Cool Policies for Cool Cities:
Best Practices for Mitigating Urban Heat Islands in North American Cities

Virginia Hewitt and Eric Mackres,
American Council for an Energy-Efficient Economy

Kurt Shickman,
Global Cool Cities Alliance

June 2014

Report Number U1405

529 14th Street NW, Suite 600, Washington, DC 20045
Phone: (202) 507-4000

Twitter: @ACEEEDC
Facebook.com/myACEEE
www.aceee.org

www.globalcoolcities.org

Global Cool Cities Alliance

ACEEE
American Council for an Energy-Efficient Economy

Contents

About the Authors

Virginia Hewitt

Virginia Hewitt is a research assistant with the Utility, State, and Local Policy program at ACEEE. She performs multi-disciplinary policy research and reporting on actions at the local and state levels. She also helps coordinate technical assistance across ACEEE. Prior to joining ACEEE in 2013, Virginia was a climate policy intern at David Gardiner and Associates in Washington, DC. She is a certified LEED Green Associate and holds a bachelor of arts in environmental science and policy from Duke University.

Eric Mackres

Eric Mackres is the local policy manager and a senior researcher at ACEEE. He provides technical assistance to communities that are beginning or expanding energy efficiency efforts. In addition, he manages ACEEE research related to local implementation of energy efficiency. Before joining ACEEE in 2010, Eric worked in environmental organizing with the State PIRGs in Michigan and on statewide affordable housing policy in California. His master's research focused on partnerships for local energy efficiency implementation. Eric earned a master of city planning and a certificate of environmental planning from the Massachusetts Institute of Technology and a bachelor of arts in political science from Albion College.

Kurt Shickman

Kurt is the executive director of the Global Cool Cities Alliance (GCCA), a nonprofit organization dedicated to helping cities reduce excess urban heat. Kurt works with cities, national governments, industry, and the public to address the economic, health, environmental, and other challenges posed by urban heat islands. Before he joined GCCA, Kurt was the director of research for the Energy Future Coalition and the United Nations Foundation's Energy and Climate team. He received his master's degree with a focus on energy policy and economics in 2007 from the Johns Hopkins School of Advanced International Studies.

Acknowledgments

The authors are grateful to all of the individuals and organizations who contributed to the development of this report. We appreciate the financial support from the Blum Center, Energy Foundation, and GAF that made this project possible.

We are particularly grateful to the energy and sustainability staff members of the cities included in our report, particularly those who facilitated the responses to our survey in Appendix B. These individuals' efforts were essential as we complied and verified information. We are also especially grateful to the individuals who reviewed and offered comments on the draft report. In alphabetical order by city, we would like to thank Ruthie Norton (Atlanta), Leah Haynie (Austin), Carl Spector (Boston), Brendan Reed (Chula Vista, California), Steve Johns (Cincinnati), Kevin Lefebvre (Dallas), David Erickson (Denver), Lisa Lin (Houston), Michael Samulon (Los Angeles), Tina Imig (Phoenix), Ingrid Fish (Portland), and Annemarie Baynton (Toronto).

Thanks also to the numerous ACEEE staff members who acted as project advisors and reviewed and commented on drafts: Steven Nadel, Maggie Molina, Jennifer Amann, Neal Elliott, and Kate Johnson. We would especially like to thank Susan Mazur-Stommen for lending her expertise and assistance to our survey design. Thanks also to those at ACEEE and GCCA who supported the production of the report and related communications, especially Patrick Kiker, Eric Schwass, Glee Murray, Fred Grossberg, Kate Hayes, and Karen Smith-Murphy. Thanks to Aileo Weinmann at Resource Media for his help with the report's press release. Thanks to our production partner, Esther Chak at Imaginary Office, for her assistance with the release of the report and the design of the infographic.

We are also grateful to the experts who commented on the draft of the report and who contributed their expertise in numerous ways. We would like to thank Dr. Arthur Rosenfeld (Lawrence Berkeley National Laboratory), Brian Stone (Urban Climate Lab, Georgia Tech), and Haley Gilbert (Lawrence Berkeley National Laboratory).

ACEEE and GCCA are solely responsible for the content of this report.

Executive Summary

The urban heat island (UHI) effect is a global phenomenon in which a predominance of dark, impermeable surfaces and concentrated human activity cause urban temperatures to be several degrees hotter than those in surrounding suburban and rural areas. Urban heat islands impose negative effects on local and global public health, air quality, energy consumption, climate resilience, quality of life, stormwater management, and environmental justice. Mitigating a city's urban heat island effect can benefit buildings, neighborhoods, cities, suburban areas, and the globe.

This report describes UHIs and discusses the ways in which some North American cities mitigate heat and its impacts. Cities experience UHIs differently, so their approaches to tackling UHI-related problems vary. We hope that jurisdictions not included in this report will be able to adopt the UHI mitigation practices presented here that are suitable to their particular circumstances.

After conducting a literature review, we distributed a questionnaire to local government contacts in 26 North American cities to gather information on their UHI mitigation activities. Their responses constitute a bank of policies, programs, and practices. This report profiles the causes, impacts, mitigation strategies, and social and institutional context of city action.

Key Findings

Cities across North America are experiencing the impacts of urban heat islands. The good news is that mitigation steps can be taken, and cities are acting. This report finds the following.

Heat waves and other natural disasters are motivating cities to implement heat-mitigation strategies. Two-thirds of the cities surveyed cited adverse natural events or an increased number of high-heat days as the trigger for considering and adopting heat mitigation policies. However, cities do not consider the urban heat island effect an exclusively environmental issue, but also a core health, safety, and service-delivery issue. Cities report varied and multiple motivations for engaging in UHI strategy development, but we noted three primary motivations most frequently: adapting to a changing climate, improving the public health and resilience of the city, and saving energy. Half of the cities cited either climate adaptation or public health and resilience as their primary motivation.

Heat-mitigation actions are embedded in a broad set of strategies and agency activities. None of the surveyed cities has a plan dedicated specifically to mitigating the urban heat island effect, but each has at least one heat-mitigation strategy integrated into other initiatives. Sometimes such strategies are hidden in plain sight. For example, stormwater management, street tree programs, and green building codes work to mitigate urban heat islands whether or not that is the city's actual intention.

Most cities are implementing both voluntary programs and mandatory policies to reduce excess heat. All but two of the cities we surveyed have established at least one voluntary policy or program for private construction, and three-quarters of the cities have established at least one mandatory private construction policy. Rebates are the most popular voluntary policy mechanism; codes or ordinances for cool or green roofs are the most prevalent mandatory policy.

Cities are setting UHI-related goals and tracking progress. Every city surveyed has established at least one UHI-related goal. The most common goal is increasing urban tree canopy; the least common is reducing city temperature. Almost all the cities we studied are tracking progress toward their goals with quantifiable metrics. Some are tracking urban heat indicators such as hospital visits or changes in temperature. Cities also track the outcomes of actions such as updating roofs and planting trees. Changes in temperature and vegetation are the most frequently tracked indicators.

More can be done in every city. More than half the cities noted that they have made significant progress on policy or program implementation. However, no city reported that they had met or nearly met any of their UHI-related goals. Additional or improved mitigation actions are still clearly needed.

Recommendations

Based on our findings, we developed a list of recommendations to enable cities and other jurisdictions to develop and/or improve UHI-mitigation planning, policies, and programs. Our recommendations fall into four categories.

Develop strategies, set goals, and track progress. We recommend that cities set quantitative goals across multiple sectors. To measure progress, cities should keep records of the UHI-mitigation measures they have implemented and collect granular data on heat indicators.

Establish policies and lead by example. Cities should establish a cost-effective mix of voluntary and mandatory programs and policies to create a suite of tools to support UHI mitigation. Local governments should lead the way by incorporating mitigation practices and technologies into their procurement policies. Each city should identify a lead agency to coordinate its UHI-related policies and programs.

Engage institutions and citizens. We recommend that cities form mutually beneficial partnerships with local institutions such as universities and energy and water utilities. Cities can leverage analytical capabilities as well as data, financial, and volunteering resources. They should also engage the public to help build support for goals and programs.

Engage with multiple levels of government. City, state, regional, and national government all play a role in UHI mitigation. Regional planning is needed to most effectively combat urban heat islands. Cities should share program performance data and work with state agencies to encourage adoption of up-to-date cool roof and pavement standards.

We hope that jurisdictions subject to UHI effects will assess their individual situations and consider adapting some of the relevant measures and policies described in this report. By implementing locally appropriate policies and practices, cities can go a long way toward mitigating the impacts of urban heat islands on their communities and the planet.

SURVEYED CITIES, AND THEIR GOALS AND STRATEGIES FOR UHI MITIGATION

Cities	Climate Zone (1–7)		Goals	Strategies: Policies and Programs — Mandatory	Strategies: Policies and Programs — Voluntary
POPULATION 3M+					
Los Angeles	3	▲	Vegetative Roofs, Stormwater Management, Urban Canopy, Other*	Cool Procurement Policies, Reflective Roofs, Other*	Reflective Roofs
New York	4	▲	Reflective Roofs, Stormwater Management, Urban Canopy, Other*	Cool Procurement Policies, Reflective Roofs, Urban Canopy	Reflective Roofs, Vegetative Roofs, Stormwater Management
POPULATION <3M					
Houston	2	▲	Vegetative Roofs, Urban Canopy	Cool Procurement Policies, Reflective Roofs	Other*
Phoenix	2		Light-colored Pavements, Stormwater Management, Urban Canopy, Other*	Cool Procurement Policies	Reflective Roofs, Urban Canopy
Dallas	3		Stormwater Management, Urban Canopy, Other*	Cool Procurement Policies, Reflective Roofs, Stormwater Management, Other*	Urban Canopy, Other*
Philadelphia	4	▲	Reflective Roofs, Vegetative Roofs, Stormwater Management, Urban Canopy, Other*	Cool Procurement Policies, Reflective Roofs	Reflective Roofs, Stormwater Management, Urban Canopy
Chicago	5	▲	Vegetative Roofs, Urban Canopy, Other*	Reflective Roofs, Stormwater Management, Urban Canopy	Cool Procurement Policies, Reflective Roofs, Vegetative Roofs, Stormwater Management
POPULATION <1M					
Austin	2	▲	Stormwater Management, Urban Canopy, Other*	Reflective Roofs, Urban Canopy	Vegetative Roofs, Other*
New Orleans	2	▲	Reflective Roofs, Vegetative Roofs, Light-colored Pavements, Stormwater Management, Urban Canopy, Other*	Stormwater Management	Other*
Atlanta	3	▲	Stormwater Management, Urban Canopy, Other*	Stormwater Management, Other*	Cool Procurement Policies, Reflective Roofs
Charlotte	3	▲	Urban Canopy		
Chula Vista	3		Light-colored Pavements, Stormwater Management, Urban Canopy	Cool Procurement Policies, Reflective Roofs, Light-colored Pavements, Stormwater Management, Urban Canopy	Other*
Las Vegas	3		Vegetative Roofs, Stormwater Management, Urban Canopy		Other*
Sacramento	3		Reflective Roofs, Vegetative Roofs, Light-colored Pavements, Stormwater Management, Urban Canopy, Other*	Cool Procurement Policies, Reflective Roofs, Urban Canopy	Reflective Roofs, Urban Canopy
Albuquerque	4		Reflective Roofs, Vegetative Roofs, Stormwater Management, Other*		Other*
Baltimore	4	▲	Reflective Roofs, Stormwater Management, Urban Canopy, Other*	Stormwater Management	Urban Canopy
Cincinnati	4	▲	Reflective Roofs, Vegetative Roofs, Light-colored Pavements, Stormwater Management, Urban Canopy, Other*	Urban Canopy	Cool Procurement Policies, Vegetative Roofs, Other*
Louisville	4	▲	Stormwater Management, Urban Canopy, Other*		Cool Procurement Policies, Stormwater Management, Other*
Portland	4	▲	Vegetative Roofs, Light-colored Pavements, Stormwater Management, Urban Canopy	Cool Procurement Policies, Vegetative Roofs	Vegetative Roofs, Stormwater Management, Urban Canopy
St. Louis	4		Stormwater Management, Urban Canopy, Other*	Urban Canopy	Reflective Roofs, Urban Canopy, Other*
Vancouver	4		Stormwater Management, Urban Canopy, Other*	Vegetative Roofs	
Washington DC	4	▲	Reflective Roofs, Vegetative Roofs, Stormwater Management, Urban Canopy	Cool Procurement Policies, Reflective Roofs, Light-colored Pavements, Stormwater Management, Other*	Vegetative Roofs, Stormwater Management, Other*
Boston	5	▲	Stormwater Management, Urban Canopy, Other*	Stormwater Management	Cool Procurement Policies, Urban Canopy
Denver	5	▲	Urban Canopy, Other*	Cool Procurement Policies, Other*	Other*
Omaha	5		Vegetative Roofs, Urban Canopy, Other*		Other*
Toronto	5		Urban Canopy, Other*	Cool Procurement Policies, Vegetative Roofs, Other*	Reflective Roofs, Vegetative Roofs, Stormwater Management, Urban Canopy

KEY

- Cool Procurement Policies
- Other*
- Reflective Roofs
- Stormwater Management
- Urban Canopy
- Vegetative Roofs
- Light-colored Pavements
- ▲ Natural Disaster Response

* Other includes the following list of goals and strategies. Goals: GHG emissions reduction, energy use reduction, disaster preparedness, urban agriculture, air quality, green building standard implementation, reducing hospitalizations, and reducing VMT. Strategies: Green Building techniques, educational campaigns, energy efficiency, and energy use reduction.

Introduction

Our cities are heating up. The urban heat island (UHI) effect intensifies this trend. This is a phenomenon in which a predominance of dark, impermeable surfaces and concentrated human activity cause urban surface, air, and atmospheric temperatures to be several degrees hotter than those in the suburban or rural surroundings (Akbari 2005). Urban heat islands have significant and wide-ranging effects on public health, air quality, energy consumption, climate adaptation, quality of life, stormwater management, and environmental justice. Given this range of impacts, city programs to reduce excess heat are often spread across a number of agencies, each with its own strategy and priorities.

Cities that take steps to mitigate UHIs see many benefits. Air-conditioned buildings may have lower energy bills, and unconditioned buildings can be cooler in the summer. Reduced thermal expansion can help roofs last longer. Entire cities can shave peak summer electric demand. Fewer people may get sick or die during extreme heat events. Local air and water quality can improve, as can a city's quality of life. Because disadvantaged neighborhoods are often the most vulnerable to heat, addressing a city's UHI can help promote social and environmental equity. Cities may also reduce the emissions that cause atmospheric warming. If less peak electricity is required, fewer greenhouse gases (GHGs) will be emitted. Localized cooling from reflective surfaces and vegetation also helps mitigate some of the warming caused by GHGs.

This report describes the many ways North American cities deal with excess heat. After a high-level overview, we go on to topic-specific discussions of various approaches to UHI mitigation. Urban heat islands are experienced differently by each city, so approaches to tackling the problem vary widely. This report provides tools for cities and jurisdictions to identify, adopt, and spread successful mitigation approaches as time- and cost-effectively as possible.

To make our analysis as broadly applicable as possible, we chose 26 large and medium-sized cities from a range of climate zones and geographic areas. We included cities whose decision makers focus on urban heat reduction as well as some in which such mitigation is a byproduct of other priorities such as stormwater management or urban beautification.

Though our study focuses on UHI activities in individual cities, we also acknowledge the advantages of addressing UHIs at the state and regional levels. Extreme heat events are not confined to city boundaries; they also affect surrounding suburbs and upwind cities. State and regional policy can address these more widespread effects while assisting local mitigation efforts.

We developed a 31-question survey to capture each city's experience with UHIs. The survey covers history and background, goals, planning documents, specific considerations, and progress. After conducting a preliminary literature review for each city, we sent the survey to city officials to collect more complete information on their UHI-mitigation activities.

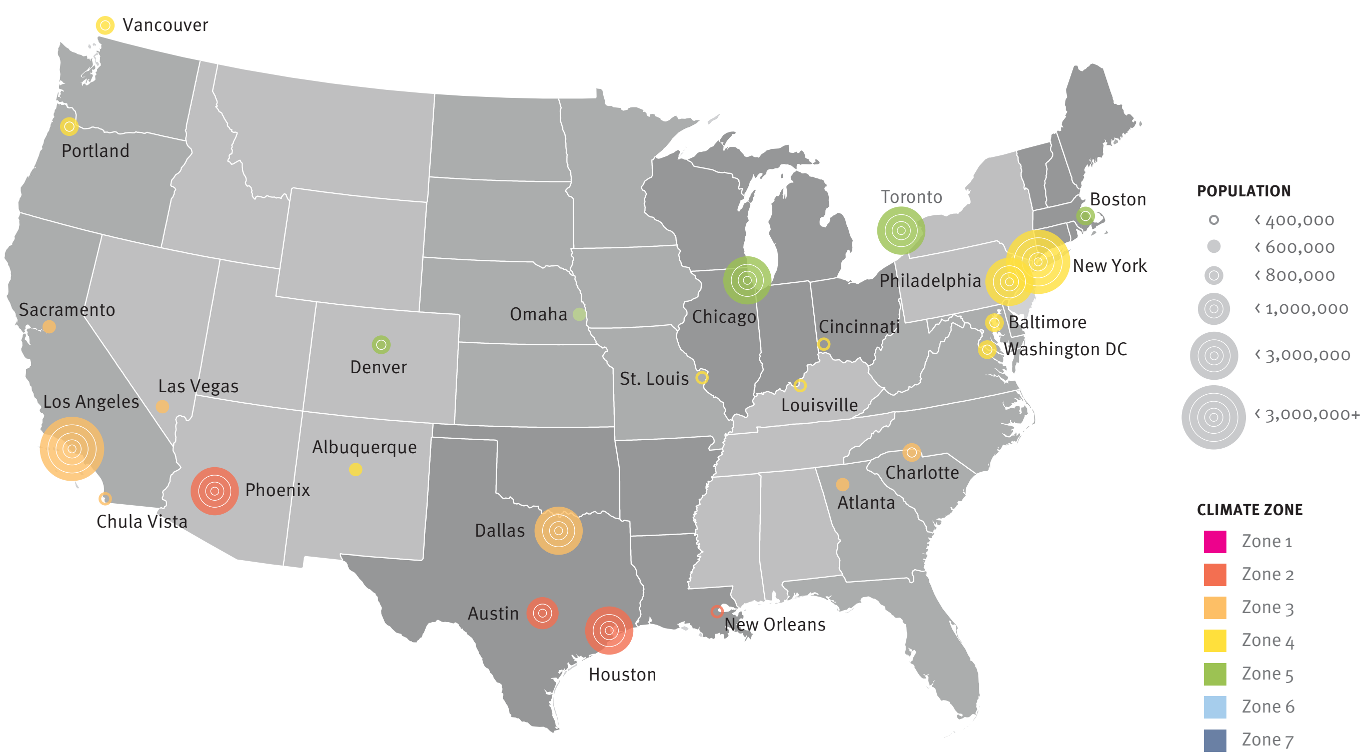


Figure 6: Map of the cities included in our study and their Census Divisions See Appendix C for a listing of the census zones.

Background

On average, UHIs make cities 7°F hotter than surrounding rural areas, and some cities have UHIs that are 15-20°F hotter (Navigant 2009). Why do cities experience the urban heat island effect? When sunlight shines on a city, some of it is absorbed by dark surfaces or air pollution and converted to heat (Trenberth 2008). This surface heat warms the surrounding air and leads to increases in temperature. Other causes of excess heat are human activity and a lack of vegetation (Navigant 2009). In Chicago, for example, the prevalence of pavement, tall buildings, and vehicular traffic all help to create and exacerbate a UHI.

Excess urban heat is a cross-cutting challenge, and cities and states have adopted an array of technologies, policies, and practices to manage its causes and effects. The most common strategies include revegetating paved areas and installing reflective roofs, reflective pavements, green roofs[1], porous pavements, and shade trees. Each strategy has its own well-documented primary benefit as well as a range of co-benefits. Each city is different in terms of climate, size, and sociopolitical condition, so each mitigation effort may be tailored and adapted to meet a city's goals.

Causes of Urban Heat Islands

Various interactions between human and natural systems cause urban heat islands. The most important factors are human activity, dark surfaces, and lack of vegetation.

