodilation and sweating, and increasing the risk of blood clots, and therefore, stroke and heart attack.[13] High outdoor heat can also worsen inflammation and chronic obstructive pulmonary disease.[14] [15] A systematic review and meta-analysis investigating mortality and morbidity outcomes of outdoor temperature on elderly populations found that it significantly increased risks for cardiovascular and respiratory diseases.[16]

Kidney failure: Exposure to high heat increases the risk of kidney damage. A systematic review found that working in high indoor temperature buildings resulted in higher rates of kidney stones among workers, and heat stress was associated with an increased risk of chronic kidney disease and kidney failure.[17] A 12-year retrospective study including 1.15 million people in Adelaide, Australia, reported that hospital admissions due to damaged kidney function increased 10% during heat waves.[18]

Mental health: High temperatures can compromise sleep and mental health. A study of 765,000 U.S. survey respondents from 2002 to 2011 found that increases in nighttime temperatures were associated with insufficient sleep, affecting lower-income and elderly participants most prominently.[19] Increased outdoor temperatures were correlated with increased rates of suicide, numbers of psychiatric hospitalizations, and exacerbation of mental health illnesses like bipolar disorder, schizophrenia, and substance abuse.[20]

Vulnerable groups

The health impacts of extreme outdoor heat are well documented and profound. Increases in ambient temperature and humidity in outdoor environments have a greater impact on vulnerable populations including the elderly, children, pregnant women, people with underlying health conditions, and socially isolated and homebound people. Outdoor workers are also vulnerable to ambient heat, but this paper doesn't focus on solutions for protecting them against the heat.

Elderly: People over the age of 65 are particularly susceptible to the health impacts of high outdoor heat. A systematic review and meta-analysis of over 16 million elderly people found that increased outdoor temperatures was correlated with more diagnosed illnesses in every system of the body including cerebrovascular, mental, cardiovascular, respiratory, genitourinary, and nervous system illnesses. There were more intestinal infections, more diabetes morbidity and mortality, and an increased rate of all-cause mortality.[21]

Children: Young children's temperature regulation systems are not fully developed, making them more vulnerable than healthy adults to increased heat exposure.[22] A systematic review of the impact of heat waves on children's mortality and morbidity determined that very young children (0-4 years) were more likely to be taken to the emergency department and be admitted to the hospital during heat waves than other summer days.[23] Higher temperatures were also associated with an increased risk of Sudden Infant Death Syndrome (SIDS) in the summer, particularly among Black infants.[24]

Pregnant women: Like young children, pregnant women are at higher risk of experiencing complications due to exposure to high outdoor heat because their capacity to regulate body temperature is diminished.[25] Three separate systematic reviews provided evidence that exposure to high outdoor heat adversely affected pregnancy outcomes, increasing the risk of lower birth weight, stillbirth, and preterm birth.[26] [27] [28] Preterm birth has significant effects on child development[29] and increases medical costs.[30]

People with underlying health conditions: Chronic heart, lung, and kidney disease make people more vulnerable to heat stress, as do diabetes and obesity.[31] [32] Also, certain medications such as diuretics and certain blood pressure drugs can reduce perspiration and make people more vulnerable to heat exhaustion and heat stroke. At the same time, numerous studies in the U.S. have shown dramatic and persistent differences in chronic health indicators among racial and ethnic minority groups. Health inequities are a result of a variety of social and economic factors, including discrimination, differential access to care, and inequitable access to safe housing, among others.[33] In Boston, Black and Latino people have the highest rates of chronic health conditions, which puts them at higher risk of heat-related morbidity and mortality.[34]

Socially isolated and homebound people: People can be socially isolated for many reasons, including health, mental illnesses, and language barriers, among others. Socially isolated people may not receive or understand heat warnings, or be able to act on them. Homebound people are especially vulnerable during heat waves. Multiple case-control studies in the U.S., France, and Australia found that homebound people are much more likely to die in heat waves compared to their more mobile counterparts.[35]

Outdoor workers: Outdoor workers exposed to extreme heat have higher rates of injuries and experience numerous heat-related health problems. A review found outdoor workers suffered from milder symptoms such as dehydration and heat rash, to more severe complications such as heatstroke, heart attack, and disruptions in cognitive, motor, and visual processing when exposed to extreme heat.[36]

Urban heat island effect

Cities are hotter than rural areas. Closely spaced buildings and roads capture and hold heat, increasing the outdoor air temperatures in cities. This phenomenon is called "urban heat island" (UHI). People living in cities are at higher risk of detrimental health effects from high outdoor temperatures because UHIs are significantly hotter than nearby rural regions, with differences of up to 18 °F. [37] [38] [39] The number of people exposed to these risks is increasing because the population is growing and the proportion of people living in cities in the U.S. is expected to rise from 83% in 2020 to 89% by 2050.[40]