HUMAN ACTIVITY

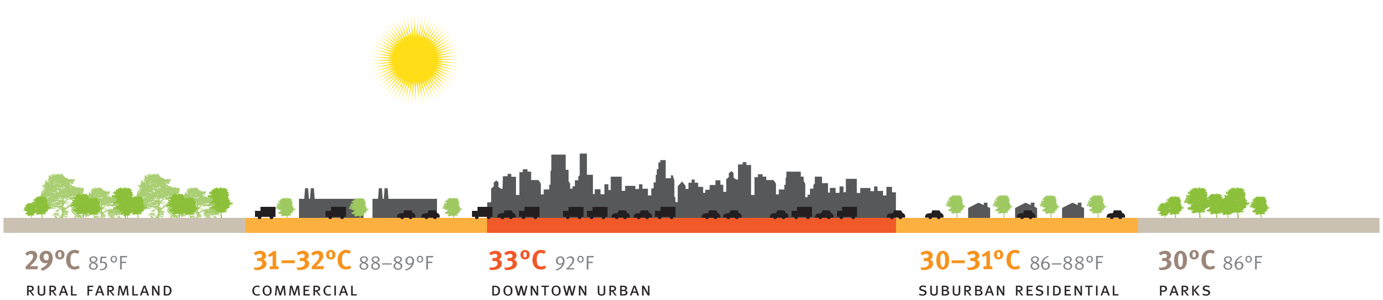
Heat island intensity directly correlates with the population of a city (Oke 1973.) In a city, the everyday activity of the population requires energy. Producing usable energy releases emissions, creates smog, and retains atmospheric heat. Tailpipe emissions and exhaust from industry and power plants increase the air temperature through the greenhouse gas (GHG) effect. The increase in demand for cooling requires more electricity for heating, ventilation, and air conditioning (HVAC). Unfortunately, the hotter it gets, the higher the demand for mechanical cooling. As people use more air conditioning, they draw more electricity from the grid, which in turn compounds GHG emissions and raises the temperature further.

DARK SURFACES

Dark surfaces have a low albedo, (a measure of solar reflectance in terms of percentage of energy reflected and absorbed).[2] Most cities are covered by dark, impermeable surfaces such as building roofs and pavement. These dark surfaces absorb sunlight during the day and store it as surface heat. A dark roof absorbs solar energy, which raises the temperature of the building and increases the cooling demand. In the evening, that surface heat slowly releases into the air, raising the ambient nighttime air temperature. For example, Akbari (2005) found that on a clear, calm night, the temperature in Los Angeles was 22°F higher than the surrounding areas. This effect can be particularly dangerous to residents during extreme heat events.

LACK OF VEGETATION

Cities have less vegetation than their surrounding rural areas. The UHI effect is exacerbated by this lack of vegetation because of reduced natural cooling potential from shade and plant evapotranspiration (Akbari 2002). During evapotranspiration, plants take in ambient carbon dioxide and other inputs and release oxygen and water vapor. The water vapor cools the leaves and, when the wind blows, the surrounding area cools.



The Urban Heat Island Effect

Source: Adapted from Lawrence Berkeley National Laboratory

1. Green roofs are any roofs that include elements of living landscaping.

2. http://www.epa.gov/heatisld/resources/pdf/CoolPavesCompendium.pdf

Impacts of Urban Heat Islands

Impacts of the urban heat island effect are widespread across a city. The presence of an urban heat island can strain the energy supply, decrease the city's air quality and quality of life, and even increase mortality.

STRAIN ON ENERGY SUPPLY

The hotter cities get, the more cooling demand there is overall. Air-conditioning units and fans draw more electricity the more they need to cool. The demand for cooling is generally highest during peak electricity hours, the late afternoon and early evening. Akbari (2005) finds that the UHI-related increase in air temperature is responsible for 5-10% of urban peak electric demand. Figure 1 shows the nonlinear increase in average electric load as maximum daily temperature rises.

Electricity demand rises steeply per degree Celsius after the threshold of 27°C, as shown in figure 1. As the electric load increases, especially during peak hours, power plants produce more electricity and release more GHGs into the air, contributing to global warming.

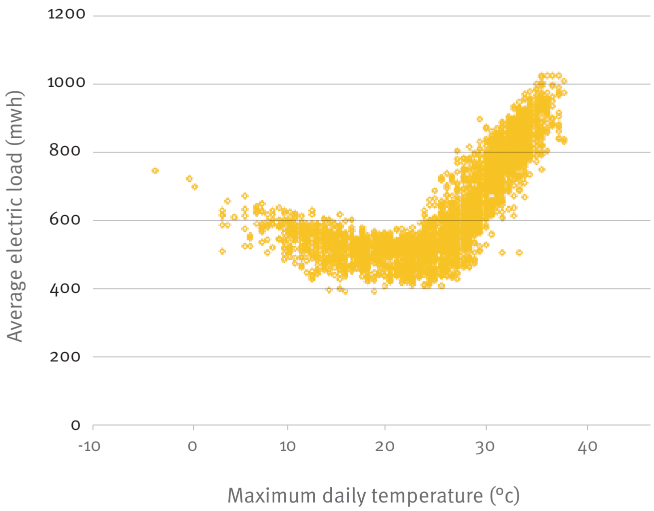


Figure 1: Average electric load per maximum daily temperature Source: Adapted from Sailor (2002). Data courtesy Entergy Corporation.

DECREASED CITY AIR QUALITY

Decreased air quality is one of the most far-reaching effects of UHIs. Poor air quality, in which the ozone and particulate matter (PM-2.5) levels from nearby coal plants are high, is detrimental to public health and the environment. The World Health Organization (WHO) estimates 21,000 premature deaths per year occur across 25 European countries because of high levels of ozone (Amann et *al. 2008).*[3] WHO further estimates that 14,000 respiratory-related hospital admissions in Europe are directly due to high ozone levels.

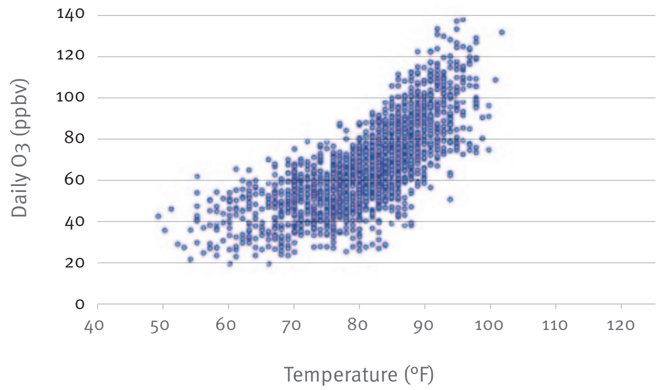


Figure 2: Correlation of smog concentration with temperature
Source: Maryland Commission on Climate Change

Urban air quality influences and is influenced by a city's temperature. An increase in temperature corresponds to the rate at which ozone feedstocks (NOx and VOCs) cook into ozone. Akbari (2005) finds that for every 1.8°F the temperature in Los Angeles rises above 71.6°F, smog increases by 5%. Figure 2 shows how smog forms in a nonlinear fashion in accordance with the maximum surface temperature at Baltimore-Washington International Airport. Each point represents an 8-hour period. At 80°F, most of the points are below the minimum EPA compliance level of 60 ppb. [4] At and beyond 90°F, the majority of points lie above minimum compliance, meaning the amount of ozone is at dangerous levels.

REDUCED QUALITY OF LIFE

People in cities subject to excess urban heat and extreme heat events experience a decreased quality of life. They are less likely to take advantage of outdoor amenities, exercise, or interact outdoors. Residents are more likely to suffer from health problems. Energy utility customers may experience higher bills. City priorities compete for the use of limited resources. Overall, a city is less pleasant when it is excessively hot.

HEIGHTENED MORTALITY

Increased daytime temperature, reduced nighttime cooling, and high air-pollution levels increase health problems and mortality, especially among low-income and elderly populations. In fact, heat is the deadliest natural disaster, causing more casualties than hurricanes, floods, and tornadoes together (Wong et al. 2012). Further, Wong states that between 1989 and 2000, studies of 50 U.S. cities recorded a rise of 5.7% in mortality during heat waves. The Centers for Disease Control (2012) found that over a 12-year period (1999-2010), excessive heat caused 7,415 premature deaths in the United States. In 1999 alone, 1,050 deaths were caused by excessive heat.

3. Ozone exceeding 70µg/m³ measured as a maximum daily 8-hour average: www.euro.who.int/__data/assets/pdf_file/0005/78647/E91843.pdf

4. Minimum EPA compliance for ozone (O_3) levels measured across an 8-hour period is 0.060ppm, or 60ppb: http://www.epa.gov/groundlevelozone/pdfs/fs20100106std.pdf

Mitigation Strategies and their Benefits

The causes and impacts of the urban heat island effect are various and widespread. However, there are strategies cities may employ to mitigate the effects. The two most common are increasing a city's amount of reflective surfaces and increasing the total amount of vegetation.

INCREASE REFLECTIVE SURFACES

At least two of the three main causes of the urban heat island effect—dark surfaces and lack of vegetation—can be mitigated through policies and programs related to buildings and city planning. Installing reflective and lighter-colored surfaces on city roadways, walkways, and roofs is a primary UHI mitigation strategy. Surfaces store solar energy as heat and release it through contact (conduction) or slowly into the air (convection). The darker a surface, the more potential it has to store heat. A light-colored or reflective surface has a very small potential to store heat because of its high albedo, or reflective power. Surfaces that reflect solar energy stay cooler themselves, release less heat into the surrounding air, and allow for nighttime cooling in a city. The EPA (2013a) reports that conventional asphalt pavement can reach summertime temperatures of 120-150°F. In contrast, a "cool" pavement can be 50-70°F cooler.

Though the primary benefit of installing reflective pavement is reducing the surface and air temperature, there are many co-benefits as well. For example, reflective pavements may increase road or sidewalk visibility at night, improve water quality by reducing water heat-shock from warm runoff into rivers, and last longer than traditionally-colored pavements due to decreased heat stress (EPA 2013a).

There are many cool pavement technologies available today. Though actual cost per square foot may differ across states and by manufacturer, the benefits of each technology are easily reportable. Table 1 shows the solar reflectance (SR), typical uses, and surface life of six typical cool pavements.

Dark roofs, like dark pavements, store heat and radiation. Dark roofs become very dangerous during heat events because they transfer the stored heat into buildings. Cool roofs, which reflect rather than absorb solar energy, reduce the demand for cooling within the building. Installing cool roofs reduces the ambient temperature of the city, which decreases the incidence of ozone and smog formation.

A cool roof can be installed during initial construction, or a coating can be applied to a pre-existing roof. As with cool pavements, actual costs differ depending on the state of purchase and manufacturer, but the benefits are more easily discernable. As a rule, including a cool roof during original construction costs less in total than converting a traditional roof to a cool one later (GCCA 2012). In addition, the life span of a reflective roof is greater than that of a traditional roof because of reduced heat stress (Akbari 2005).

Many cool technologies cost less than or the same as "dark" technologies. Table 2 presents a variety of traditional roofing technologies, their solar reflectance, the applicable cool roofing technologies, the cool roof's associated solar reflectance, and the life expectancy and price premium for cool roofing technology.

Pavement type	Solar Reflectance (SR)	Typical uses	Surface life
Clear resin binders	Depends on the composition of the aggregate	New construction or maintenance for streets, sidewalks, parking lots, etc.	20 years
Coatings (cementitious, elastomeric)	New: 35–55%	Coatings for preventive maintenance for streets, driveways, parking lots, etc.	1–5 years
Light-colored aggregates (chip seal)	Depends on the composition of the aggregate	Overlay for preventive maintenance for highways, streets, parking lots.	2–5 years
Light-colored cement (slag, white cement)	New: 70–80%	New construction or maintenance for highways, streets, sidewalks, parking lots, etc.	40 years
Porous asphalt cement, Pervious Portland Cement Concrete, reinforced grass pavements	Depends on the type of pavement used	New construction, to aid with stormwater management	Varies
Portland Cement Concrete	New: 35–50% Aged: 20–35%	New construction or maintenance for highways, streets, sidewalks, parking lots, etc.	40 years

Table 1: Solar reflectance, typical uses, and surface life of six common cool pavements
Source: GCCA cool pavement materials and LBNL common pavement types tables, http://www.coolrooftoolkit.org/wp-content/pdfs/CoolRoofToolkit_Full.pdf

Common traditional roofing technology	Dark roof solar reflectance	Applicable cool roof technology	Cool roof solar reflectance	Life expectancy	Price premium (US$ per ft^2)
Asphalt shingle	0.05 –0.15	White or cool-colored shingles	0.25	15–30 years	0.00 – 0.75
Built -up roof with dark gravel	0.10 –0.15	White gravel	0.30 –0.50	10 –30 years	0.00
Built -up roof with aluminum coating	0.25 –0.60	White smooth coating	0.75 –0.85	10 –30 years	0.50 –1.50
Clay tile	0.20	Unglazed red terracotta tile	0.40	50+ years	0.00
		Colored tile with cool pigments	0.40 –0.60	50+ years	0.00
		White tile	0.70	50+ years	0.00
Concrete tile	0.05 –0.35	Colored concrete tile with cool pigments	0.30 –0.50	30–50+ years	0.00
		White concrete tile	0.70	30–50+ years	0.00
Liquid applied coating	0.05	Smooth white	0.70 –0.85	5–20 years	0.00
Unpainted corrugated metal	0.30 –0.50	Coated with white paint	0.55 –0.70	20 –50+ years	0.00 –1.00+
Dark-painted corrugated metal	0.05 –0.10	Colored metal with cool pigments	0.40 –0.70	20 –50+ years	0.00
Modified bitumen with mineral surface capsheet (SBS, APP)	0.10 –0.20	White coating over a mineral surface (SBS, APP)	0.60 –0.75	10 –30 years	0.50
Single-ply membrane	0.05	White membrane (PVC, EPDM)	0.70 –0.80	10–20 years	0.10 –0.15
		Colored membrane with cool pigments	0.40 –0.60	10–20 years	0.00
Wood shake	0.35 –0.5	Left bare	0.40 –0.55	15–30 years	0.00

Table 2: Traditional roofing versus cool roof technologies
Source: GCCA, DOE guidelines for selecting a cool roof, and coolcalifornia.org, http://www.coolrooftoolkit.org/wp-content/pdfs/CoolRoofToolkit_Full.pdf

As with any roof, there is a cost associated with maintaining cool roofs. Humid climate zones are conducive to mold, mildew, and moss growth. Heavy foliage may fall on the roof, reducing the reflectance and cooling benefits. These roofs may need periodic cleaning. In cold climates, some cool technologies may incur a winter heating penalty. During the winter, the low angle of the sun and potential snowfall renders roof color irrelevant (GCCA, 2012). During daylight hours, the residents of a building may prefer the heating benefit of the sun. To combat this effect, proper ceiling and roof insulation can keep warmth in the home during the winter while enhancing energy savings year round.

INCREASE VEGETATED SURFACES

Increasing the total vegetation of a city is another well-documented method for mitigating the UHI effect. All vegetation has the potential to provide these ecosystem services and co-benefits to a city and surrounding areas: stormwater filtration, groundwater recharge, reduced stress on combined sewer overflow systems, improved public recreation space, and increased urban habitat. Potential vegetation actions include installing green roofs, planting trees to shade the south and west of homes, and using grass pavers [5] where possible. The decision to vegetate an area should be considered by each city in conjunction with its climate situation and water availability.

Green roofs also offer a building decreased heat absorption and radiance, leading to cooler surface and air temperatures and less demand for electric cooling. A green roof's cooling benefits are only seen locally. Green roofs do not hold the reflective properties of cool roofs and cannot combat an increase in global temperature (GCCA 2012). However, green roofs do provide additional co-benefits such as increased air quality through CO_2–O_2 exchange, stormwater filtration, aesthetic value and amenity space, opportunity for urban agriculture, and cooling via evapotranspiration (Bass 2012).

There are two main categories of green roofs: intensive and extensive. Intensive green roofs are the most expensive option, with costs based on inputs and design. Intensive roofs have deep soil layers, are heavier per square foot than traditional roofs, and require many inputs, but they can be agriculturally productive and aesthetically pleasing. Extensive green roofs are less expensive than intensive roofs but still more expensive than any cool roof option on average (GCCA 2012). Extensive roofs have shallow soil layers, are lighter per square foot than intensive green roofs, and require minimum maintenance, yet they may not be productive or as aesthetically pleasing.

A city can achieve additional cooling by planting shade trees. Shade trees stop solar energy from reaching a building or the ground below. A study by Akbari (2002) records that shade trees produce an oasis effect, significantly cooling the ambient area. Besides ambient cooling benefits, shade trees can directly cool a building, produce oxygen, clean the air of pollutants, provide habitat, and reduce stormwater runoff. They are also aesthetically pleasing (McPherson et al. 2005). At the same time, McPherson's 2005 study of 5 U.S. cities identifies costs associated with vegetation, including inspections, potential damage to infrastructure, public liability, litter removal, irrigation, pruning, planting, and removal. The actual costs to a municipality vary in accordance with climate, species, and weather-related disasters.

Revegetating a previously paved area eliminates the negative effects that dark pavement imposes on a city. In addition, revegetating previously impervious land makes it pervious again. Pervious land absorbs rain and stormwater, filtering it before it enters a body of water or recharging a groundwater aquifer. Pervious land reduces the stress a combined sewer overflow system may experience during a rain or stormwater event (Bass 2012). A grass paver is an example of a paving technology that allows for percolation. Completely revegetating previously paved areas also benefits public recreation since grassy or packed-dirt fields are more amenable to outdoor activities than are paved areas.

Social and Institutional Context of City Action

While all urban heat islands have similar impacts, their intensity may vary from city to city. The cities we studied are positioned uniquely in terms of climate, demographics, and sociopolitical context. Therefore, priorities and goals for mitigating each UHI effect differ for each specific situation. There are many reasons a city may be prompted to develop an urban heat island strategy or initiative. Some may have experienced a traumatic heat wave, while others may have tracked the effects of UHIs over time. Other cities, recognizing the increased chance of future extreme heat events, preemptively develop mitigation policies and programs. And still others have not identified mitigating UHI effects as a priority but are in fact already mitigating urban heat with urban tree canopy or stormwater management initiatives. UHI mitigation policies and programs can effect positive change with respect to many city priorities and goals.

VULNERABLE POPULATIONS

In addition to the natural and built environments, the population of a city with an urban heat island is also at risk of feeling its effects. Cities might be motivated by social concerns to develop a UHI-mitigation strategy, and they may identify vulnerable neighborhoods or populations for targeted action. Unfortunately, some sectors of city populations—the elderly, the homeless, low-income populations, and people with preexisting health conditions—and certain neighborhoods are disproportionately vulnerable to urban heat island effects. Children, adults with preexisting heart or lung disease (especially asthmatics), and the elderly are more susceptible to worse health because of poor air quality (EPA 2013b). Additionally, the negative effects of an UHI acutely affect those who are constantly exposed to poor air quality, including outdoor laborers and homeless people. Another consideration is that in some utility jurisdictions, peak electricity may be more expensive than off-peak. This unfairly punishes low-income people, who may not be able to afford air conditioning and are subjected to continuous heat stress.

5. Grass pavers are cement slabs featuring lattice pattern openings. Grass may grow and water may percolate through the openings.

STATE AND LOCAL AUTHORITIES

Various levels of government have control over policies and programs relating to UHI mitigation. For instance, building construction and maintenance codes may be set at the state or local level. However, in some cases, states may establish a minimum standard but allow localities to require stricter codes.[6] Land-use ordinances, urban planning, and zoning are typically determined at the city or county level, but the locality itself determines municipal construction and procurement requirements. Beyond government, there are a variety of private stakeholders—utilities, developers, contractors, and building owners—who play important roles in incentivizing and mainstreaming UHI-mitigation measures.

California is an example of a state leading the way in UHI mitigation. In August 2003, a disastrous heat wave hit Western Europe, causing over 50,000 premature deaths from Copenhagen to Rome. In response to this event, the California Energy Commission mandated that, effective 2007, flat roofs built as part of new construction of commercial buildings in California, including multifamily residential, must be white. Since the cool-roof market is based largely on the rebuilding of existing roofs that last about 20 years, the California standard allowed for annual market growth for cool re-roofs of about 5%. By comparison, new commercial buildings are growing at about 1% per year. The same statistics apply to single-family homes and low-rise residential buildings.

The switch to compliant white membranes and coatings in California worked smoothly, given two years advance notice of the effective date. Building owners and developers approved the new standards, architects specified compliant materials, and manufacturers, retailers, and electric utilities complied. In addition, the utilities had already started giving rebates for white roofs. As a result, a new white roof or a white replacement roof costs no more than a new dark-colored roof.

Large cities can also show leadership in UHI mitigation. When a city beats statewide standards, it shows that stricter standards are possible. Large cities can also serve as examples for states that do not yet have up-to-date standards.

LIMITATIONS OF LOCAL ACTIONS

Though the urban heat island effect imposes acute impacts on affected areas, the issue is not confined to the political boundaries of a city. UHI causes and impacts are regional. Urban areas outside a city's jurisdiction contribute to the region's UHI and increase temperatures within a city. The expressways, turnpikes, and highways that ring many cities are usually under the jurisdiction of regional transportation authorities or the state. Parking lots and buildings outside a city also contribute to the regional effect. Suburbs often are not subject to the codes and ordinances of their neighboring city and may not have the same commitment to UHI mitigation. In addition, many cities, especially those on the East Coast, lie in close proximity to one another, so close in fact that an atmospheric heat island may cover more than one city. These realities mean that large-scale regional and multi-jurisdictional cooperation is needed to combat the negative effects. Each mitigating action eases the effect on the entire area, and ultimately on the planet. As UHI mitigation policies and technologies saturate the market and are accepted as standards, the global incidence of traumatic heat waves may decrease, buildings may see lower cooling costs, and environmental impacts may become more socially equitable.

6. ACEEE State and Local Policy Database, Energy Code Stringency: http://www.aceee.org/node/3006/all

Methodology

Many levels of local government can enact policies to mitigate the urban heat island effect on their jurisdiction. Cities, counties, school districts, and metropolitan planning organizations all have authority over areas of land and portfolios of buildings. However, according to UHI and mitigation literature, cities and metropolitan areas are most commonly affected by UHIs. Therefore, to narrow our scope of study, we focused on city jurisdictions. City governments have direct authority over the building stock and land area within most urban areas and, as a result, the most authority to influence the adoption of UHI mitigation measures.

To gather information on current UHI mitigation activities in our sample of 26 North American cities, we first undertook a literature review and then distributed a questionnaire to each city's local government contacts. Our resulting findings constitute a bank of practices, policies, and programs. We hope that cities or jurisdictions not included in this report will be able to see similarities with the cities we focused on and identify suitable UHI mitigation policies and practices.

While city governments are the focus of this research, other jurisdictions and private entities can also apply many of the best practices presented here. Councils of governments (COGs), for instance, may consider the tools presented here for regional use. (COGs are regional planning bodies serving many adjacent cities and counties.) A university which has many buildings and paved and non-paved areas on its campus may also consider its role in UHI mitigation. Campus-scale mitigation may provide the university with the local benefits presented in this report.

Survey Design

To gather policy and program information from the selected cities, we developed a 31-question survey (see Appendix A). The goal of the survey was to collect qualitative and quantitative information about each city's UHI history, its goals and plans to mitigate the UHI effect, the city's history with and attitude towards the presence of an urban heat island, and the UHI's effects on the city's natural, social, and built environment. We also collected anecdotal and subjective data from our respondents to gauge social acceptance of, and progress towards, the established goals. Finally, we asked respondents to share any of their programmatic materials that might be valuable to other jurisdictions.

Prior to distributing the survey, we researched public documents, records, reports, and web pages. We used this research to pre-populate many of the objective questions. To ensure accuracy and currency, we instructed the respondents to review, correct, and update the pre-populated answers.

City Selection

For our research sample, we selected 26 medium and large cities from the United States and Canada based on three criteria. We chose cities who had implemented some UHI mitigation actions or developed a UHI mitigation strategy, who had developed strategies that might be applicable to other North American cities, and who represented a diversity of geographies and climates.

To satisfy the first criterion, we established a list of cities we knew had implemented some UHI mitigation actions, or had developed a mitigation strategy. We gathered this information through our background research, industry knowledge, and familiarity with current local practices.

To satisfy the second criterion, we narrowed our set of cities to those that had strong prior experience with strategy development applicable to a broad sample of other North American cities. For example, we included cities who appeared in the 2013 City Energy Efficiency Scorecard (Mackres et al. 2013) who had strong strategy development experience. To make the study more applicable to other North American cities, we selected cities with a mixture of large (>800,000) and medium (between 240,000 and 800,000) resident populations, as shown in figure 3.

The median city population in our sample is 627,804. Chula Vista has the smallest population, with 243,916 residents, and New York has the largest, with 8,336,697. We included large cities to satisfy the first criterion because the literature notes that they have many UHI mitigation policies and programs in place, some of which may be applicable to smaller communities. We included medium-sized cities in our sample to gather policies and practices applicable to a larger number of North American cities.

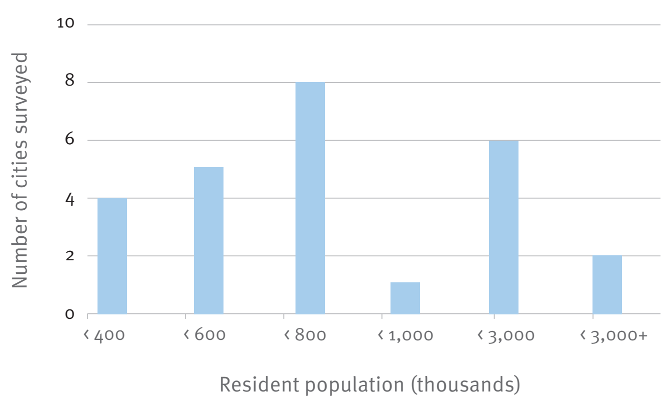


Figure 3: Number of cities in sample by resident population (n=26)

The third criterion was to represent a diversity of geographic locations and climate zones. We included at least one city from every U.S. Census region and division. In addition, we chose a mixture of cities spanning the largest International Energy Conservation Code (IECC) climate zones of the continental United States. Used for the application of building codes, the IECC climate zones and subzones divide the nation into 24 regions based on temperature, precipitation, heating degree days (HDD), and cooling degree days (CDD) (DOE 2013). The zones run north to south from zone 1 (tropical) to zone 7 (alpine or arctic); the subzones run east to west from the moist east coast (A) to the marine west coast (C). Figure 4 is a map of the United States with the IECC climate zones color-coded. Figure 5 shows the number of cities we surveyed within each climate zone.

We have included at least one city from every U.S. Census Bureau Division. Though cities may set different goals based on sociopolitical conditions, we assumed that cities within a similar climate zone will have similar experiences with urban heat islands and so may have similar goals and priorities. See Figure 6 on page 7 of this report.

Appendix C presents the geographical and climatic situation of each of the study cities in terms of Census division, population, land area, heating degree days, and cooling degree days.

Survey Distribution

In each city we identified a staff member, usually in the sustainability office or its environment department, to be our survey respondent. Of the 26 cities surveyed, 18 responded. We distributed the pre-populated survey to our designated respondents and asked that they complete the survey to the best of their ability within 2-3 weeks. Some of our respondents (9 of 26) returned completed surveys by the deadline. Four opted out of completing the survey at this time, and we offered them the option of commenting on the report draft. After we extended the deadline to engage cities that had not returned the survey on time, nine more cities returned their survey, stretching our final return count to 18 of 26. We used public data for the remaining eight cities. The list of cities that completed and returned the data requests can be found in Appendix B.

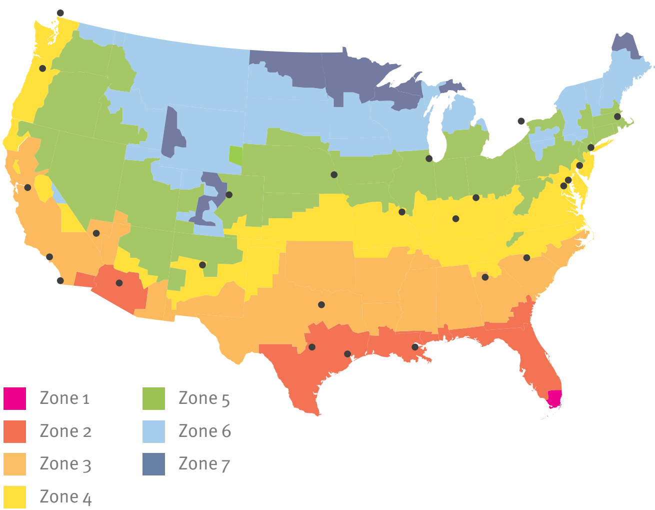


Figure 4: Official International Energy Conservation Code (IECC) map of climate zones

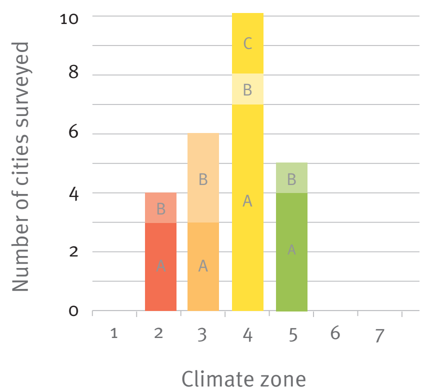


Figure 5: Number of cities in our sample by International Energy Conservation Code (IECC) climate region (n=26)

Results and Discussion

We focused our background research and survey questions on the following topics:

- **History, origin, and motivations.** Background of events sparking UHI mitigation interest in the city
- **Strategy types.** A strategy or plan to mitigate UHI effects with discrete goals
- **Goals.** Description of goals established for local government operations, across the community, and to achieve social benefit
- **Policies and programs.** Voluntary and mandatory policies and programs
- **Implementing agencies.** Agencies involved in program development and implementation, and any goals and policies specific to local government operations
- **Market drivers.** Discussion of the market sectors and associated demand drivers
- **Tracking indicators.** Progress tracking, UHI indicators, and heat trends
- **Funding and budgeting.** Level of spending from both city and non-city sources
- **Progress.** Subjective opinion about achieving goals, with specific consideration of perceived or actual aids and hindrances

We discuss our findings for each of these topics in the remainder of this section. Charts and figures outline common trends, and we discuss their relevance and importance.

Trigger for UHI mitation actions	Cities
Increased number of high-heat days	7
Extreme heat events with documented mortality	6
Results of an academic study or research	5
Increased (non-heat) extreme weather	4
Extreme loss of trees	4
Overwhelming past power outages	2
Result of community involvement/stakeholder working groups	2

Table 3: Origins of UHI strategies

Origins and Motivations of UHI Strategies

We asked our survey respondents to think about the origin of their UHI mitigation strategies and whether there was a particular event that triggered their consideration of the UHI effect as the cause of city problems. Without prompt, the responses fell into 7 categories. Table 3 identifies the 7 response categories and the number of cities citing each cause. Some cities' responses were counted more than once because they encompassed multiple categories.

The most common triggers reported were extreme heat or non-heat weather events, loss of trees, and an increased number of high-heat days. Austin is an example of a city that suffered an extreme heat event, in 2011. A summer of record-breaking heat and drought led to wildfires in surrounding areas that burned over 30,000 acres, killed two people, and destroyed approximately 1,600 homes. Austin developed particular programs in response to this event including replanting lost trees and building greener, energy-efficient buildings and resilient infrastructure.

Chula Vista, California and Washington DC, however, both indicated that some or most of their strategies were proactive rather than reactive; they hoped to mitigate disasters before they struck. Cities can prevent disasters and maintain environmental quality by taking ongoing action to mitigate heat. They need only to refer to the many cases of lost lives and damaged infrastructure to see why they should take action before a heat disaster occurs.

Depending on their geographic, political, and social context, we found that cities have different motivations for pursuing UHI mitigation actions. For instance, New Orleans, situated in the low-lying Mississippi Delta, is strongly motivated by stormwater management priorities. Denver, situated near the Rockies, is motivated to keep its infrastructure resilient against yearly temperature extremes. Dallas is a North Texas city in the Great Plains where rainfall is rare, the summers are especially hot and dry, and the buildings are air conditioned much of the year. Accordingly, Dallas is motivated by energy savings. The city's Green Building Ordinance requires that energy efficiency and water conservation practices be applied to all new construction, public or private. Its green-building policies and cool technologies have reduced cooling energy use and saved money.

We asked each city to indicate as many motivations as they liked among eight categories. The categories and the number of cities that indicated them are as follows:

- Building energy savings (22)
- Public health and resilience (16)
- Stormwater management (17)
- Climate adaptation (12)
- Quality of life (11)
- Improving affordable housing (5)
- Disaster preparedness (7)
- General sustainability (9)

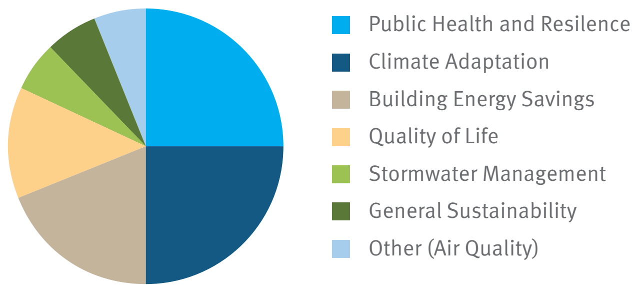


Figure 7: The primary motivations for development of UHI mitigation goals (n=16)

We also allowed respondents to include motivations that did not fit into any of these categories. Their answers included improving poor air quality, reducing citywide power draw, rehabilitating brownfields, and reducing crime. Some cities also mentioned place-specific motivations. Denver, for example, included reduced snowpack and earlier snowmelt among its motivations for taking action against the UHI effect.

Finally, we asked each city to indicate its *primary* motivation for developing UHI mitigation policies and programs. Figure 7 shows the primary motivations given by the 16 cities that responded to this question.

The two most common primary motivations are climate adaptation, and public health and resilience. Building energy savings rounds out the top three. The frequency of these motivations plus "quality of life" shows that cities do not consider the UHI effect as a purely environmental issue, but also as a core health, safety, and service delivery issue.

New Orleans shows how a trigger for UHI concern developed into a long-term motivation. Hurricane Katrina proved to be more than an environmental catastrophe. The hurricane had disastrous implications for the health, safety, and services of the city. Flooding from the storm destroyed the city's stormwater management systems, caused many deaths, triggered extensive power outages, and damaged the energy infrastructure. In Katrina's aftermath, city decision makers began considering green infrastructure options. Today, the UHI mitigation strategies of New Orleans are largely based on stormwater management and disaster resilience. The city has been promoting the use of permeable pavements, bioswales, green roofs, tree planting, and revegetation of paved areas, all to manage stormwater runoff. It also has been encouraging passive-heating and -cooling home design to help citizens stay comfortable during future power outages. New Orleans shows how strong motivations translate into policy priorities and citywide goals.

Strategy Types

Cities plan and organize their strategies for mitigating the urban heat island effect in a variety of ways. (The strategies found in each surveyed city are listed in Appendix B.) Each of the cities in our study developed mitigation strategies as discrete policies or as initiatives nested within other city priorities. An example of a discrete policy is Trees Atlanta, which strives to rehabilitate and strengthen the urban forest of Atlanta. An example of a nested initiative is the green infrastructure priority within Imagine Austin. Imagine Austin is a multifaceted document with many priorities and goals. The green infrastructure priority aims to improve the urban ecosystem through green building and green stormwater management.

Figure 8 shows the types of planning documents cities have published. If a city implements UHI mitigation across multiple documents, we count each as distinct.

Fourteen cities mentioned that their UHI mitigation policies and programs are included in an overarching comprehensive climate action plan; eleven include them in a sustainability plan. Climate action and sustainability plans are crosscutting documents and intuitive placements for UHI issues. Including UHI mitigation within either of type of plan enables cities to reach multiple goals and achieve many co-benefits simultaneously.

New York City's PlaNYC, for example, is an all-encompassing sustainability plan. First released in 2007 by Mayor Michael Bloomberg, PlaNYC aims to prepare to sustainably accommodate a million additional residents, strengthen the city's economy, combat climate change, and enhance quality of life. Under PlaNYC, agencies work to mitigate the city's UHI effect through efforts such as urban canopy, complete street, city resilience, affordable housing, and quality of life.

Twelve of the cities include UHI mitigation elements in multiple planning documents. In some cases, the documents explicitly refer to the UHI effect, and in others the issue is plainly presented but not named as such. Philadelphia includes the UHI effect in three discrete planning documents: Greenworks, TreePhilly, and the Green City Clean Waters Implementation and Adaptive Management Plan. These three umbrella documents encompass the complete UHI mitigation efforts of Philadelphia within the areas of sustainability, tree management, and stormwater management.

None of the cities has published a singular planning document encompassing all its UHI mitigation plans, goals, policies, and programs. This finding indicates that UHI issues are of concern, but have not yet become prominent enough to be considered on their own.

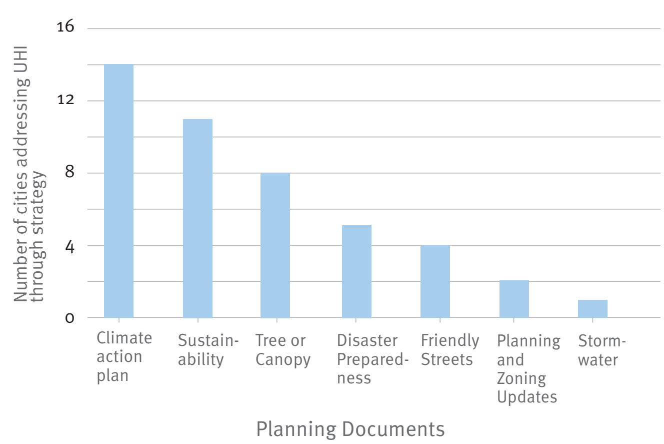


Figure 8: Strategies chosen by cities to govern UHI mitigation policies (n=24)

Goals

We asked cities if they had established one or more goals relating to the following five categories: urban canopy, urban fabric permeability (permeable ground surfaces), vegetated roofing, reflective roofing, and temperature reduction. The goals of each city can be found in Appendix D, Table D-1. Figure 9 shows the number of city goals from each category. Some cities reported multiple goals; in these cases, each goal is counted. Qualitative versus quantitative goals are also indicated within each category. We discuss this distinction below.

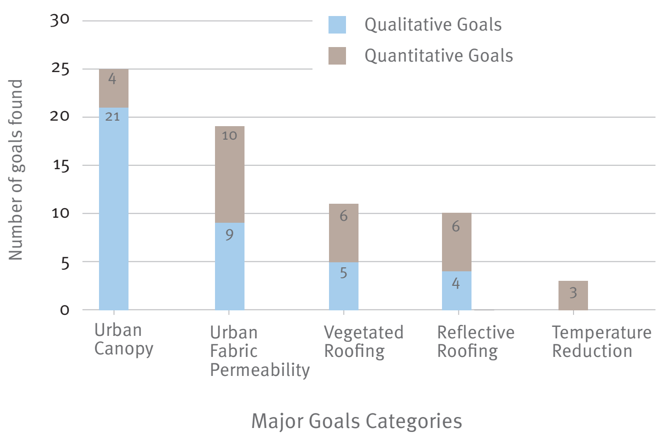


Figure 9: Number of goals by category and type (n=26)

Twenty-one cities have established a measurable quantitative goal for developing an urban canopy, making it the most common goal category. For example Vancouver, British Columbia, set a goal in 2012 to plant 150,000 trees on city land by 2020. Four cities have established qualitative urban canopy goals, such as the goal in Omaha's master plan to "implement landscaping practices which reduce heat and air pollutants" The least mentioned goal was temperature reduction. Three cities have qualitative temperature goals in place: Baltimore, Washington, and Chicago. One city, New York, has the quantitative goal of reducing the average ambient temperature by 1°F.

The prevalence of urban canopy goals illustrates a city's preference for measurable and highly visible projects. More trees on streets are obvious to the public, but an average decrease in ambient temperature may be less noticeable. Setting goals with measurable outcomes has the benefits of ease of reporting and achievability. To account for an action's involvement in UHI mitigation, city temperature and other impacts should be measured alongside other progress.

Some cities noted goals outside of the five categories in figure 9. These goals (with the number of cities citing them) include

- reducing GHG emissions (14)
- achieving community-wide energy efficiency (6)
- improving air quality (5)
- focusing on climate mitigation (4)
- reducing local-government building energy use (3)
- developing green-building standards or requirements (3)
- increasing urban agriculture (3)
- participating in an education campaign (2)
- improving on a variety of public health indicators (2)
- recharging groundwater (1)

One of the key goals of UHI mitigation is social and environmental equity. Cities can set goals to mitigate heat, reduce building energy use, or improve public health and way of life. These goals can encompass the entire community or specific areas. We collected information on the number of cities that have included social issues in their mitigation strategies. Three-fifths (18) of the cities do include social and environmental equity in their UHI mitigation efforts. Many cities have identified particularly vulnerable populations and geographies and have begun to develop strategies to ensure that the needs of vulnerable people are addressed. Four cities have specific goals to mitigate heat in the affordable housing stock: New York, Chula Vista, Washington, and Philadelphia. Eight cities (Boston, New York, Philadelphia, Baltimore, St. Louis, Phoenix, Portland, and Los Angeles) indicated they have goals to mitigate heat in vulnerable neighborhoods. For this report, we defined "vulnerable" quite broadly as "sectors of population less able to manage the effects of a UHI than other sectors." To pinpoint vulnerable sectors of population, cities must understand what "vulnerable" means in their own social and environmental context.