Urban heat islands can be attributed to a combination of reduced greenspace and shade trees, buildings spaced closely together, and solid, dark surfaces that trap and emanate outdoor heat.[41] Building materials can also play a role; cinder block and brick buildings retain heat and maintain high temperatures throughout the night. Temperatures from UHIs peak at night, making it harder to sleep and to recover from the daytime heat. Poor sleep, a critical public health concern, can lead to declines in worker productivity and cognitive functioning, and exacerbate mental illness.[42] The effects of UHIs are greater in historically redlined neighborhoods like Roxbury and Dorchester, where temperatures are on average 6°F warmer than non-redlined neighborhoods in the Greater Boston area.[43] [44] Historically redlined neighborhoods in Boston are often today's Environmental Justice communities.[1]

> *Redlining is the discriminatory and unethical practice of marking areas with sizable mixed-race or Black populations to warn mortgage lenders and insurance providers not to lend money or provide services to people who live in those neighborhoods. Redlining practices also include unfair and abusive loan terms for borrowers and penalties for prepaying loans.*

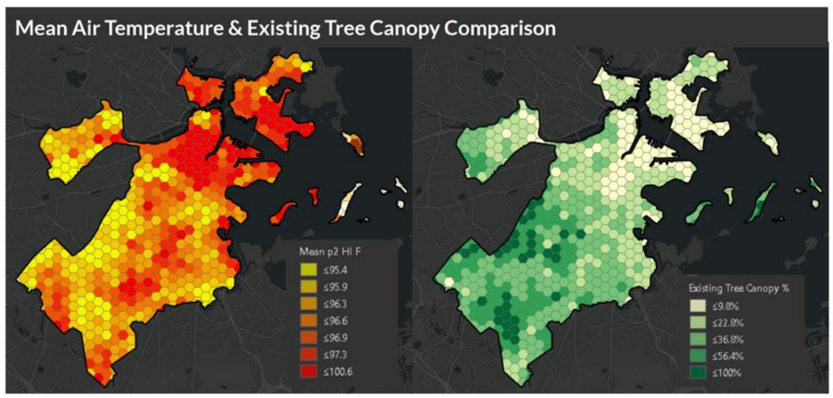
[1] In Massachusetts, a neighborhood is defined as an Environmental Justice community if:

- the annual median household income is not more than 65 per cent of the statewide annual median household income;
- minorities comprise 40 per cent or more of the population;
- 25 per cent or more of households lack English language proficiency; or
- minorities comprise 25 per cent or more of the population and the annual median household income of the municipality in which the neighborhood is located does not exceed 150 per cent of the statewide annual median household income.

Tree canopy can lower urban temperature

Trees provide many benefits to communities, including reducing stormwater runoff, lowering summer heat, reducing temperatures and energy use in buildings, removing air pollution, and improving human health.[45] Unfortunately, Boston's tree canopy has not increased over the last five years. [46] An analysis showed increasing canopy cover in Boston will help reduce neighborhood heat and planting trees in the hottest neighborhoods will have the greatest benefit.[47]

Figure 2: Screenshot from Boston *Tree Canopy Assessment* [48]



Indoor heat

When summer outdoor temperatures rise in Boston, indoor temperatures also rise; they are directly correlated.[49] This contrasts with winter, when outdoor and building temperatures are not correlated; when it's cold outside, it's warm indoors. While most studies of heat mortality focus on outdoor temperature,[50] exposure to indoor heat must be considered, too.[51] People spend more time indoors (90%) than outdoors (10%) and those most vulnerable to indoor heat and least likely to be able to leave their buildings – the elderly – will make up 20% of the U.S. population by 2030.[52]

Effects of indoor heat on health

Buildings mediate the effects of outdoor heat. Case-control studies conducted in St. Louis, Kansas City, Chicago, Paris, and Australia following heat waves found risk factors for dying during a heat wave were affected by building characteristics. In Table 1, studies demonstrated that people who lived on top floors or who lacked air conditioning or nearby shade were more likely to suffer heat stroke or die from heat-related complications than those living in lower floors and cooler buildings.

Table 1: Building-associated risk factors for elderly deaths in heat waves

Risk factors	Location of Case-Control Study	Odds Ratio
No air conditioning	St Louis/Kansas City (1980)[53]	49.4
	Chicago (1995)[54]	3.3
	Chicago (1999)[55]	5.0
	France (2003) [56]	2.0
	Meta-Analysis (2007)[57]	4.3
	Australia (2009)[58]	250
No shading around building	St Louis/Kansas City (non-fatal heat stroke)	1.9
	France	2.7
Living in the top floor of a building	Chicago (1995)	4.7
	France	2.3

In Table 2, studies revealed homebound elderly people were at least three times more likely to die in a heat wave compared to more mobile people.