Methodologies used to identify vulnerable communities vary. New York City, for example, defines vulnerability as "affordable housing, low- and mixed-income homes, shelters, and senior and veteran housing." St. Louis defines vulnerability within its context of UHI mitigation as "underserved communities." In order to establish a standard methodology, the University of Michigan, in partnership with the DC Office of Planning and the Center for Clean Air Policy, is mapping vulnerability in three cities: Detroit, Washington, and Cleveland. Using global imaging systems (GIS), building information, and socioeconomic data, this study is pinpointing the vulnerability to extreme temperatures on a neighborhood level. Its methodology may be applied to other cities to better identify their vulnerable sectors.

In the Origins and Motivations section above, we described how cities documented UHI-related events and how they set priorities in reaction to those events. Chicago established its goal of having green roofs on 6,000 buildings by 2020 in reaction to a deadly 1995 heat wave. Fortunately, not all of our studied cities have suffered a heat-related disaster. Cities see similarities among their peer communities and set goals and establish policies that look to the future, mitigating a heat island before the effects become disastrous. For example, Chula Vista, on the coast of southern California, instituted a community-wide parking lot shade tree requirement and is currently researching porous pavement technologies.

Cities may choose to set qualitative or quantitative mitigation goals. Some cities reported having strict quantitative goals, while others had developed only qualitative goals. Baltimore set a quantitative goal that "30% of the city's commercial buildings and 10% of homes will have reflective roofs by 2020," whereas Albuquerque qualitatively aims to "incorporate reflective roofing materials whenever possible."

A city's dedication to an issue and its political landscape influence whether it sets quantitative or qualitative goals, or both. Qualitative goals have an open-ended deadline and allow for flexible, on-demand participation. A city may set a qualitative goal to introduce an issue or a technology to the city without making the new approach a hard requirement. In Albuquerque, for example, citizens and businesses may voluntarily incorporate reflective roofing materials into building projects. They do not incur a penalty if they fail to do so.

Many cities do choose to set quantitative goals. For example, in 2009, New York City set the goal of transforming one million square feet of rooftops into cool or reflective roofing every season, so that by 2035 all of the rooftops in NYC would be cool. Strong quantitative goals have four key aspects: a baseline year, an end date, an affected area, and a measureable target. The New York City cool-roof goal has a baseline year (2009), an end date (2035), an affected area (all rooftops), and a measurable goal (100%). With appropriate data, progress is quantifiable and the goal is actually achievable.

End dates are invaluable to goal setting. Short-term goals require immediate action and therefore may be easier to achieve than long-term goals. With that in mind, a good strategy for keeping long-term goals on track is to break them down into nearer-term goals. New York City is doing this. Because 2035, the year when all New York roofs are to be cool, is many years in the future, the city has committed to retrofitting four million square feet of rooftop each year.

Policies and Programs

Cities can draw on a variety of policy options to increase the adoption of UHI mitigation measures by local government and the private sector. UHI-sensitive municipal construction and procurement choices are some of the easiest policies for a city to implement. When local governments lead by example, they can catalyze mitigation actions throughout the community.

In our survey, we asked if any of the following UHI mitigation technologies were required in local government procurement policies: reflective roofs, vegetated roofs, reflective pavement, porous pavement, shade trees, or re-vegetation of paved areas. Thirteen cities required at least one UHI mitigation technology in its procurement policies. Each procurement policy in place in our sampled cities is identified in Appendix D, Table D-3.

The most common requirements were for reflective and vegetated roofs, in place in nine and eight of all cities respectively. These mitigation policies may be the most common because of their ease of adoption and visibility. Local governments have direct control over a significant number of buildings within a city (the municipal building stock), all of which have roofs that need regular maintenance and periodic replacement, irrespective of type. By requiring reflective or green roofs on municipal buildings, a local government can make a strong impact on mitigating the city's UHI effect with minimal effort. Furthermore, since reflective and green roofs are highly visible in the community, cities see them as a prime lead-by-example initiative. Chicago's city hall features a green roof where educational outings and community gatherings are hosted. Toronto's city hall also features a green roof which is accessible to the public and available for events. Citizens can easily see that their local government is dedicated to energy efficiency, city temperature reduction, and tax-dollar savings.

Cities may also implement voluntary policies and programs to engage the private sector. Potential voluntary mechanisms include

- offering financial or nonfinancial incentives
- connecting citizens with contractors or loan products
- public awareness or education campaigns

Examples of incentives include

- rebates for construction or purchase of a desirable technology
- tax abatement for constructing in a certain way
- preferential permitting in order to fast-track designs and construction that help the city realize its UHI mitigation goals
- height or square footage bonuses for incorporating green building standards

Voluntary UHI policies and programs are listed in Appendix D, Table D-4. Figure 10 shows the voluntary policy mechanisms offered by our surveyed cities to encourage the private sector to engage in cool technologies.

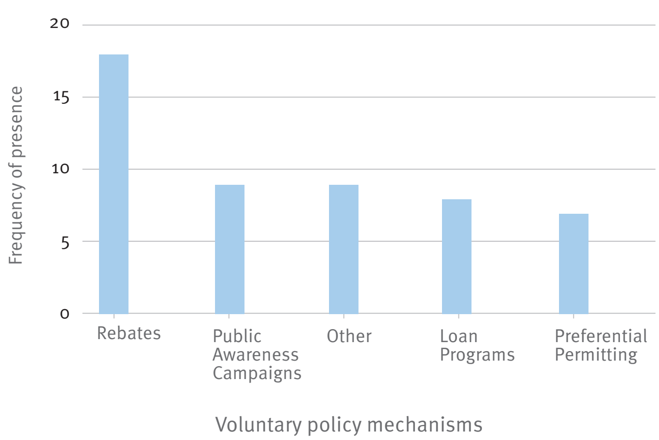


Figure 10: Voluntary policy mechanisms for private construction in surveyed cities (n=26)

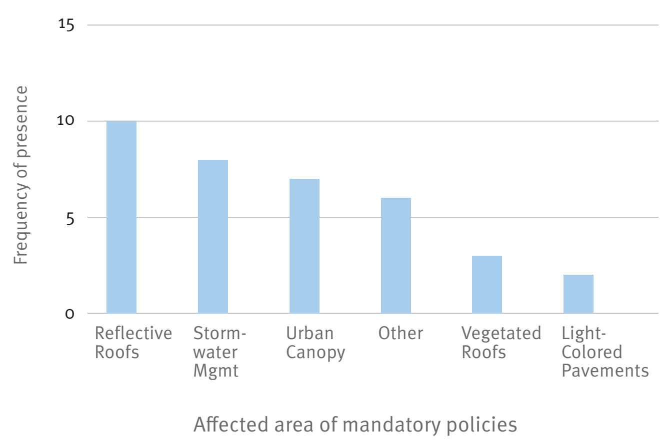


Figure 11: Mandatory policies for private construction in surveyed cities (n=26)

If a measure's societal benefit is especially high, a city may require compliance with mandatory measures relating to the construction and management of private buildings. Mandatory requirements in building, zoning, land use, or resource protection codes or ordinances may include cool or green roofs, shade trees, green landscaping, and cool pavements. A list of mandatory UHI policies can be found in Appendix D, Table D-5. Figure 11 shows the types of technologies our surveyed cities require across private-sector development through mandatory policy mechanisms such as codes and ordinances.

We found that 24 cities surveyed have established at least one voluntary policy or program for private construction, and 20 cities have established at least one mandatory policy. Rebates, in 18 cities, are the most common policy in place for private construction. The Portland Bureau of Environmental Services offers its customers a "treebate" of a $15 to $50 credit on their stormwater/sewer bill for purchasing and planting a tree on their property. The next most popular policies are mandatory codes or ordinances for cool or green roofs. Ten cities, including Dallas and Houston, have a requirement for roofs. In Dallas, Resolution 09-2986 authorized an ordinance amending the City Code to expand the "cool roof requirements for commercial buildings less than 50,000 square feet to include the installation of vegetated roofs on roofs with slopes of 2:12 or less." Dallas Green Building Resolution 12-2428 adopted that ordinance. In Houston, "roofs with slope up to 2:12 must have a minimum solar reflectance of 0.70 across the roof surface, with the exception of areas covered by green roofs, roof-top decks, or solar panels" (Houston Commercial Energy Conservation Code of 2011).

Cost-benefit analysis plays a major role in developing citywide programs. Cities naturally want to see returns on their investments, either financially or in terms of increased societal benefit. Cities use cost/benefit analyses to be careful of their use of taxpayer dollars and frame decisions in terms of financial, societal, and environmental costs and benefits. For example, understanding the cost of infrastructure replacement versus the opportunity cost of keeping existing infrastructure helps a city decide when to replace existing "dark" infrastructure with cool technologies.

Fifteen of our studied cities indicated that they conducted various cost/benefit analyses of their programs. Boston noted that full implementation of cool roofs across the city would provide a net benefit of $81 per ton of GHGs reduced. The city of Phoenix reported that for every $1 the city spent on planting or caring for city trees, it saved $2.23 in ecosystem services. Chula Vista is in the process of evaluating the place-specific effectiveness and durability of cool paving technologies before mandating the use of these technologies. Laying and maintaining pavement is one of the highest costs the city incurs.

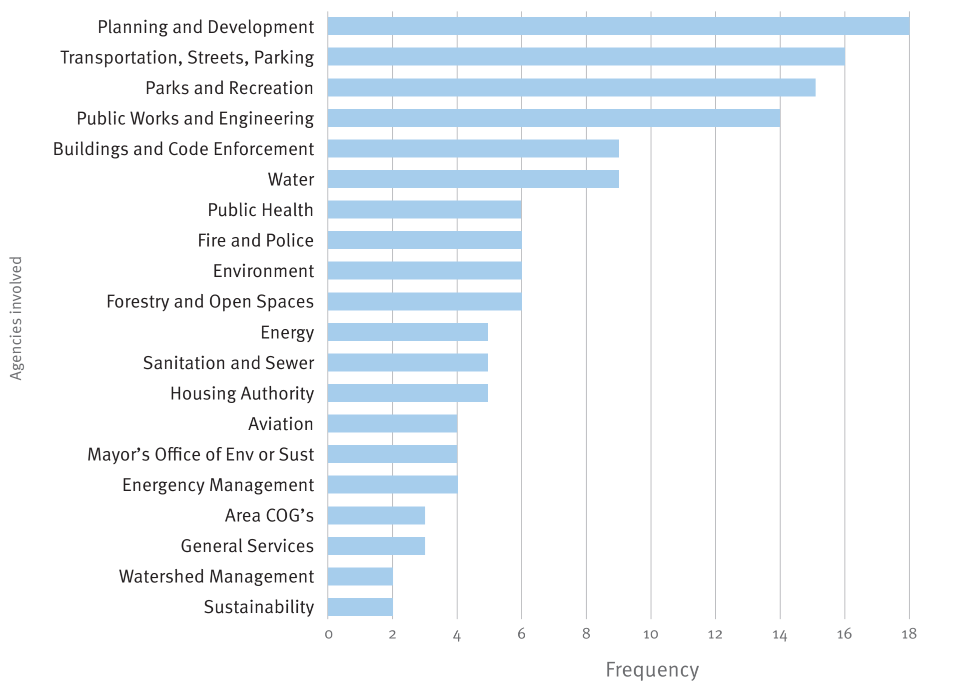
Implementing Agencies

Irrespective of strategy framing, motivation, or planning, no city relied on a single department to run all UHI programs and implementation but rather involved multiple agencies. The agencies involved in UHI mitigation in each of our studied cities are named in Appendix D, Table D-2. Figure 12 shows the agencies mentioned and their frequency.

Four cities indicated that a single agency is the lead for UHI plans and strategies. For example, Cincinnati's strategies focus heavily on tree maintenance and replacement, so as the leader of that initiative, the Park Board is the lead agency. Houston focuses on cool roofs; therefore the Department of Public Works and Engineering, Planning and Development Division, Building Code Enforcement runs the roofing program and enforces the energy codes.

The administrative burden may ease when one agency has full authority over a program. A single agency may assume ownership of a whole suite of programs in order to streamline tasks, responsibilities, funding, monitoring, and reporting. Or, a lead agency may assume a facilitator role for inter-agency interaction. When one agency coordinates actions among agencies, a larger citizen base may be engaged, departmental expertise can be leveraged, and many more co-benefits may be realized.

Figure 12: Frequency of planning or implementing agencies across all studied cities



Market Drivers

A technology becomes fully implemented quickly and easily if there is demand within the private market. We asked our survey respondents to describe the market demand in their cities for various mitigation technologies. Of our respondents, 15 cities indicated that demand exists for cool (white or reflective) roofs, 6 indicted demand for vegetated roofs, and 6 indicated demand for cool (porous or reflective) pavements. Beyond these categories, five cities indicated private-sector demand for street trees and two indicated strong private-sector interest in engaging in city-run programs. Each respondent mentioned private-sector demand in the commercial sector. Only three cities indicated such demand in the residential sector.

Next we asked respondents to indicate whether the market growth for cool roofs and pavements is driven by pure market demand or by policies. Phoenix and Baltimore indicated that the private sector demands cool technologies. Nine cities indicated that policy is the main driver of cool technology adoption, and four said that a mixture of both demand and policy drives the cool technology markets. We also asked about perceived negative impacts of cool technologies. Nine of our respondents indicated that there are one or more perceived negative impacts for cool technologies within their markets. Five cities noted that the public perceives cool technologies as having a high cost burden. Three cities cited concern about the effectiveness of the technologies in solving UHI issues. In four cities there is some public concern that reflective building materials may create glare. Four cities perceive cool technologies as less durable than traditional alternatives, or as requiring increased maintenance. Finally, one city attributes the low market penetration of cool technologies to a lack of public awareness.

To further understand private demand for cool technologies, we asked our respondents about their perceived cost. Close to half of our responding cities believe their market sees cool technologies as more expensive than traditional, and half believe their market sees cool technologies as having a cost equal to traditional technologies. Interestingly, Los Angeles notes that its market sees cool roofs as cheaper than traditional roofs, which may be due to the city's many subsidies and rebates for cool roofs and the tax it levies on non-reflective roofs.

Tracking Indicators

Many cities track and report progress over time to gauge success relative to goals. In the cities surveyed, 21 track progress in some way, and 18 publish their tracked data. The most recent progress report, if available, for each city studied is found in Appendix B. Cities keep track of how many trees are planted, green streets installed, cool and green roofs installed, and square feet of land made permeable. Fourteen cities track urban heat trends, and many track more than one. The complete list of heat indicators tracked can be found in Appendix D, Table D-6. Table 4 outlines the trends monitored by our study cities.

Tracking heat trends is critical to understanding the effect heat has on a city, and it provides insight into progress. The most tracked heat trend is temperature variation. This may be surprising since only three cities reported having temperature-related goals. However, the daily temperature is one of the easiest trends to track. Cities can track temperatures themselves or obtain temperature data from a third party. The second most tracked trend is change in vegetation. Citywide surveys or aerial mapping techniques can compare amounts of vegetation across time.

Tracked Urban Heat Trends	Cities
Temperature Variation	7
Change in Vegetation	6
Hospital Visits	3
Environmental Public Health	2
Precipitation Rates	2
NAAQS Non-Attainment Days	1
Carbon Emissions	1
Change in Albedo	1

Table 4: Urban heat trends tracked by cities (n=26)

To understand further how these trends and indicators are tracked, we asked about the scale on which data are collected and reported. Responses included by city block (2), by census track (3), citywide (1), by neighborhood (4), and by building (2). Some cities offered additional information, noting that some indicators, such as temperature, were tracked daily, and some, such as heat-related hospital visits, were tracked by count.

Many cities obtain data from a third party. Louisville receives temperature and precipitation data from the National Oceanic and Atmospheric Administration (NOAA). Portland receives city maps of vulnerability from Portland State University's Sustaining Urban Places Research Lab. To engage the public in heat trend tracking, New York City offers an online public health portal where people can access neighborhood-level data across many environmentally related indicators of public health.[7]

Funding and Budgeting

We also collected data on program funding. Information on funding and budgeting can be found in Appendix D, Table D-2. Eight of our respondents were able to describe some of their city's funding of UHI mitigation policies and programs. Many of our respondents indicated that the city did not track mitigation expenditures, or that they were so tightly interwoven into other city projects that funding for UHI mitigation within the city budget was not quantifiable.

Local governments are not the only entities funding UHI mitigation programs. Nineteen cities indicated that funding is available from non-city sources such as nonprofit groups, local utilities, philanthropic foundations, or local universities. Many cities partner with groups or

7. http://a816-dohbesp.nyc.gov/IndicatorPublic/Default.aspx

foundations dedicated to specific environmental causes. For example, Portland partners with Friends of Trees, Dallas with Texas Trees Foundation, and Los Angeles with CityPlants. Philadelphia's TreePhilly partners with the Tookany/Tacony Frankford Watershed Partnership for tree planting and maintenance programs.

Cities reported additional funding sources. Some cities fund programs with state financial assistance. For example, Pennsylvania state PENNVEST loans funded a $30 million green streets project in Philadelphia. Many cities are served by energy or water utility programs that include funding for UHI mitigation measures. Georgia Power, for instance, offers rebates for reflective roofs. In Baltimore, funds from the Exelon purchase of Constellation Energy funded the construction of 22 cool roofs in 2013.

Progress Toward Goals

To wrap up our survey, we asked our respondents to consider the goals set by their city and to reflect on progress. For each goal type, the respondents could gauge progress on a sliding scale from "no plan or implementation" to "goal achieved." The goals were temperature decrease, urban fabric permeability, green roofs, cool roofs, and street trees. The cities that responded to this section noted a range of outcomes from minimal to significant implementation. None indicated that it had met any of its stated goals. Table 5 shows the total number of responses for each level of implementation across all goal types. To keep responses anonymous, we report high-level aggregated results for this section.

Though the majority of cities that track heat indicators track temperature data, only three cities have qualitative goals in place for temperature reduction, and none mentioned that they measure progress toward a goal for temperature decrease. Since these goals are qualitative, there is no end goal toward which to measure movement. Increasing the urban canopy was the most popular goal cited and the one closest to being met.

To help cities implement new programs or expand established ones, we asked our respondents what furthered or hindered their progress. One city reported that its progress was driven by a "strong and immediate" need for policy. Some cities indicated that their city council's adoption of green building codes was the driving force behind implementing green or cool roofs. Some mentioned that the interconnectedness of initiatives was especially helpful in driving progress across the board. For example, a single educational campaign can cover many aspects of UHI mitigation, and community retrofit programs can involve a good deal of stakeholder interaction. Reported factors that enable progress are

- mayoral commitment
- community commitment
- green building codes
- interconnected initiatives
- partnering with a university
- achieving the "Tree City" designation from the Arbor Day Foundation

Conversely, some respondents noted that having too many city priorities is detrimental to the progress of any single priority. Lack of funding was the most frequently mentioned hindrance. The factors that cities mentioned as hindering progress are

- lack of data on cool technologies
- lack of knowledge of the city's specific needs
- lack of funding
- too many city priorities
- lack of citizen UHI education
- need for helpful policies
- lack of momentum

Goal Types	Minimal Implementation	Some Implementation	Significant Implementation	Goals Nearly Met	Total
Urban Canopy	0	5	6	0	11
Cool Roofs	0	1	4	0	5
Green Roofs	1	1	3	0	5
Urban Fabric Permeability	0	4	2	0	6
Temperature Decrease	0	0	0	0	0

Table 5: Aggregated responses of progress toward each overarching goal type

Case Studies

In addition to the results of our survey, we present three detailed case studies: Houston, Cincinnati, and Washington. These case studies illustrate the cities' progress from identifying the UHI effect as an important policy priority to developing policies and goals, and how those policies translate to city-specific programs that encourage progress.

Houston, We No Longer Have a Problem

"Cool" is not usually the first word that comes to mind when people think about Houston. On the edge of the bayou in southeastern Texas, Houston is anything but cool year-round. In 2007, Mayor Bill White took the first step to change that by commissioning an independent impact study for cool roofs from the Houston Advanced Research Center (HARC). His focus was the economic cost and benefit of addressing Houston's excess heat, as well as any co-benefits. The year before, HARC had undertaken a study of Houston's urban heat island. The study, entitled Cool Houston!, found:

- Dark roofs and pavements in Houston can reach 160°F on summer days.
- When heated, asphalt pavements release contaminants that wash into the city's streams and bayous.
- Concentrated areas of dark surfaces and other conditions create super-heated hot spots where temperatures are well above the average urban temperature.
- In a 27-year span (1972-1999), Houston lost 25 acres of tree canopy per day.

The 2006 HARC study recommended that light-colored or porous pavement be used in parking lots and on sidewalks, reflective roofing be deployed on flat-roofed commercial and industrial buildings, and shade trees be planted. The light-colored roofing recommendation sparked Mayor White's interest, prompting the cool-roof follow-up study. Houston found that in addition to providing energy savings, cool roofs reduce thermal expansion and contraction and extend the life span of the roof itself, thus reducing construction material waste in landfills. These potential environmental and economic benefits inspired the adoption of a cool-roof requirement in the Houston Commercial Energy Conservation Code of 2008.

The Energy Conservation Code, enforced by the Code Enforcement Division of the Department of Public Works and Engineering, requires that air-conditioned government, commercial, and multifamily residential buildings that install or replace low-slope roofs have a minimum initial solar reflectance of 0.70 and a minimum thermal emittance of 0.75. The code includes exemptions for vegetated roofs, solar panels, and architectural features like skylights and deck space. To further encourage cool-roof deployment on private buildings, the Mayor's Office of Sustainability ran the one-off Houston Green Office Challenge, an energy-efficiency incentive program that helped finance energy-saving retrofits. Any project that saved 15% or more of the building's energy was eligible for $20,000 to $500,000 incentives. These projects included cool or green roofs.

In addition to being among the first cities to adopt a cool-roof ordinance, Houston also has published a robust goal of planting one million trees over three to five years. The program, Million Trees + Houston, is a collaborative effort between the Houston Department of Parks and Recreation and the nonprofit group, Trees for Houston. It is further supported by the tree and shrub ordinance (Chapter 33, Houston Code of Ordinances).

Increasing the number of cool roofs and shade trees in Houston will combat UHI effects, reducing building energy use and polluted stormwater run-off. The city's adoption of the conservation code and the tree ordinance, paired with multidepartment and citizen involvement, has made an immediate and lasting positive impact in cooling Houston.

Staying Cool to Solve Problems in Cincinnati

Sustainability is more than a goal for Cincinnati, Ohio—it is a commitment to sustaining and improving a way of life. In 2008, Cincinnati was in the middle of the hottest ten-year period on record. To make matters worse, the city's urban canopy was under attack as the emerald ash borer and the Asian Longhorned Beetle threatened to destroy 40% of the city's trees. The heat wave and insect infestation made it obvious to city officials that they had to consider urban heat island mitigation. In response, the city council adopted the Climate Protection Action Plan to promote innovative sustainability actions in Cincinnati and inspire action around the country. The plan focused on voluntary measures to reduce GHG emissions, boost the economy, and keep the city clean.

Five years later, the Green Cincinnati Plan Steering Committee, a group of expert stakeholders from Cincinnati led by the Office of Environmental Quality, updated the original action plan. The 2013 Green Cincinnati Plan focuses on climate adaptation, and its overarching goals are adapting to prolonged heat events, rehabilitating the urban canopy, and mitigating the urban heat island. Many short- and medium-term goals are set within each major goal area, including city-specific motivations such as saving energy for buildings and protecting the neighboring rivers and streams. The plan includes qualitative goals to drive citizen discussion and market demand, as well as quantitative goals to keep the programs on track. Green Cincinnati identifies a number of benefits to reducing heat in the city including improved health, lower utility bills, and beautification.

The following goals, based on the history of the city and its population, aim to improve Cincinnati:

- Increase the acreage of high-quality green space by 10% by 2020 through parks and rooftop gardens
- Incorporate specific language for heat emergencies into the city emergency plan
- See no increase in heat-related hospital admissions
- Plant 2 million more trees by 2020, incorporating them into infrastructure and roadways
- Apply reflective coating to asphalt and increase cool pavements
- Encourage green and cool roofs to help reduce the total energy consumption in the built environment by 15%

Cincinnati is home to nearly 300,000 people. Not every citizen is equally equipped to manage extreme heat, whether for financial, age, or health reasons. The plan recognizes the need to focus efforts on these highly vulnerable populations.

To meet all these goals, public and private sector groups adhere to a mixture of mandatory and voluntary implementation measures. Implementation is spearheaded by the Office of Environmental Quality with stakeholder input, and volunteer hours are provided by the Green Umbrella, Cincinnati's sustainability alliance, boasting over 200 member organizations and 100 individuals. This group helps area businesses, organizations, and buildings take action toward sustainability. For example, the Greater Cincinnati Energy Alliance (GCEA), developed through the Green Umbrella, gathers funding to increase energy efficiency in homes and businesses in Cincinnati and the surrounding counties.

The 2013 Green Cincinnati Plan recommends that the city government deploy cool roofs on new construction and major renovation. This action will decrease taxpayers' energy bills as well as mitigate Cincinnati's urban heat island. To combat the emerald ash borer and the Asian long-horned beetle, the Park Board cuts down infected trees and plants new ones on city land and streets. Street tree planting is funded by a tree tax, applicable to every foot of private property abutting public right-of-way. To inspire green building in the community, including green and cool roofs, the Department of Planning is developing expedited permitting for construction that follow the green development regulations. These have more stringent energy efficiency and environmental requirements than the traditional building code.

The 2013 Green Cincinnati Plan has been in effect for one year, and its component implementation programs and policies are still being developed.

Cooling down the Capital: UHI Programs in Washington, DC

Washington, DC is an ecologically and socially diverse city that leads the way in addressing the equally diverse challenges posed by its urban heat island. Mitigating the UHI effect is an emerging area of interest to the local government of the District. In past years, various independent UHI programs were developed and run to accomplish individual goals. The District is now moving towards consolidating these programs to mitigate the UHI effect across the city as a whole while focusing on specific vulnerable neighborhoods. The city is assessing its neighborhood-level vulnerability to extreme heat events with a team led by the University of Michigan.

In 2013, the District commissioned a study by the Global Cool Cities Alliance that found that more cool roofs and vegetation could have reduced mortality by 7% during historic extreme heat events. Key programs and their supporting policies to mitigate the UHI effect and avoid future heat-related deaths are outlined below.

SUSTAINABLE DC

This document is a roadmap for sustainable action in the District. The UHI-related goal is to raise environmental equity by greening affordable housing and low-income communities. Among many priorities, Sustainable DC supports the Green Building Act of 2006, ensuring that affordable public housing projects reach both LEED and Enterprise Green Communities certification. Sustainable DC specifically notes the importance of cool and green roofs in saving energy in residential buildings to increase the health of the inhabitants, environmental equity, and city competitiveness. The District Housing Authority oversees the affordable housing program, installing cool roofs and enforcing other green building requirements.

RIVERSMART SUITE OF PROGRAMS

The Department of General Services (DGS) and the District Department of the Environment (DDOE) run a threefold stormwater management program in various watersheds in the District.

On the neighborhood scale, River Smart Communities offers a 60% rebate for low-impact development projects. This program inspires projects to help build 25 miles of green alleys.

RiverSmart Rewards offers single-family homes stormwater utility-fee reductions for green infrastructure installed on private property or off-site. This program inspires projects to help the District reach its goal of using 75% of landscaped area to capture, filter, or reuse rainwater. These projects may include rain gardens, vegetated areas, bioswales, or permeable paved areas. Each participating home is eligible for rain-barrel rebates, among other benefits and rewards. RiverSmart Rewards implements DDOE stormwater regulation, which requires that 1.2 inches of stormwater management be incorporated into landscaping. In the future, the District will incorporate the affected land area into the Urban Wetland Registry. The registry will facilitate restoration or creation of additional wetland habitat by planting and maintaining 140 acres of wetlands along the rivers and streams of the District.

Finally, RiverSmart Homes aims to double the number of participating single-family homes in RiverSmart and push the District closer to its overall goal of installing 2 million new square feet of green roofs. Since its implementation, RiverSmart has increased the permeability of 5,500 single-family home sites and boosted the permeability of the entire District to 57%.

DC ENERGY CONSERVATION CODES

The District has been deploying cool and green roofs since 2006. The Green Building Act of 2006 required that all private buildings larger than 50,000 square feet and all publicly financed projects be LEED certified. The LEED certification includes points for cool and green roofs as well as stormwater management. The DC government owns or provided funding for the construction of close to 400 buildings across the District. The DC Energy Conservation Code of 2008, enforced by the District Department of Consumer and Regulatory Affairs, requires inclusion of a cool or green roof on new construction or major retrofits of District-funded buildings. The 2013 update to the code includes compulsory adherence to the 2012 IECC with additional cool roof requirements for private commercial and residential buildings. All flat (2:12) commercial roofs must have a minimum initial SRI of 78 or be ENERGY STAR® cool-roof certified. This code is enforced by the DGS public building division. To continue expansion of green roofs and reach the goal of 2 million new square feet, DGS offers a Green Roof Rebate of $7 per square foot of “greened” area for most wards in the District and $10 per square foot in immediate watershed areas.

SMART ROOF PROGRAM

The Smart Roof Program is a comprehensive assessment of 11 million square feet of District properties to evaluate the structural soundness and economic feasibility of a variety of cool roofing technologies. The technologies to be studied include vegetated, reflective, blue, and solar pV. For the assessment, 3 million square feet of district roofing will be retrofitted. Additionally, DGS will be converting 10 million square feet of existing bituminous roofing into cool roofing over the next ten years.

TREE CANOPY RESTORATION

The District Department of Transportation (DDOT), in conjunction with DDOE and Pepco, the local electric utility, works to restore the DC urban canopy. The program emphasizes thoughtful placement, for example, planting trees in areas where they will provide the maximum amount of shade for buildings and pedestrians while ensuring that the branches do not interfere with electric or telephone lines or other important infrastructure. The primary goal of the restoration project is to plant 8,600 new trees citywide per year until 2032. It is easy to see the achievements of this project just by walking anywhere in the District. Since 2006, 810 acres of canopy have been added in parks, lining streets, and in tree boxes. To date, DC boasts a 35% tree canopy cover. In comparison, canopy cover in Portland, Oregon, was 29.9% in 2010, and 29% in Boston in 2007. To further decrease the effects of UHI, DDOT uses the Green Alleys policy to ensure that permeable pavement is included around tree boxes, parks, and sidewalks.

Recommendations

This report describes current UHI mitigation policies and programs in North American cities. We hope that city sustainability managers and other leaders are able to draw similarities between cities in the report and their own city. We recommend that they focus on the following priorities as they design their own UHI mitigation programs.

Establish goals related to specific strategies:

We recommend that cities set goals related to individual indicators of the UHI effect, even ones that might be difficult to meet or monitor. Goals should be set across multiple sectors. The most common goal we noted in our study was increasing urban tree canopy. This goal's prevalence reflects its importance and visibility to the community. The least common goal was reducing city temperature. Though this goal may be more difficult to reach or even verify on a climatic scale, addressing the causes of increased temperatures is a key strategy for reducing urban heat islands. Setting goals across sectors will help with overall temperature reduction.

Establish quantitative goals:

We recommend that cities develop quantitative goals that include a unit of measurement and a level to reach by a hard and fast deadline. Quantitative goals facilitate the monitoring and measurement of progress as well as leaders' accountability. Qualitative goals, on the other hand, can never be reached due to their very nature. Qualitative goals do however have the advantage of introducing an idea to city leaders, who may pilot its implementation before establishing quantitative metrics.

Track heat indicators:

We recommend collecting data on the following trends: temperature variation, change in vegetation, heat-related hospital visits, air quality (ozone levels and smog), and heat-related deaths. Cities should track these indicators across a spectrum of time periods. Acute daily and weekly effects are significant, but decadal or longer tracking is critical to understanding the trends in a city's climate. Conversely, granular tracking of heat indicators shows how the UHI affects neighborhoods and pinpoints vulnerability. As discussed above, though an urban heat island is a citywide issue, its effects are disproportionately distributed, causing the most harm to vulnerable neighborhoods. Cities can target programs to those areas and monitor the progress that those programs are making.

Use cost-effectiveness testing:

We recommend that cities test the cost effectiveness of their programs, and that they tailor the tests to the type of program and investment. The cities we surveyed noted a variety of preferred cost-effectiveness tests. To find an appropriate test, cities could consult the National Efficiency Screening Project best-practices guide (NHPC 2014) or another such guide. These protocols can help cities use their funds wisely and account for positive and negative externalities associated with UHI policies and programs.

Develop both mandatory and voluntary policies:

We recommend that cities consider a mix of voluntary and mandatory policies and programs. A suite of tools can encourage technology adoption in a variety of market sectors. Voluntary policies encourage individuals and businesses to make informed choices about green-building materials and UHI-mitigation technologies for their own homes or companies. The market for green building materials and UHI mitigation technologies is full of viable options, and voluntary policies present these options without requiring homes or businesses to act. Mandatory policies, on the other hand, can help to push a measure or technology through the market quickly. Some technologies produce such great societal benefit (or their absence creates such a steep societal cost) that they must be mandated across the community. Los Angeles, for example, has recognized the benefits of reflective roofing for both the city and the planet. The LA Cool Roof Ordinance ensures that the local and global communities see these benefits.

Lead by example:

We recommend that local governments incorporate as many mitigation practices and technologies as are possible and effective for their city. Cities should document their experiences with these practices to demonstrate cost-effectiveness, energy savings, and other benefits. Implementing cool technologies in municipal facilities reduces urban heat islands and encourages community action. Documentation provides an example of what a city can achieve if cool technologies and practices are expanded throughout the market.

Identify a lead agency:

We recommend that local governments identify a lead agency to take responsibility for the city's UHI-mitigation policies and programs. Cities will take a more coordinated approach to UHI mitigation if there is a clear lead agency. When one agency coordinates actions, a larger citizen base may be engaged, departmental expertise can be leveraged, and many more co-benefits may be realized. A single agency may assume ownership of a whole suite of programs in order to streamline tasks, responsibilities, funding, monitoring, and reporting. Alternatively, a lead agency may facilitate inter-agency interaction.

Partner with local institutions:

Partnering with local institutions is a mutually beneficial best practice. Funding and volunteers may be available through third parties with similar goals such as academic institutions, utilities, and nonprofit organizations. These institutions may have related missions and additional resources. Many cities mentioned the benefits of establishing partnerships with local universities. Atlanta partners with the Urban Climate Lab at Georgia Tech, which provides technical expertise and policy guidance on issues specific to urban heat island mitigation. Many utilities also promote and incentivize UHI mitigation measures that save energy. Baltimore partners with its local utility, Baltimore Gas and Electric, which helps fund cool roofs in the community.

Engage citizens:

We recommend that cities engage stakeholders in policymaking to identify concerns and misunderstandings, and eventually build support for further action. Public outreach efforts are crucial for getting programs and policies off the ground. Atlanta, for example, mentioned that its citizens feel the impacts of increased urban temperatures yet lack an understanding of how cool technologies might address the issue. An example of public engagement is the Baltimore Energy Challenge, a competition that also educates citizens on low- and no-cost ways of saving electricity. Run in neighborhoods and schools, the program engages both children and adults.

Use third-party data:

We recommend that cities engage in data-sharing partnerships with nongovernmental third parties. Because gathering granular heat-related data can be a challenge for cities, they should look into acquiring them from third parties who collect such data for their own purposes. Access to these data could save lives. NOAA, for example, has been tracking weather data (temperature, precipitation, and so on) since 1970. These data are available by request to many cities and regions. Most hospitals track indicators of heat-related public health issues, and they may be able to aggregate these data for local governments. Universities may also be able to provide data on indicators such as air quality, temperature, and changes in vegetation.

Develop multiple sources of funding:

Much program funding comes from city tax dollars, but other sources should be considered as well. Diversified funding helps programs stay afloat in the event that a funding source shrinks or disappears. State-level departments and federal agencies are a good source of grants. Nonprofits may also provide funding and services; for example, many cities are home to nonprofits that engage in tree planting campaigns. Utilities may have demand-side management programs that help fund retrofits to promote energy efficiency. Cool or green roofs may qualify for funding under some of these programs. Private philanthropy through individual donations, foundation grants, or university donations can also provide funding.

Adopt up-to-date cool-roof and pavement standards at the state and regional level:

Cities that have adopted UHI programs should support the statewide adoption of similar efforts. We recommend that cities share program performance data with relevant state agencies to help design and legislate standards. The relationship with the state can also work in the other direction to encourage the adoption of good UHI policy at the local level.

Although many cities have urban heat islands, their effects vary from city to city. Cities subject to UHIs represent every climate zone, population demographic, and sociopolitical context. We hope that these jurisdictions will assess their individual situations and consider adopting some of the relevant measures and policies described in this report. By implementing locally appropriate policies and practices, cities can go a long way toward mitigating the impacts of urban heat islands on their communities and the planet.

References

Akbari, H. 2002. "Shade Trees Reduce Building Energy Use and CO_2 Emissions from Power Plants." *Environmental Pollution* 116: S119-S126. http://svinet2.fs.fed.us/psw/programs/cufr/products/12/psw_cufr703_Akbari_Reduce_Energy_Use.pdf

---------. 2005. *Energy Saving Potential and Air Quality Benefits of Urban Heat Island Mitigation*. Berkeley, CA: Lawrence Berkeley National Laboratory.

Amann, M., D. Derwent, B. Forsberg, O.Hanninen, F. Hurley, M. Krzyzanowski, F. de Leeuw, S. Liu, C. Mandlin, J. Schneider, P. Schwarze, and D. Simpson. 2008. *Health risks of ozone from long-range trans-boundary air pollution*. Copenhagen: World Health Organization. http://www.euro.who.int/__data/assets/pdf_file/0005/78647/E91843.pdf

Bass, B., 2012. *Mitigating the Urban Heat Island with Green Roof Infrastructure*. Toronto: Institute for Environmental Studies, University of Toronto. http://www.coolrooftoolkit.org/knowledgebase/mitigating-the-urban-heat-island-with-green-roof-infrastructure/

CDC (Centers for Disease Control and Prevention). 2012. *Number of Heat-Related Deaths, by Sex- National Vital Statistics System, United States, 1999-2010*. Atlanta: Centers for Disease Control and Prevention. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6136a6.htm

DOE (U. S. Department of Energy). *Building Science-Based Climate Maps*. January 2013. Washington, DC: U.S. Department of Energy. http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/4_3a_ba_innov_buildingscienceclimatemaps_011713.pdf

EPA (U.S. Environmental Protection Agency). 2013a. *Heat Island Effect, Cool Pavements*. Accessed February 26, 2014. http://www.epa.gov/heatislands/mitigation/pavements.htm

---------. 2013b. *National Ambient Air Quality Standards (NAAQS)*. Accessed February 28, 2014. http://www.epa.gov/ttn/naaqs/

GCCA (Global Cool Cities Alliance). 2012. *A Practical Guide to Cool Roofs and Cool Pavements*. Washington, DC: Global Cool Cities Alliance. http://www.coolrooftoolkit.org/wp-content/pdfs/CoolRoofToolkit_Full.pdf

Mackres, E., K. Johnson, A. Downs, R. Cluett, S. Vaidyanathan, K. Schultz. 2013. *The 2013 City Energy Efficiency Scorecard*. Washington, DC: American Council for an Energy-Efficient Economy. http://aceee.org/research-report/e13kg

McPherson, G., J. Simpson, P. Peper, S. Maco, and Q. Xiao. 2005. "Municipal Forest Benefits and Costs in Five US Cities." *Journal of Forestry* 103 (8): 411-416.

NHPC (National Home Performance Council). 2014. *The Resource Value Framework: Reforming Energy Efficiency Cost-Effectiveness Screening*. Washington, DC: National Home Performance Council. http://www.nhpci.org/publications/NHPC_NESP-Recommendations-Final_20140328.pdf

Navigant Consulting. 2009. *Assessment of International Urban Heat Island Research: Review and Critical Analysis of International UHI Studies*. Prepared for U.S. Department of Energy. http://apps1.eere.energy.gov/buildings/publications/

Oke, T. 1973. "City Size and the Urban Heat Island." *Atmospheric Environment* 7(8) 769-779.

Sailor, D. 2002 "Urban Heat Islands, Opportunities and Challenges for Mitigation and Adaptation. Sample Electric Load Data for New Orleans, LA (NOPSI, 1995)." Presentation at the 2002 North American Urban Heat Island Summit. May.

Trenberth, K., Fasullo, J., Kiehl, J., 2008 "Earth's Global Energy Budget." *Bulletin of the American Meteorological Society* March 2009 311- 323. http://echorock.cgd.ucar.edu/cas/Staff/Fasullo/my_pubs/Trenberth2009etalBAMS.pdf

Wong, K., Paddon, A., and Jimenez, A., 2012. "Review of World Urban Heat Islands: Many Linked to Increased Mortality." *Journal of Energy Resources and Technology* 135(2).