Table 2: Individual risk factors for elderly deaths affected by indoor heat in heat waves

Risk factors	Location of Case-Control Study	Odds Ratio
Confined to bed	Chicago (1995)	5.5
	France	7.5
	Meta-analysis	6.4
Unable to care for self	St. Louis/Kansas City	5.0
	Meta-analysis	3.0
Did not leave home each day	Chicago (1995)	6.7
	Chicago (1999)	5.8
	Meta-analysis	3.4
No transportation (could affect ability to move to a cooler building)	Chicago (1995)	3.3

Beyond the case-control studies of deaths during heat waves, the health effects of indoor heat are not well studied. A systematic review of indoor temperature and health identified only 22 studies that examined the relationship between indoor heat and health. It found that indoor temperatures higher than 79°F negatively affected health, with the strongest evidence for impacts on respiratory health, diabetes management, and schizophrenia and dementia symptoms. A significant limitation was that few studies recorded the health impacts as temperature rose; they reported them above a specific temperature, making it difficult to determine if there is a dose-response relationship at lower temperatures. The review concluded that **to protect at-risk groups from negative health effects, the current maximum indoor threshold should remain 79°F** and the authors called for more studies of the health impacts of indoor heat.[59]

AIR CONDITIONING PROTECTS AGAINST HEAT-RELATED ILLNESSES

As the climate warms, air conditioning (AC) will become more essential for home safety. In a cohort of over 72,000 people, a retrospective study found that people without central AC were 72% more likely to die in periods of high outdoor heat than those with AC.[60] Due to limitation in the study, the impacts of window and wall AC units were not analyzed, but case-control studies of deaths following heat waves suggest these units are protective; some AC is better than no AC. In a study of the decline in heat-related fatalities since 1960, residential AC explained the entire decline; surprisingly, access to healthcare was not found to reduce heat-related mortality.[61] Cooling from fans has limited use during a heat wave because fans do not cool the body at indoor temperatures above 95°F.[62]

NEED FOR AIR CONDITIONING IS INCREASING

Average electricity consumption for AC is increasing. A study of Los Angeles, CA; Washington, DC; Phoenix, AZ; Tucson, AZ; and Colorado Springs, CO found for each 2°F rise in daily maximum temperature above 68°F, average electricity consumption rose 2-4%.[63] While energy use for heating is declining, the U.S. Energy Information Administration projects energy use for AC will increase more than any other energy use.[64] Highly efficient AC will be needed to avoid overburdening the grid and to avoid summer electricity peaks, which consume the dirtiest fuels.[65]

DISPARITIES IN ACCESS TO AIR CONDITIONING

Despite increases in AC use, disparities remain. The latest results from the 2009 Residential Energy Consumption Survey show that 87% of U.S. households are now equipped with central AC or window AC, leaving about 13% of households nationwide without cooling in the summer.[66] In climates like Boston, the proportion of people without AC is higher because in marine climates fewer people have AC than the national average.[67] Wealthier households are more likely to have central AC instead of window units, and they are also more likely to use AC because they can afford it.[68] Low-income households already spend a larger part of their income on energy and may not be able to afford higher electricity bills. On average, low-income households pay 7.2 percent of their income for energy, more than three times the 2.3 percent that higher-income households pay.[69] Disparities in access to central AC also exist across racial lines. In a study of four U.S. cities, white households were twice as likely to have central AC as Black households.[70]

Residential buildings are not the only buildings lacking AC—the majority of Boston schools lack AC.[71] In the June 2021 heat wave, many Boston schools' indoor temperatures exceeded 79°F, the threshold for healthy indoor temperatures.[72] A 2018 study from Harvard's Kennedy School of Government found consistent heat exposure negatively impacts learning and productivity. The study also concluded AC "almost entirely offsets these effects."[73]

Boston's heat wave plan includes the implementation of cooling centers to meet the needs of residents without AC, but cooling centers have some limitations. Cooling centers are public air-conditioned buildings or pools throughout the city for people to visit during the day to escape the heat. The cooling centers are in Boston's Roxbury, Fenway, Downtown, Allston/Brighton and East Boston neighborhoods. However, an analysis demonstrated that the city's cooling centers did not meet the needs of residents.[74] Temperatures in UHIs peak at night and cooling centers cannot provide overnight relief from heat. They also cannot provide relief to people unable to leave their homes or schools. Access to efficient, affordable AC in all residential buildings and schools will be critical as temperatures rise.

Policy recommendations:

Boston can protect its most vulnerable residents from the health risks of rising temperatures by investing in interventions that cool neighborhoods and buildings and help maintain indoor temperatures below 79°F. We offer six policies to mitigate indoor heat-related illness and death.

Reduce neighborhood heat

1. Develop policies to preserve and protect existing trees on government and private property. Reinvest in Boston's plan to plant 100,000 trees.[75] Trees provide natural neighborhood cooling. The neighborhoods with the highest temperatures and fewest shade trees and environmental justice communities should be prioritized to receive resources first.