Appendix A: Sample Survey

STRATEGY

1. Does your city have a stand-alone urban heat island (UHI) mitigation strategy/plan?
   O Yes.
   O No, but UHI mitigation is included as part of a broader strategic initiative
   Please describe and include a link.

2. If there is a UHI mitigation strategy, what is/are the quantitative and/or qualitative goal(s)? (please discuss all that apply):
   O temperature reduction
   O sq. ft. of reflective roofs
   O sq. ft. of vegetated roofs
   O urban fabric permeability
   O increased number of shade trees
   O other
   Please provide details, including the specific language of the goal(s), whether the goals has been codified as formal city policy, and a weblink to where the strategy or goal(s) is published.

3. Which issues motivated your city to adopt a UHI mitigation strategy? (please indicate ALL that apply):
   O building energy savings
   O public health and resilience to heat events
   O storm water management
   O climate adaptation
   O quality of life
   O improving affordable housing
   O disaster preparedness
   O general sustainability?
   O Other: ________________
   Please describe.

4. Of the issues discussed above, which one was the primary reason to adopt an urban heat island mitigation strategy? (Please indicate ONE):
   O building energy savings
   O public health and resilience to heat events
   O storm water management
   O climate adaptation
   O quality of life
   O improving affordable housing
   O disaster preparedness
   O general sustainability?
   O Other: ___________
   Please describe.

5. Did a particular event or events lead to the development of the strategy? Please describe the origin of the strategy.

SOCIAL IMPLICATIONS OF UHI POLICY

6. Have social issues (i.e., health equity, environmental justice, disproportionate vulnerability to extreme heat in lower income communities) been considered, identified by or integrated into the UHI strategy?
   Please provide the language in the strategy related to the identified issues.

7. Are there specific goals for mitigating excess heat in affordable housing?
   O Yes
   O No
   If yes, please provide the language in the strategy related to those goals.

8. Are there specific goals for mitigating excess heat in neighborhoods with vulnerable populations?
   O Yes
   O No
   If yes, please provide the language in the strategy related to those goals.

POLICIES AND PROGRAMS

9. Which city agencies are engaged in implementing the UHI mitigation policy? Is there one agency designated as the lead agency?
   Please include the name and role of these agencies and links to their websites.

10. Are any of the following items required or included in local government procurement guidelines? (please check all that apply):
    O Reflective/Vegetated roofs
    O Reflective/porous pavement
    O shade trees on site
    O re-vegetation or ground permeability requirements
    O other
    Please describe procurement policies.

11. Are any of the following voluntary policies or programs available for private construction in your city through any entity? (please check all that apply):
    O rebates
    O preferential permitting
    O loan programs
    O public awareness campaigns
    O other
    Please describe any voluntary policies.

12. Are any of the following mandatory policies in place for private construction in your city from any level of government? (please check all that apply):
    O Codes
    O Ordinances
    O Requirements for public buildings
    O Other
    Please describe any mandatory policies.

13. Has a benefit-cost analysis of UHI policies or programs been completed for your city?
   - O Yes
   - O No

   If yes, please describe the results and include a link to the report or attach the file.

14. In your opinion, is there a market demand for any of the following in your city? (Please check all that apply):
   - O cool roofs
   - O Pavement
   - O vegetated roofs
   - O other UHI mitigation technology ___________________________

15. If demand exists, in your opinion, is it currently greater for (please check one):
   - O commercial buildings
   - O residential buildings

   Please describe.

16. Which do you see as driving market growth in your city more?
   - O policy
   - O market demand

   Please describe.

17. Are there any perceived potential negative impacts to adopting cool roofs/cool pavements in your city?

   Please describe.

18. Based on the experience in your local market, how have costs compared between reflective roofs/pavements and traditional materials?
   - O reflective roofs/pavements cost less
   - O reflective roofs/pavements cost about the same
   - O reflective roofs/pavements cost more

MONITORING & MEASUREMENT

19. Does the city track and/or report progress toward its UHI goals?
   - O Yes
   - O No

   Please describe the tracking methodology and provide us with the most recent progress report.

20. Does the city track urban heat trends such as heat vulnerability?
   - O Yes
   - O No

   Please describe the methodology used. If this data is publicly available please provide a link to the data.

21. At what resolution is urban heat trend data collected? (Please check all that apply):
   - O Census track
   - O Neighborhood
   - O Block
   - O Building

22. Have you identified or measured tangible impacts on the city as a result of its UHI mitigation policies (i.e., changes in quality of life metrics, quantifiable air quality, peak electricity, energy use, or health improvements)? Please describe impacts identified.

BUDGET AND SPENDING ON UHI STRATEGIES

23. What was the level of city spending, in dollars, for all UHI mitigation efforts in the most recent year available?

24. What is this spending as a portion of the city's total annual budget?

25. In total, including all prior years, what has the city spent in dollars on UHI mitigation to date?

26. Has the city procured funding from non-city sources for UHI initiatives or leveraged the UHI initiatives of other entities (e.g., utilities, foundations, NGOs, businesses, other regional governments) to achieve city goals?
   - O Yes
   - O No

   Please describe the sources and level of non-city funding and/or activities.

YOUR OPINION: PROGRESS AND CHALLENGES

This section solicits your personal opinions. Responses from this section will not be attributed to a particular person or city but will be used in aggregate to help better understand and assess the state of UHI mitigation policy in the U.S.

27. In questions 1 and 2 you identified specific goals for your city's UHI mitigation strategy. In your opinion, how would you describe the overall progress made towards achieving these goals?
   - O No plan developed
   - O Plan in place, but no implementation
   - O Minimal implementation and/or budget
   - O Some implementation
   - O Significant implementation
   - O Goals nearly met
   - O Goals met or nearly met, considering new goals

   Please describe the progress toward each of your goals.

28. What conditions, opportunities, or strategies have been most conducive to furthering your city's UHI mitigation programs and policies?

29. What have been the most significant barriers to furthering the UHI mitigation programs, policies, and deployment in your city?

FURTHER INFORMATION AND PROGRAM MATERIALS

30. What else should we know about the UHI mitigation efforts in your city?

31. Please share with us programmatic design/implementation documents that were developed by your city to support your UHI mitigation programs. These could include your strategy, progress reports, RFPs for implementing partners, checklists, program applications for building owners, cost-benefit/effectiveness analyses, marketing materials, and more. These documents will not be published in the final report, but we will share them on CoolRoofToolkit.org or other sites so other cities and groups can more easily replicate your best practices.

Thank you for participating in our survey, we will be sharing aggregated results from this data and providing you a chance to review a draft of the resulting report in a few months!

Appendix B:
Data Request Respondents and City Planning Documents

UHI PLANNING DOCUMENTS AND/OR RELATED WEBSITES AS WELL AS DATA REQUEST RESPONDENT FOR EACH CITY STUDIED

City	State	UHI Planning Documents and Website Public Reporting	Data Request Respondent
Albuquerque	NM	Vision for the City Climate Action Plan	
Atlanta	GA	Connect Atlanta Trees Atlanta Power to Change Atlanta Atlanta Rising, 2012 Report	Ruthie Norton, Senior Project Manager, Mayor's Office of Sustainability
Austin	TX	Urban Forest Plan Imagine Austin Austin Climate Protection Plan Cool Spaces Green Roofs GIS Map	Leah Haynie, Program Coordinator, Parks and Recreation Department
Baltimore	MD	Baltimore CAP Disaster Preparedness (DP3)	Kristin Baja, Climate and Resilience Planner, Department of Planning
Boston	MA	Complete Streets Natural Hazards Mitigation Plan Grow Boston Greener A Climate of Progress: Climate Action Plan Update 2011	Carl Spector, Director of Climate and Environmental Planning, Boston Environment Department
Charlotte	NC	Trees Charlotte	—
Chicago	IL	Chicago Climate Action Sustainable Chicago 2015 (2013)	—
Chula Vista	CA	Climate Action Plan Climate Action Plan Progress Report 2013	Brendan Reed, Environmental Resource Manager, Public Work Department
Cincinnati	OH	Green Cincinnati Plan Tree canopy analyses	Steve Johns, Sustainability Coordinator, Office of Environment and Sustainability
Dallas	TX	ForwardDallas! GreenDallas 2013 Annual Progress Report, including GreenDallas; Sustainability Plan Progress Report, 2014	Kevin Lefebvre, Senior Environmental Coordinator, Office of Environmental Quality
Denver	CO	Department of Environmental Health Metro Denver Urban Forest Assessment (2013)	David Erickson, Environmental Site Assessment Program Manager, Department of Environmental Health
Houston	TX	Cool Houston Plan	Lisa Lin, Sustainability Manager, Office of the Mayor

City	State	UHI Planning Documents and Website Public Reporting	Data Request Respondent
Las Vegas	NV	Sustainable Las Vegas Sustainable Energy Strategy, 2012 Progress Report	—
Los Angeles	CA	Green LA Climate LA	Ted Bardacke, Deputy Director, Sustainability, and Michael Samulon, Sustainability
Louisville	KY	Sustain Louisville Tree Advisory Commission Multi-Hazard Mitigation	—
New Orleans	LA	Comprehensive Zoning Ordinance New Orleans Redevelopment NORAworks	Charles Allen III, Coastal and Environmental Affairs
New York	NY	PlaNYC Progress Report 2013	John Lee, Deputy Director for Green Buildings and Energy Efficiency, Mayor's Office of Long Term Planning and Sustainability
Omaha	NE	Omaha Master Plan Omaha Green Streets Omaha By Design Report Card	—
Philadelphia	PA	Green City Clean Waters TreePhilly Greenworks Greenworks 2013 Progress Report	Alex Dews, Policy and Program Manager, Mayor's Office of Sustainability
Phoenix	AZ	Climate Action Plan SustainPHX Tree and Shade Master Plan 2014 City Council Report Sustain PHX Annual Report, 2012–13	Richard Proctor, Energy Management
Portland	OR	Grey to Green Climate Change Preparation Climate Action Plan Grey to Green Accomplishments Climate Action Plan Two-Year Progress Report 2012	Michael Armstrong, Policy, Research and Operations Manager, and Ingrid Fish, Policy and Research Analyst, Bureau of Planning and Sustainability
Sacramento	CA	Climate Action Plan GHG Emissions Inventory; State of the Trees Report	Misha Sarkovich, Demand Side Specialist, Sacramento Municipal Utility District
St. Louis	MO	St. Louis Sustainability Forest ReLeaf Annual Report	Catherine Werner, Sustainability Director, Mayor's Office

City	State	UHI Planning Documents and Website Public Reporting	Data Request Respondent
Toronto	ON	Climate Action Plan Sustaining and Expanding the Urban Forest Eco-Roof Incentive Program Status Report	Annemarie Baynton, Senior Environment Planner, Toronto Environment Office
Vancouver	BC	Extreme Hot Weather The Greenest City 2020 Action Plan	—
Washington	DC	Sustainable DC 2013 Report	Bill Updike, Green Buildings Specialist, Department of the Environment, and Paul Lanning, Vice President, BLUEFIN, LLC

Appendix C:
Geographical and Climatic Characteristics of Cities

The climate zone column displays the IECC climate zone in which each city lies. The US Census Bureau counts the population every ten years and then projects a population between the census years. The population indicated is the 2012 projection based on the 2010 census. The land area of each city is available through the Department of Commerce. Heating degree days (HDD) and cooling degree days (CDD) serve as an indicator of climatic similarity. An HDD is the total degrees the average daily ambient temperature reaches below 65°F (the balance point) multiplied by the days of occurrence. A CDD is the total degrees the average daily ambient temperature reaches above the balance point multiplied by the days of occurrence.

The U. S. census divisions are:

1. New England
2. Middle Atlantic
3. East North Central
4. West North Central
5. South Atlantic
6. East South Central
7. West South Central
8. Mountain
9. Pacific

*Census divisions established by U.S. Census

** 2012 population projection based on 2010 census

†HDD and CDD gathered from http://www.weatherdatadepot.com/

‡Climate Zone determined by: http://blog.certainteed.com/wp-content/uploads/2010/05/Climate-Zones-8_DOE.jpgy

City	State	Census division *	Climate zone ‡	Population **	Land area (sq. mi.)	HDD † 2012	HDD 2013	CDD 2012	CDD 2013
Albuquerque	NM	8	4B	555,417	187.70	3,599	4,169	1,762	1,559
Atlanta	GA	5	3A	443,775	131.80	1,964	2,698	2,096	1,763
Austin	TX	7	2A	842,592	297.90	1,300	1,928	3,270	3,029
Baltimore	MD	5	4A	621,342	80.90	2,914	3,536	2,201	2,026
Boston	MA	1	5A	636,479	48.40	4,831	5,517	864	920
Charlotte	NC	5	3A	775,202	297.70	2,653	3,269	1,621	1,585
Chicago	IL	3	5A	2,714,856	227.20	5,116	6,678	1,262	825
Chula Vista	CA	9	3C	243,916	49.60	1,330	1,493	1,032	697
Cincinnati	OH	3	4A	296,727	77.94	4,186	5,159	1,322	1,028
Dallas	TX	7	3A	1,241,162	340.50	1,644	2,124	3,319	3,284
Denver	CO	8	5B	634,265	153.30	5,324	6,300	1,107	996
Houston	TX	7	2A	2,160,821	599.60	766	1,248	3,453	3,278
Las Vegas	NV	8	3B	596,424	135.80	1,699	1,887	4,089	3,766
Los Angeles	CA	9	3C	3,857,799	469.00	1,183	893	1,175	1,218
Louisville	KY	6	4A	605,110	997.30	3,408	4,505	1,834	1,420
New Orleans	LA	7	2A	369,250	180.60	720	931	3,371	3,406
New York	NY	2	4A	8,336,697	302.60	4,068	4,669	1,195	1,272
Omaha	NE	4	5A	421,570	127.10	4,944	6,417	1,626	1,294
Philadelphia	PA	2	4A	1,491,812	134.10	4,192	4,798	1,256	1,254
Phoenix	AZ	8	2B	1,488,750	516.70	750	917	4,982	5,023
Portland	OR	9	4C	603,106	133.40	4,342	4,397	332	539
Sacramento	CA	9	3C	477,891	97.90	2,554	2,368	1,174	1,320
St. Louis	MO	4	4A	318,172	61.90	3,532	4,729	2,216	1,728
Toronto	ON	—	5A	2,615,060	240.00	5,859	6,946	701	556
Vancouver	BC	—	4C	603,502	44.39	8,250	5,875	15	45
Washington	DC	5	4A	646,449	61.40	3,196	3,855	1,900	1,719

Appendix D:
Abbreviated Survey Responses

TABLE D-1: CITY GOALS FOR UHI MITIGATION EFFORTS

City	Goal types	Notes
Albuquerque	Reflective roofs	Incorporate reflective roofing materials whenever possible.
	Vegetated roofs	Incorporate green roofing and additional shading to city buildings.
	Urban fabric permeability	Stormwater: Goal 3, Condition 20: Develop a stormwater system that protects the lives and property of residents.
	Climate adaptation	Preparedness: Goal 2, Condition 17: Be prepared to respond to emergencies, natural disasters, catastrophic acts, and other events that threaten the health and safety of the public.
	Urban agriculture	Phase in edible landscaping to existing facilities to reach 25% by 2020. Require all new city facilities to include a minimum of 25% edible landscaping.
	GHG emissions reductions	20% reduction of GHG emissions from 2000 levels by 2012; 25-30% reduction by 2020, 80% reduction by 2050.
Atlanta	Urban fabric permeability	Provide a minimum of 10 acres of green space per 1,000 residents.
	Urban canopy	Protect and restore the city's tree canopy to 40% coverage.
	GHG emissions reductions	Reduce city-wide GHG emissions 25% by 2020, 40% by 2030, and 80% by 2050.
	Reduce government building energy use	Reduce Atlanta city government building energy use 15% by 2020, 40% by 2030, and 80% by 2050.
Austin	Urban canopy	Create an urban forest plan with tree canopy goals.
	Urban fabric permeability	Create a green infrastructure plan for public land and public rights-of-way.
	Community energy efficiency	By 2020, ensure that 80 MW of new energy savings will result from energy efficiency.
Baltimore	Temperature reduction	Yes
	Reflective roofs	30% of the city's commercial buildings and 10% of homes will have reflective roofs by 2020.
	Urban fabric permeability	Encourage development of Green Streets in flood-prone areas and throughout the city. Encourage use of permeable pavement in noncritical areas — low-use roadways, sidewalks, parking lots, and alleys where soils permit proper drainage. Design pavement that withstands longer periods of extreme heat events.
	Air quality	Work with partners to improve air quality and reduce respiratory illnesses.
	Urban agriculture	Double the size and number of food-producing gardens by 2025.
	Urban canopy	Increase the city's urban tree canopy with a focus on communities identified as UHI-vulnerable. Double Baltimore's tree canopy from 20% to 40% by 2037.
	Public outreach	Educate Baltimore citizens on low- to no-cost ways to save energy through grassroots efforts in neighborhoods and schools.

City	Goal types	Notes
Boston	Urban fabric permeability	Provide 25% of the green-scape zones with vegetated areas.
	Urban canopy	Increase tree canopy by 100,000 new trees from 2007 to 2020, expanding the urban canopy from 29% to 35%.
	GHG emissions reductions	Reduce GHG emissions from buildings by 25% by 2020.
	Groundwater recharge	Recharge one inch of rainfall in groundwater conservation districts.
	Building design	Use green walls. All projects over 50,000 square feet meet LEED standards.
Charlotte	Urban canopy	Increase tree canopy cover to 50% by 2050.
Chicago	Temperature reduction	Design to reduce surface temperatures.
	Vegetated roofs	Increase rooftop gardens to 6,000 by 2020.
	Urban canopy	Plant 1 million trees by 2020. Plant more than 1 million trees on private and public property.
	GHG emissions reductions	Reduce GHGs to 25% below 1990 levels (5.1MMTCO$_2$e).
Chula Vista	Urban fabric permeability	Study the use of high-reflective, porous paving materials and thinner pavements to reduce absorption and retention of heat, and the use of urban landscape and vegetation to reduce direct sunlight on pavement surfaces.
	Urban canopy	Include shade trees in all new parking lots.
Cincinnati	Reflective roofs	Promote cool roofs.
	Vegetated roofs	Promote green roofs. Increase the acreage of high-quality green space by 10% by 2020 through parks and rooftop gardens.
	Urban fabric permeability	Apply high-reflectivity coatings to asphalt. Increase cool pavements. Reduce impervious surfaces. Increase the acreage of high-quality green space by 10% by 2020 through parks and rooftop gardens.
	Urban canopy	Plant 2 million trees by 2020. Develop an urban forest. Incorporate trees and green infrastructure into roadways.
	GHG emissions reductions	Reduce GHG emissions 2% per year achieving a 24% reduction from 2006 levels.
	Community energy use reduction	Reduce the total energy consumption in the built environment by 15%
	Public health	See no increase in the number of heat-related hospital admissions.
Dallas	Vehicle reduction	Reduce vehicle miles traveled (VMT) Consider shared parking and other parking reduction strategies
	Urban fabric permeability	Establish standards for natural site drainage and reducing impervious coverage. Promote grassy swales, biofilters, eco-roofs, green streets, and pervious pavement. Develop street designs and standards for narrower streets, greater filtration, and stormwater conveyance.
	Urban canopy	Determine Dallas's baseline tree canopy coverage and establish a monitoring program to be updated regularly.
	GHG emissions reductions	Increase organizational GHG reductions to 39% over 1990 levels. Reduce GHG emissions from waste-to-energy projects at landfill and wastewater treatment.

City	Goal types	Notes
Denver	Urban canopy	Plant one million trees between 2006 and 2025. Preserve the city's 19% tree canopy cover.
	Public outreach	Initiate a community-wide extreme-heat educational campaign to better prepare the general public for an extreme-heat event.
	Reduce government building energy use	Reduce city-portfolio energy use by 20% per square foot by 2020 from a 2011 baseline.
	Community energy use reduction	Decrease total community-wide emissions below 1990 levels by 2020.
Houston	Urban canopy	Plant one million trees over three to five years.
Las Vegas	Vegetated roofs	Implement a green roofs program.
	Urban fabric permeability	Develop neighborhood parks and urban mini-parks. Set paving reduction standards. Retain natural arroyos and use pedestrian linkages between natural spaces. Explore potential for permeable hardscape.
	Urban canopy	Double the average tree canopy of 10% coverage to 20% coverage by 2035. Maintain Recognition by the National Arbor Day Foundation as a Tree City USA.
Los Angeles	Vegetated roofs	Incorporate rooftop green spaces as an energy efficiency mechanism.
	Urban fabric permeability	Revitalize the Los Angeles River with 588 acres of habitat rehabilitation and 11 miles of river restoration.
	Urban canopy	Plant 1 million trees throughout LA.
	Climate mitigation	Develop comprehensive plans to prepare for climate change effects on the city, including increased drought, wildfires, sea-level rise, and public health impacts.
	GHG emissions reductions	Reduce the city's GHG emissions to 35% below 1990 levels by 2030.
Louisville	Urban fabric permeability	Incorporate sustainability into the land-development code and the comprehensive plan by 2015. Replace and reforest parks property and provide nature-based recreation by 2018. Expand green infrastructure citywide by 2018.
	Urban canopy	Establish a robust urban tree canopy. Plant 10,000 trees by 2015.
	Reduce government building energy use	Decrease energy use from a 2006 baseline in municipal operations by 30% by 2018.
	Community energy-use reduction	Decrease energy use from a 2006 baseline city-wide by 25% by 2025.
	Air quality	Achieve and exceed NAAQS on an ongoing basis.
	Climate mitigation	Mitigate the risk of climate-change impacts by 2018. Develop a community-wide mitigation effort.
New Orleans	Reflective roofs	Maximize reflective surfaces.
	Vegetated roofs	Encourage green roofs for stormwater management.
	Urban fabric permeability	Promote use of semi-pervious paving materials. Encourage bioswales and landscaped lots for stormwater management.
	Urban canopy	Reach 50% tree canopy by 2030. Require parking lot shade trees, use trees, canopies, colonnades, and galleries for shade along pedestrian streets.
	Building design	Incorporate passive heating or cooling systems in buildings where possible.

City	Goal types	Notes
New York	Reflective roofs	Coat one million square feet of rooftop each season. By 2035, all flat roofs in NYC will be cool.
	Urban fabric permeability	Ensure 85% of New Yorkers live within a 10-minute walk of a park by 2030.
	Urban canopy	Plant 1 million trees by 2030. 70% will be municipally funded and planted in public spaces; 30% will be privately funded and planted on private property.
	Community energy use reduction	Reduce energy consumption and make our energy systems cleaner and more reliable. Decrease the residential building energy use per capita on a three-year rolling average.
	GHG emissions reductions	Reduce GHG emissions by over 30%.
	Air quality	Achieve the cleanest air quality (average PM2.5) of any big US city.
Omaha	Vegetated roofs	Promote sustainable and green infrastructure to protect natural resources.
	Air quality	Improve air quality.
	Urban canopy	Implement landscaping practices that reduce heat and air pollutants.
	Public health	Support ongoing monitoring and public reporting of health outcomes and prevention strategies.
Philadelphia	Reflective roofs	Retrofit 15% (84,400) of housing stock with insulation, sealing, and cool roofs.
	Vegetated roofs	80 green roofs (16 acres), with additional 21.7 acres under construction at 60 sites
	Community energy use reduction	Reduce citywide building energy consumption by 10% to 109.85 T BTUs
	GHG emissions reductions	Reduce municipal and community GHG emissions by 20%.
	Urban fabric permeability	Add 450 greened acres; add 163 porous pavement projects, totaling 72.3 acres.
	Urban canopy	Increase tree coverage to 30%, including 300,000 new trees by 2025.
Phoenix	Urban fabric permeability	Study options for building materials and paving surfaces that minimize the absorption of heat.
	Urban canopy	Achieve an average of 25% tree canopy coverage by 2030. Encourage the planting of mature trees (and other vegetation).
	GHG emissions reductions	Reduce GHG emissions from city operations to 5% below the 2005 levels by 2015.
Portland	Vegetated roofs	Increase total eco-roof acreage.
	Urban fabric permeability	Research, evaluate, and pilot porous paving, de-paving, vegetation, and reflective paving. Reduce impervious area by 600 acres.
	Urban canopy	Implement the tree codes. Implement and expand the city's Urban Forest Management Plan. Cover 10% of the central city, commercial and industrial areas, and 33% of the entire city with urban canopy.

City	Goal types	Notes
Sacramento	Reflective roofs	Promote or require reflective roofs.
	Vegetated roofs	Promote or require green roofs and promote rooftop agriculture.
	Urban fabric permeability	Require paving for new development to meet minimum solar reflectivity index (SRI) values. Incorporate cool pavement into regular maintenance of existing streets, sidewalks, parking areas, and bike lanes.
	Urban canopy	Enhance the urban forest in existing suburban neighborhoods. Plant 1,000 new trees annually across all of Parks and Recreation land. Achieve 35% urban canopy.
	GHG emissions reductions	Reduce emissions 15% to 1990 levels by 2020, 38% by 2030, and 83% by 2050.
	Climate mitigation	Foster a community that is resilient to the effects and impacts of climate change.
St. Louis	Urban fabric permeability	Increase the city's green space.
	Urban canopy	Increase trees by 16,000 to a 15% canopy cover. Plant 13,479 acres of urban canopy on vegetated and impervious acres.
	GHG emissions reductions	Reduce GHG emissions 25% by 2020 and 80% by 2050.
Toronto	Urban canopy	Double the tree canopy to 34%. Provide Toronto with 40% canopy cover by 2022.
	GHG emissions reductions	Reduce citywide GHG emissions 30% from the 1990 level by 2020 and 80% by 2050.
	Air quality	Reduce smog-causing pollutants 20% from a 2004 baseline by 2012.
Vancouver	Urban fabric permeability	Create four to six mini parks.
	Urban canopy	Plant 150,000 new trees on city land by 2020.
	Building design	Require all buildings constructed from 2020 onwards to be carbon neutral in operations.
	GHG emissions reductions	Reduce GHG emissions by 5% below 1990 levels by 2020. Reduce energy use and GHG emission in existing buildings by 20% over 2007 levels.
	Urban agriculture	Increase urban food production by 50% over 2010 levels by 2020.
Washington	Temperature reduction	Reduce urban temperature.
	Reflective roofs	Retrofit up to 3 million square feet of District-owned roofs.
	Vegetated roofs	Install 85,000 sq. ft. or more of new green roofs.
	Urban fabric permeability	Achieve 75% permeability. Install 25 miles of green alleys. Double homes in Riversmart. Develop an Urban Wetland Registry to facilitate restoration or creation of wetland habitat. Plant and maintain an additional 140 acres of wetlands.
	Urban canopy	Achieve 810 new acres of tree canopy, or 2% of total urban area, since 2006. Plant 8,600 new trees per year through 2032. Develop an Urban Wetland Registry to facilitate restoration or creation of wetland habitat. Plant and maintain an additional 140 acres of wetlands.

TABLE D-2: IMPLEMENTING CITY AGENCIES WITH THE LEAD AGENCY IF DESIGNATED, THE IMPACTS RESULTING FROM UHI MITIGATION, AND EXTERNAL FUNDING

City	Agencies involved (lead agency)	Impacts of UHI mitigation	Entities that provide funding for city UHI programs
Albuquerque	—	—	—
Atlanta	Mayor's Office of Sustainability; Department of Watershed Management; Department of Public Works; Department of Parks; Department of Planning; Atlanta Police Department; Office of Enterprise Assets Management; Department of Aviation	Dr. Brian Stone at Georgia Tech has modeled the effects of mitigation strategies and policies. His report shows the impact for Atlanta's population in 2050 and will be published for public review later in 2014.	Trees Atlanta accepts donations and volunteers to plant trees in the downtown metro area, inside the I-285 beltline.
Austin	Office of Sustainability; Parks and Recreation; Watershed Protection; Homeland Security and Emergency Management; Health and Human Services; Public Works; Planning and Development Review; Austin Water; Austin Energy; Austin Fire; Office of Real Estate Services; Neighborhood Housing and Community Development; Austin Transportation Department; Building Services; Aviation	—	EPA grants
Baltimore	The Baltimore Office of Sustainability; Department of Health; Parks and Recreation	—	Dept. of Housing & Community Development; utilities merger; local grants; university contributions
Boston	Boston Transportation; Boston Public Works; Environmental and Energy Services; Parks and Rec; Neighborhood Services; Office of Environment, Energy, and Open Space; Boston Redevelopment	Thousands of trees have been planted but it is too soon to measure for other results.	City of Boston; Massachusetts Department of Conservation and Recreation; Boston Natural Areas Network; EPA; state-level grants.
Charlotte	—	—	—
Chicago	Water Management; Buildings; Department of Aviation; Innovation and Technology; Planning and Development; Streets and Sanitation; Transportation	City Hall Green Roof has achieved 730% evapotranspiration.	Campus Parks Programs, Chicago Trees Initiative
Chula Vista	Fire Department; Development Services; Public Works; Engineering; Building Code Enforcement	Chula Vista has only started and not quantified results yet.	SDG&E
Cincinnati	Park Board; Department of Transportation and Engineering; Planning Department	Tree planting efforts maintain the status quo in regards to the Emerald Ash Borer.	Western Wildlife Corridor; Hamilton County Park District; Spring Grove Cemetery and Arboretum; Private Foundations; Duke Energy Foundation; Releaf

City	Agencies involved (lead agency)	Impacts of UHI mitigation	Entities that provide funding for city UHI programs
Dallas	Office of Environmental Quality; Public Works; Equipment and Building Services; Dallas Water Utilities; Park & Recreation; Street Services; Sustainable Development and Construction/Building inspection; Sanitation Services; Trinity Watershed Management/Stormwater Management; Aviation; Code Compliance; Convention and Event Services; Dallas Public Library; Dallas Police; Dallas Fire Rescue; Communications and Information Services; Dallas Marshal's Office; Strategic Customer Services; Housing; Cultural Affairs; Financial Services; City Design Studio	The impacts of UHI on the community are being studied. As the city's sustainability plan evolves, these elements will be evaluated in decision making.	—
Denver	Denver Water; Denver Parks and Recreation Forestry Office, Office of the City Forester	As part of the climate action plan and 2020 goals, Denver has seen significant reductions in GHG emissions, per capita energy use, and per capita water use.	The partners of Mile High Million are listed here.
Houston	Parks and Recreation; Harris County; Texas Department of Transportation; Department of Public Works and Engineering; Planning and Development Services Division; Building Code Enforcement Branch	—	Private donations; Greater Houston Partnership Roofing Committee; Real Estate Council; Roofing Contractors Association; Houston Parks Board; Houston Arboretum and Nature Center; Keep Houston Beautiful; Mercer Arboretum; Scenic Houston; Trees for Houston; Texas Urban Forestry Council
Las Vegas	Planning and Development; Administrative Services; Leisure Services; Urban Planning and Development.	9% urban canopy over 84,563 acres	Many partnerships
Los Angeles	Department of Neighborhood Empowerment; Parks and Recreation; Environment LA; LADWP; Urban Forest; Department of Sanitation; Bureau of Engineering; City Planning; Building and Safety; LAFD; Department of Emergency Preparedness	—	Municipal and private partners; LADWP; CityPlants; Climate Resolve
Louisville	Office of Sustainability; Department of Technology Services; Metropolitan Sewer District; Metro Parks; Codes and Regulation; Economic Growth and Innovation; Planning and Design; Public Health and Wellness; Air Pollution Control District; Parking Authority of River City; Transit Authority of River City	Mean, maximum, and minimum air temperatures have increased since 1970.	Private grants; Ecotech LLC
New Orleans	City Planning Commission; Public Works; Capital Projects; Coastal and Environmental Affairs	New public buildings that were designed with energy-efficient HVAC systems and cool roofs are performing to their designed standards.	Many partnerships
New York	There are over 25 agencies involved in the writing and implementing of PlaNYC and its subsequent policies and programs.	By November 2013, 800,000 trees have been planted since 2007. In 2012 80,000 trees were planted and 63 green streets were completed. 5,753,560 square feet of roofs are cool roofs.	ConEdison; other corporations; professional associations; building-owners; housing associations; local development corporations; nonprofits; coating and supply vendors;
Omaha	Douglas County; Metropolitan Area Planning Agency; Papio-Missouri River Natural Resources District	—	—

City	Agencies involved (lead agency)	Impacts of UHI mitigation	Entities that provide funding for city UHI programs
Philadelphia	Parks and Recreation; Philadelphia Water Department; Philadelphia Corporation for Aging; Philadelphia Department of Public Health; The Office of Emergency Management; and the Mayor's Office of Sustainability	163 porous pavement projects totaling 72.3 acres; 80 green roofs totaling 16 acres, with 21.7 acres under construction across 60 sites	PENNVEST Loans; the Tookany/Tacony Frankford Watershed Partnership; Pennsylvania Horticultural Society; Energy Coordinating Agency; EnergyWorks; Philadelphia Gas Works EnergySense; Philadelphia Housing Authority; Philadelphia Housing Development Corporation
Phoenix	Office of Environmental Programs; Aviation Department; Department of Public Works; Parks and Recreation; Water Services; Street Transportation Department	52,000 square feet of cool roofs; 13% vegetative cover.; average of 92 days over 100 degrees annually	Arizona Public Service; Arizona State Forestry Division; Arizona Community Tree Council; Office of Arts and Culture; Arizona Municipal Water Users Association; National Arbor Day Foundation; NOAA
Portland	Bureau of Planning and Sustainability; Environmental Services; Parks and Recreation; Portland Bureau of Transportation; Water Bureau; Multnomah County Health Department	The city has 500,000 new trees and plants, 32,000 new street trees; 867 green street facilities; 39 acres of green roofs (398 total). The Department of Environmental Services purchased 406 acres of wetlands, headwaters, habitats of important species, and urban forest; 4,100 acres of watershed has been revegetated since 2008.	Friends of Trees; Portland State University
Sacramento	Department of Public Works; Department of Transportation; SMUD; General Services; Parks and Recreation; Community Development	SMUD has planted more than 500,000 trees since 1990.	—
St. Louis	Parks; Recreation and Forestry; Commissioner of Forestry; City Green Team; Planning and Urban Design Agency; St. Louis Metropolitan Sewer District	18.2% canopy cover	2009 EECBG; ARRA
Toronto	Parks; Forestry; Recreation; Environment and Energy Division; City Planning; Toronto Buildings; Toronto Water; Toronto Public Health	Trees planted, square meters of green roofs, square meters of cool roofs, funded eco-projects	—
Vancouver	—	12,513 trees planted since 2010.	—
Washington	District Department of the Environment; District Department of General Services; Office of Planning; District Department of Transportation; District of Columbia Housing Authority; DC Water; District Department of Consumer and Regulatory Affairs; Metropolitan Washington COG	5,500 single-family homes have rain gardens, shade trees, and vegetated roofs. 8,600 trees are planted every year. The city has 57% urban permeability and 2,178,000 square feet of vegetated roofs.	Federal Grants; Washington Metro Council of Governments; NGOs; private-sector partners

TABLE D-3: PROCUREMENT POLICIES FOR MUNICIPAL DEVELOPMENT

City	Procurement policy	Notes
Albuquerque	Other	Follows the EPA Environmentally Preferable Purchasing guidelines
Atlanta	Reflective roofs	30% of Atlanta's fire stations have a reflective cool roof, and nearly 100% of Atlanta Public Schools have a reflective cool roof.
	Vegetated roofs	The first green roof in Atlanta was built on the City Hall roof in 2003. It was built to raise awareness and demonstrate benefits.
	Other	Atlanta follows the EPA standards for green products and cleaning supplies
Austin	—	—
Baltimore	—	—
Boston	Vegetated roofs	The Green Roof Demonstration Project was an installation of green roofs on two terraces of City Hall to "be a resource for developers and individuals interested in exploring green roof technologies and to provide information on green roofs to the general public, including the costs and benefits of green roofs.
	Other	Boston follows the EPA Environmentally Preferable Purchasing guidelines and developed the Green Information Technology Roadmap.
Charlotte	—	—
Chicago	Reflective and vegetated roofs	In Chicago, the city of Chicago and Cook County share a building downtown. The City's half of the roof is green, the County's half of the roof is white. In this challenge, the white half of the roof proved to be 2 degrees cooler than the green half.
	Porous pavement	Chicago's green alley program was piloted to improve the stormwater runoff in the city's alleys.
Chula Vista	Reflective roofs	All California cities are now required under Title 24 to enforce new low-slope cool roof, insulation, and solar-ready requirements.
	Shade trees	Shade trees are required on-site in parking lots.
Cincinnati	Reflective roofs	Recommendations include requiring cool roofs for new construction and major renovation of city facilities.
	Reflective pavement	Green Cincinnati recommends legislation requiring paved roads to be covered with cool pavement.
	Other	Supplies, services, and construction that are environmentally preferable are suggested.
Dallas	Reflective roofs	Dallas Green Building Program (Council Resolution 03-0367)
	Vegetated roofs	Dallas Green Building Program (Council Resolution 03-0367)
	Reflective pavement	Green Cement Purchasing Policy (Council Resolution 11-0657)
	Shade trees	Tree Resolution (90-1496); Tree Preservation Ordinance (Council Resolution 94-1988, Ordinance 22053); Great Trinity Forest Management Plan (Council Resolution 08-2779)
	Other	Integrated Stormwater Management (Council Resolution 08-0421); Idling Ordinance (Council Resolution 11-2976, Ordinance 28456)
Denver	Shade trees	Trees must be protected and preserved, with tree loss mitigated by planting more than is taken.
	Other	LEED best practices and Greenprint Denver construction guidelines

City	Procurement policy	Notes
Houston	Reflective roofs	City projects with low-slope roof over conditioned space must meet the Houston Cool Roof Code provisions.
	Shade trees	The number of shade trees on-site is determined by the City of Houston Tree and Shrub Ordinance
	Other	City Energy Efficiency Policy Administrative Procedures
Las Vegas	—	—
Los Angeles	Reflective roofs	All California cities are now required under Title 24 to enforce new low-slope cool roof, insulation, and solar-ready requirement
	Revegetation	The City's Landscape Ordinance aims to reduce landscape irrigation water use, the urban heat island effect, the dependence on fossil fuels to heat and cool buildings, erosion, and increasing ground water recharged.
	Other	Los Angeles must follow the EPA's Environmentally Preferable Purchasing guidelines. All City of Los Angeles building projects 7,500 square feet or larger are required to achieve Leadership in Energy and Environmental Design (LEED) Certified standards.
Louisville	Reflective roofs	Three buildings have white roofs.
	Vegetated roofs	Two buildings have green roofs.
New Orleans	—	—
New York	Other	Local Law 119 describes the energy efficiency considerations required before purchasing.
Omaha	Other	Omaha follows the EPA's Environmentally Preferable Purchasing guidelines.
Philadelphia	Vegetated roofs	Bill 080025: Green Roof Tax Credit Ordinance, a new section of the Green Municipal Guidelines, signed by the City Council in December 2009.
Phoenix	Shade trees	Shade tree guidelines are in place.
	Other	Phoenix follows the EPA Environmentally Preferable Purchasing guidelines. Buildings must be LEED standard.
Portland	Vegetated roofs	All new city-owned facilities will have an eco-roof covering at least 70% of the roof and high-reflectance Energy Star-rated roof material on remaining roof areas, where practical.
	Shade trees	The city protects existing trees and requires planting of new trees through its tree code.
	Revegetation	All development in the city, public or private, must manage 100% of stormwater on-site, which results in extensive bioswales, eco-roofs, and other distributed green infrastructure.
Sacramento	Reflective roofs	All California cities are now required under Title 24 to enforce new low-slope cool roof, insulation, and solar-ready requirement.
St. Louis	Other	St. Louis follows the EPA Environmental Preferable Purchasing guidelines. EE and GHG reduction guidelines for new and major renovation of municipal buildings requires a statement of energy usage that is 30% more stringent than code.
Toronto	Vegetated roofs	Toronto requires green roofs to be constructed on city-owned buildings during new construction and replacement.
	Other	Toronto has the Green Standard, a two-tier set of performance measures for sustainable site and building design for capital projects.
Vancouver	—	—

City	Procurement policy	Notes
Washington	Reflective roofs	Reflective roofs are required in all construction.
	Vegetated roofs	The city is evaluating sustainable roofing options.
	Porous pavement	DDOT installs permeable paving around tree boxes.
	Street trees	DDOT installs street trees and bioretention in public space. Substantial improvement projects and 1.2 inches of stormwater management are required for new construction.