2. Reduce solar heating by installing cooling or reflective components on buildings, roofs, and city surfaces. Dark-colored roofs trap solar heat and increase indoor temperatures. Painting rooftops white is a low-cost intervention that can be implemented on a large scale. Projects to paint rooftops white in several New York City neighborhoods were quite successful in cooling buildings and reducing AC use.[76] Boston should prioritize reducing solar heating in assisted living facilities and nursing homes, public and subsidized housing, municipal buildings, the hottest neighborhoods, and environmental justice communities.

3. Incentivize "green roofs" in zoning policies. The City of Cambridge provides an incentive to create green roofs and recently passed an ordinance requiring future development and significant rehabilitation of buildings of more than 25,000 square feet to put plants or a blend of plants and solar panels on their rooftops.[77]

Reduce building heat

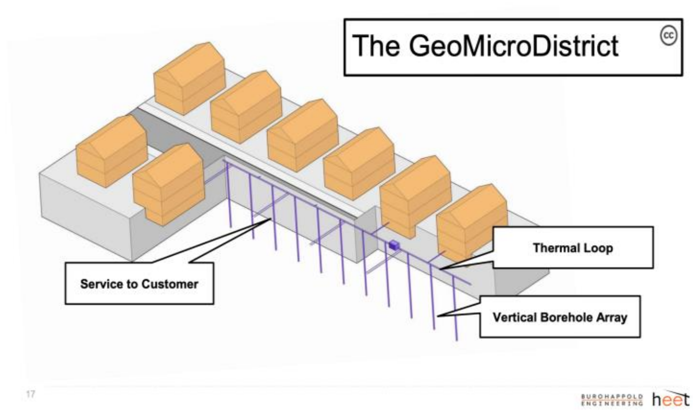
4. Advocate for and invest in energy efficiency programs for environmental justice communities, assisted living facilities, nursing homes, public and subsidized housing, and municipal buildings like Boston schools. The energy efficiency program should include insulation as well as indoor and outdoor shading options, like window

coverings, shrubbery, vines, etc. Insulated and shaded buildings are cooler in the summer and cost less to cool.

5. Subsidize the installation and operation of air-source and ground-source heat pumps because they provide more efficient cooling than traditional window AC units. Prioritize environmental justice communities, assisted living facilities and nursing homes, public and subsidized housing, and municipal buildings like schools.

6. Advocate for and support the expansion of utility-scale, networked ground-source heat pumps, also known as GeoMicroDistricts. The system is made of water loops installed in existing utility corridors in the street, replacing gas pipes. Heat pumps in individual buildings transfer thermal energy between a shared district water loop and their own heating and cooling distribution systems.[78] Networked ground-source heat pumps provide the most efficient mechanism of heating and cooling currently available, as exemplified by Colorado Mesa University.[79] Eversource is piloting this type of system in Massachusetts, and National Grid has requested permission to do so as well. Utility-scale delivery of heating and cooling offers more equitable access than heat-pump adoption alone because the responsibility and cost for installation is transferred from homeowners and building owners to the utilities. Prioritize communities most vulnerable to heat, including the hottest neighborhoods and environmental justice communities.

FIGURE 3: UTILITY-SCALE NETWORKED GROUND-SOURCE HEAT PUMPS: GEOMICRODISTRICT [80]



Benefits to Bostonians

These policies can help decrease forecasted increases in energy consumption in the summer, save money, reduce healthcare costs, improve air quality, and save lives.

- Reducing temperatures in cities can decrease energy consumption from AC by 20%. Nationally, reductions in urban heat can save $10 billion per year in energy costs.[81]
- Transitioning from fossil-fuel based heating to air-source, ground-source heat pumps and GeoMicroDistricts will improve access to energy-efficient cooling which will have the benefits of reducing healthcare costs, improving education, and saving lives. It will also reduce carbon emissions, helping Boston meet its goal to be carbon neutral by 2050.
- Energy efficiency improvements to buildings and heat pumps will improve air quality. Air pollution from burning fossil fuels is responsible for 13% of deaths in the United States.[82]

Conclusion

Access to affordable cooling is as essential to health and well-being as access to adequate heating is in winter. The City should invest in equitable heat resilience solutions to protect Boston's most vulnerable people. It should focus on neighborhood and building cooling efforts, prioritizing neighborhoods with racial and ethnic minority groups, neighborhoods with the highest summer temperatures, low-income households, senior housing and care facilities, and municipal buildings, like Boston schools. Boston has yet to experience a severe heat wave like the 2003 France heat wave, which killed an estimated 15,000 people. However, the risk of a high fatality heat wave increases every year. City officials must act to ensure that Boston does not suffer a similar catastrophe.

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