TABLE D-4: VOLUNTARY POLICIES AND PROGRAMS IN PLACE IN STUDIED CITIES

City	Policy type	Topic and notes
Albuquerque	Preferential permitting	**Other:** The Green Path permitting structure is an expedited permitting process for commercial and residential construction projects at certain LEED or Build Green New Mexico levels.
Atlanta	Rebates	**Reflective roofs:** Georgia Power Company provides a rebate for many energy-efficient appliances, including reflective roofing.
Austin	Rebates	**Vegetated roofs:** Austin offers incentives and bonuses for projects that incorporate a green roof into a new project.
	Public awareness campaigns	**Other:** Educational outreach campaign
Baltimore	Rebates	**Urban canopy:** Rebates and free tree programs are available through Tree Baltimore.
	Loan programs	**Other:** Homeowners, depending upon income, receive five-year or deferred loans and have the ability to select their contractor and the type of roofing materials.
Boston	Other	**Urban canopy:** Grow Boston Greener offers grants to buy and plant trees on any public piece of land in Boston.
Charlotte	—	—
Chicago	Preferential permitting	**Vegetated roof, Stormwater Management:** Expedited green permits for construction involving a green roof, rainwater harvesting, solar roof, solar thermal, wind turbine, geothermal.
Chula Vista	Preferential permitting	**Other:** Green buildings meeting CalGreen Tier2 are eligible for expedited permitting.
	Loan programs	**Other:** Loan programs are available to help private entities leverage affordable housing construction to meet LEED certifications.
Cincinnati	Preferential permitting	**Other:** Preferential permitting is available through the planning department- and funded by EECBG.
	Loan programs	**Vegetated roof:** Ohio EPA, Metro Sewer District of Greater Cincinnati, and Cincinnati Office of Environment and Sustainability wrote the Green Roof Loan Program of $5M for linked-deposit, below-market-rate loans for vegetative roofs for residential, commercial, and industrial buildings.
	Public awareness campaigns	**Other:** The Green Umbrella is the region's sustainability alliance, with a membership of 200 organizations and 100 individuals.
Dallas	Public awareness campaigns	**Urban canopy and Other:** GreenDallas.net; Building Inspection Website; Dallas Trees
	Preferential permitting	**Other:** Ordinance No. 28813 allows building projects to be eligible for expedited permitting if the construction qualifies as LEED Silver, Green Built Texas, or another green building standard.
Denver	Loan programs	**Other:** Denver's Office of Economic Development provides low-interest loans for energy-intensive businesses to invest in renewable energy or energy efficiency projects.
Houston	Rebates	**Other:** Offices that completed a project that resulted in 15% or more energy savings for the building are eligible for an incentive ranging from $20,000—$500,000. Projects may include cool or green roofs.
	Other	**Other:** Houston enacted a partial tax abatement for commercial buildings that meet LEED standards.
Las Vegas	Rebates	**Other:** There are incentives available through the Green Building Program and the Southern Nevada Green Building Partnership to provide energy efficiency retrofits to existing buildings and to stimulate new green construction.

City	Policy type	Topic and notes
Los Angeles	Rebates	**Reflective roofs:** The municipal utility (LADWP) offers rebates for cool roofs and window treatments.
Louisville	Rebates	**Stormwater management:** Green Incentives and Savings Program established financial incentives for commercial and industrial private property owners to help offset green infrastructure construction as well as provide an opportunity for credits on stormwater fees.
	Preferential permitting	**Other:** Land Development Code includes Green Building and Site Design Incentives: additional building height, parking reduction for projects that incorporate various design elements: paving and roofing materials with high SRI, open space, and vegetated roof.
New Orleans	Rebates	**Other:** Energy Smart Program
	Loan programs	**Other:** NOLA Wise Revolving Loan Program
New York	Rebates	**Other:** Tax credit
	Public awareness campaigns	**Reflective roofs:** NYC Cool Roofs
	Other	**Stormwater management:** Department of Environmental Protection gives $2.6M in grants for green infrastructure projects focused on managing and capturing stormwater. **Vegetated roofs:** Green Roof Property Tax Abatement offers $4.50 per square foot abatement for installation of green roofs, up to $100,000. **Reflective roofs:** Cool it Yourself program encourages cool rooftops with a white coating or membrane.
Omaha	Rebates	**Other:** Omaha Master Plan recommends offering rebates to rental properties in which both parties would benefit from reduced energy use, with a goal of reaching 10% of the residential and commercial stock each year.
	Loan programs	**Other:** Omaha Master Plan recommends providing loans, financing mechanisms, and energy-efficient mortgages to rental properties in which both parties would benefit from reduced energy use, with the goal of reaching 10% of the residential and commercial stock each year.
Philadelphia	Rebates	**Stormwater management:** PWD and the Philadelphia Industrial Development Corporation launched the Stormwater Management Incentives Program, which offers stormwater bill credits to owners of impervious commercial properties who build and maintain green stormwater management projects.
	Public awareness campaigns	**Reflective roofs:** RetroFIT Philly is a partnership between the city, Energy Coordinating Agency, and Dow Construction Materials to run the Coolest Block Contest. The contest provided cool coatings to an entire block that met certain quantitative and qualitative criteria. The contest raised awareness and led to the political appetite for adopting a cool roofs ordinance.
	Other	**Stormwater management:** A cost-sharing program is available to eligible customers for residential landscape improvements to manage stormwater; **Urban canopy:** The zoning code provides credits for preserving existing trees. Erase Your Trace allows for individuals to purchase carbon offsets in the form of new trees.
Phoenix	Rebates	**Urban canopy:** Arizona Public Service provides rebates for energy efficiency measures, including trees and cool roofs.
	Loan programs	**Other:** Arizona Public Service provides loans for energy efficiency upgrades.
	Public awareness campaigns	**Other:** Arizona Public Service runs public awareness campaigns for energy efficiency.
	Other	**Reflective roofs:** Administered by the Planning and Zoning Department, the Heat Island Mitigation voluntary requirements are located in the city-adopted International Green Construction Code of the International Green Building Council. For roofs with slopes less than 2:12, an SRI of 60 is required, and for slopes greater than 2:12, an SRI of 25 is required.

City	Policy type	Topic and notes
Portland	Rebates	**Urban canopy, Stormwater management:** Treebates are available for residential customers of the Bureau of Environmental Services. Citizens may purchase a tree, plant it in their yard, complete a form, and receive $15- $50 credit to their stormwater and sewer bill.
	Other	**Vegetated roofs:** The Green Building Code includes an Eco-Roof mandate which offers a FAR bonus for buildings which incorporate an eco-roof.
	Public awareness campaigns	**Vegetated roofs:** Free workshops are available for residents through Environmental Services for learning more about eco roofs. The Grey to Green initiative involved extensive public education and outreach.
Sacramento	Rebates	**Urban canopy, Reflective roofs:** Various SMUD rebates for energy efficiency, shade trees, and cool roofs are available to city and residents and businesses
	Loan programs	**Other:** Commercial PACE program will help ensure that the Plan is successfully implemented by the City, residents and businesses.
St. Louis	Rebates	**Urban canopy:** Commissioner of Forestry plants street trees on private property at no charge.
	Loan programs	**Reflective roofs:** Set the PACE St. Louis is a financing tool available to citizens of St. Louis making energy-efficient upgrades to residential and commercial buildings. Eligible projects include Cool Roof and Cool Wall systems. Steep roofs must have 0.25 initial and 0.2 aged reflectivity, and low-sloped roofs must have 0.65 initial and 0.5 aged reflectivity. Green Roofs are considered case-by-case.
	Public awareness campaigns	**Other:** Sustainable Neighborhoods Initiative
Toronto	Rebates	**Reflective roofs, Vegetated roofs:** Toronto's Eco-Roof Incentive provides rebates for both cool and green roof installations on residential, commercial, industrial, and institutional buildings. Eligible green roof projects receive $75 per square meter up to $100,000. Eligible cool roof projects may receive a rebate of $2-$5 per square meter up to $50,000.
	Public awareness campaigns	**Stormwater management, Urban canopy:** The Department of Urban Planning has released Design Guidelines for greening surface parking lots, which offers many recommendations to parking lot designers for integrating dark skies requirements, stormwater management, minimal impervious pavement, pervious pavement, and greenery.
	Other	**Vegetated roofs:** Live Green Toronto invested $20 million in retrofitting subsidies for Toronto's homes and businesses building innovative projects such as green roofs.
Vancouver	—	—
Washington	Rebates	**Vegetated roofs:** DDOE has multiple programs for green infrastructure, including a green roof rebate program, stormwater utility fee reductions for green infrastructure, 60% of costs of green infrastructure retrofits, and installations of green infrastructure for single-family houses.
	Public awareness campaigns	**Other:** The District government undertakes public awareness campaigns around the mayor's sustainability goals.
	Loan programs	**Stormwater management:** The District allows water efficiency and green infrastructure financing under its Property Assessed Clean Energy program.
	Other	**Other:** DDOE and other agencies work closely with local commercial real estate entities via the Green Building Advisory Council.

TABLE D-5: MANDATORY POLICIES REQUIRED IN THE STUDIED CITIES

City	Policy type	Notes
Albuquerque	—	—
Atlanta	Ordinances	**Stormwater management:** Stormwater Management Ordinances promote the use of Green Infrastructure on new and redevelopment projects in the City.
	Requirements for public buildings	**Other:** Green Building: requires that municipal facilities over 5,000 square feet shall meet at least LEED Silver standards; having green or cool roofs are a way to earn this certification.
Austin	Codes	**Reflective roofs:** The City of Austin adopted IECC 2012 with local amendments including reflective roofing for commercial buildings. Exceptions to the reflective roof requirements include vegetative roofs, roof-top pools, or integrated solar PV permanently adhered to the roof surface.
	Ordinances	**Urban canopy:** Tree and Natural Area Preservation: Ordinances 031023-10 and 031211-11 provide stricter requirements for the preservation of Austin's most valuable trees. Shaded Parking Ordinances mandating 50% Canopy Coverage within 15 years for all new parking lots. A minimum of 80% trees required for parking lots are to be large shade-producing native shade trees. A minimum of 50% of the trees in non-parking lot areas are to be shade-providing trees.
Baltimore	Other	**Stormwater management:** Baltimore Green Building Standards, stormwater fee, and Critical Area standards.
Boston	Codes	**Stormwater management:** The 2011 update of the climate action plan proposes a cool roof requirement that all new construction will have light-colored or vegetated roofs. Urban Farming: Zoning Code (Article 89) authorizes urban farming on the ground and roof level—both in open air and in a greenhouse.
	Other	**Other:** Zoning Code Article 37 requires all projects over 50,000 square feet meet LEED standards for certification. (Actual certification is not required.) Green roofs and other actions that reduce UHI are among the available credits for certification.
Charlotte	—	—
Chicago	Codes	**Reflective roofs:** As designated in the Energy Efficiency Zoning Code new low-sloped roofs have a minimum three-year reflectance of 0.5, medium sloped roofs a minimum reflectance of 0.15.
	Ordinances	**Stormwater management:** The Stormwater Ordinance requires large developments to capture the first half-inch of rain on-site. **Urban canopy:** The Landscape Ordinance requires Parkway Trees, Screening, Internal Plantings. The Open Space Impact Fee Ordinance collects fees based on the number of units in new residential developments to create public open spaces in Chicago.
Chula Vista	Codes	**Reflective roofs;** All California cities are now required under Title 24 to enforce new low-slope cool roof, insulation, and solar-ready requirements (increase reflectance from 0.55 to 0.63 for new construction and alterations). Urban canopy, stormwater management, light-colored pavements: Code 18.32.110 requires planting of trees in subdivisions: 1) a mixture of shade trees and cool pavement to cover 50% of parking lots 5-15 years after installation 2) street trees must maximize shade cover 3) an existing tree shall account for 150% the shade cover of a new tree.
	Ordinances	**Reflective roofs:** Cool Roof Ordinance: Ordinance 3227 Tier 2 cool roof measures are mandatory in Climate Zone 10 for new low-rise residential developments.
Cincinnati	Codes	**Urban canopy:** A tree tax approved by city council and authorized by Ohio revised code at the rate of $0.18 per front foot on all property that abuts public right of way within the city.

City	Policy type	Notes
Dallas	Codes	**Reflective roofs, vegetated roofs:** Mandatory reflectance for residential and commercial low-sloped roofs: on installation = 0.65, aged = 0.50. Resolution 12-2428 requires all buildings 50,000 square feet or less with a slope of 2:12 incorporate a vegetated roof.
	Ordinances	**Stormwater management:** Ordinance 28813 requires that all plots of construction must allow 70% of the land area to be permeable or capture water runoff for on-site infiltration. It also requires that ENERGY STAR roofs be installed on all roofs with slope of 2:12 or greater, except when a vegetated roof is installed.
	Requirements for public buildings	**Other:** All Public Works projects are built to the LEED Gold Standard.
Denver	Other	**Other:** Denver is on track to adopt the 2015 International Building Code, which results in up-to-date building and energy efficiency standards for all new construction in Denver.
Houston	Codes	**Reflective roofs:** Houston Cool Roof code
	Ordinances	**Reflective roofs:** Low-slope roofs up to 2:12 must have minimum solar reflectance of 0.70 and thermal emittance of 0.75. Exceptions include a portion of roof that is a garden, green roof, deck, or covered in solar panels.
Las Vegas	—	—
Los Angeles	Codes	**Reflective roofs:** All California cities are now required under Title 24 to enforce new low-slope cool roof, insulation, and solar-ready requirements: (increase reflectance from 0.55 to 0.63 for new construction and alterations).
	Ordinances	**Other:** Ordinance 181480 requires new construction to exceed Cal Energy Code requirements by 15%. **Reflective roofs:** Cool Roof Ordinance
Louisville	—	—
New Orleans	Ordinances	**Stormwater management:** All private construction within the City is subject to relevant building codes and ordinances. The current zoning ordinances are being updated to address a number of issues regarding stormwater management and UHI.
New York	Codes	**Reflective roofs:** Minimum SRI for low slope roofs must equal 0.78. 2008 Construction Codes require that most new construction includes rooftops that are 75% reflective or rated highly reflective by Energy Star. Effective January 1, 2012, roof alterations or replacements to existing buildings must also use reflective material.
	Ordinances	**Reflective roofs:** Local Law 21 allows cool roofs as a mitigation strategy. Alterations involving the recovering or replacing of an existing roof covering shall comply with section 1504.8 of the New York city building code unless the area is less than 50% of the roof area and less than 500 square feet.
	Other	**Urban canopy:** MillionTrees NYC seeks to ensure that private entities will plant 250,000 trees by 2030.
Omaha	Ordinances	**Other:** The Master Plan is a product of Ordinance #38882, approved Dec. 4, 2010.
Philadelphia	Codes	**Reflective roofs:** The Philadelphia Cool Roof law (Bill No. 090923 Title 4 of Philadelphia Code) states, “Roof Coverings over conditioned spaces on low-slope roofs (‹ 2:12) on newly constructed buildings and additions to existing buildings shall be Energy Star rated as highly reflective.” Exceptions include green roofs, rooftop athletic facilities, and pv roofs.
Phoenix	—	—
Portland	Codes	**Other:** Codes for Green Building include Eco-Roof mandates.
Sacramento	Codes	**Reflective roofs:** All California cities are now required under Title 24 to enforce new low-slope cool roof, insulation, and solar-ready requirements: (increase reflectance from 0.55 to 0.63 for new construction and alterations). **Urban Canopy:** Regulations for trees in the city of Sacramento are found in Chapter 12.56 of the City Codes.

City	Policy type	Notes
St. Louis	Ordinances	**Urban canopy:** According to Ordinance 68607 Tree preservation and replacement-should suffer no net loss in population and canopy of urban forest, preserve trees wherever possible, increase and expand population and canopy of urban forest.
Toronto	Ordinances	**Other:** The Toronto Green Standard requires new Tier-1 construction designs to demonstrate 15% energy efficiency over the Ontario Building Code, and Tier-2 construction designs to demonstrate 25% energy efficiency over the OBC. Green and cool roofs are a way to ensure these savings.
	Requirements for public buildings	**Vegetated roofs:** The City of Toronto requires that where technically feasible, green roofs be constructed on all new city-owned buildings and existing buildings where roofs are scheduled to be replaced.
	Other	**Vegetated roofs:** The Toronto Green Roof Bylaw requires green roofs to be built on all new construction over six stories tall with a minimum floor area of 2,000 square meters. Required covered area ranges from 20-60% of the roof, depending on the presence of solar panels, terraces, and recreational space.
Vancouver	Ordinances	**Vegetated roofs:** Port Coquitlam Green Roof By-law states that all new buildings over 5,000 square meters must have a green roof.
Washington	Codes	**Stormwater management:** Green Area Ratio (GAR) zoning measure sets standards for landscape. **Reflective roofs:** Cool roof standards for commercial buildings are found in DC Energy Conservation Code, 2008. The 2013 codes for the District include cool roof requirements for commercial and residential sectors. **Light-colored pavements:** Green Construction Code includes provisions for more reflective site hardscapes, shading, and pervious/permeable pavements. **Other:** The Green Building Act of 2006 requires LEED certification and includes points for cool and vegetated roofs and private buildings larger than 50,000 square feet.
	Requirements for public buildings	**Other:** The Green Building Act of 2006 requires LEED certification and includes points for cool and vegetated roofs for all public and publically financed commercial projects. Residential projects that involve at least 15% of public financing are required by the act to meet the Enterprise Green Communities criteria, which also include cool and green roof provisions.

TABLE D-6: INDICATORS OF URBAN HEAT TRACKED BY STUDIED CITIES

* Where "Yes" is indicated, please refer to Appendix B for the most recent progress report.

City	UHI goal tracking (yes/no)	Public reporting (yes/no)*	Urban heat trends	Resolution of data collected
Albuquerque	Yes	—	—	—
Atlanta	Yes	Yes	—	—
Austin	Yes	Yes	In 2011 Austin had 90 days over 100 degrees F. 6,000 trees were planted in Austin in 2010.	Block
Baltimore	Yes	—	The city has planted trees, installed roofs, and converted pavement.	Neighborhood, Block, Building
Boston	Yes	Yes	The city is working with some local universities to develop an ongoing measure of UHI and the way it changes over time. Boston has been mapping the satellite trends in heat across the Boston–D.C. area.	Census Track
Charlotte	—	—	—	—
Chicago	Yes	Yes	311 and 911 calls for heat-related emergencies; LANDSAT True Color mapping using GIS to map vegetation change, albedo change, area of reflective surfaces; Temperature change over day and night across Urban Heat island; NDVI in relation to temperature; Albedo in relation to temperature	—
Chula Vista	Yes	Yes	No, San Diego County does all tracking in relation to public health.	—
Cincinnati	Yes	Yes	The Health Department completed a Health impact Assessment on prolonged heat.	—
Dallas	Yes	Yes	—	—
Denver	Yes	Yes	Heat emergencies	—
Houston	No	—	—	—
Las Vegas	Yes	Yes	The City of Las Vegas has 84,563 acres with 9% urban canopy.	—
Los Angeles	No	—	It has been reported that the high temperature in Los Angeles has shown a steady increase from 97 degrees Fahrenheit (36 C) in 1937 to 105°F (40 C) in the 1990s.	Neighborhood
Louisville	Yes	—	Louisville has been collecting temperature and precipitation data from NOAA since 1948. From the 60-year data set, the mean maximum and minimum air temperatures have increased since 1970.	—
New Orleans	No	—	—	—

City	UHI goal tracking (yes/no)	Public reporting (yes/no)*	Urban heat trends	Resolution of data collected
New York	Yes	Yes	The public can view New York City's tracking method for environmental public health through the NYC Health Department portal. NYCCAS has launched a local air-quality study that will monitor and model neighborhood level air quality across the city.	Heat events are tracked by heat index at LaGuardia Airport. Air quality is tracked on the citywide and neighborhood level using land-use regression modelling. Asthma incidence is tracked by ER visits and hospitalizations across three age groups. Heart attack incidence is measured across the hospitals. Housing sustainability is measured across energy use per capita. Climate change is tracked by GHG emissions compared to gross city product.
Omaha	Yes	Yes	—	—
Philadelphia	Yes	Yes	—	—
Phoenix	Yes	Yes	ASU estimates that Phoenix has an 11–13% vegetative cover. Phoenix has an average of 92 days over 100 degrees annually and can be up to 15 degrees warmer than adjacent desert and farmland. ASU provides thermal images of two- mile air temperatures.	—
Portland	Yes	Yes	Bureau of Planning and Sustainability reports annually to City Council on carbon emission trends, fossil fuel use, and CAP implementation progress. Portland State University has developed an urban heat island with 2009 data.	Census Track
Sacramento	Yes	Yes	Sacramento County is designated a severe nonattainment area for exceeding a number of state and national ambient air quality standards based on regulation. Sacramento's poor air quality has significant effects for public health; hot summers make Sacramento especially susceptible to an increase in heat-related illness.	—
St. Louis	Yes	Yes	—	Census Track
Toronto	Yes	Yes	—	—
Vancouver	—	—	—	—
Washington	Yes	Yes	DC tracks trees planted, cool and green roofs, green alleys, and permeable land.	Neighborhood