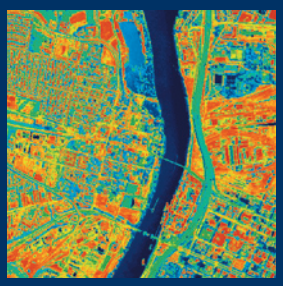
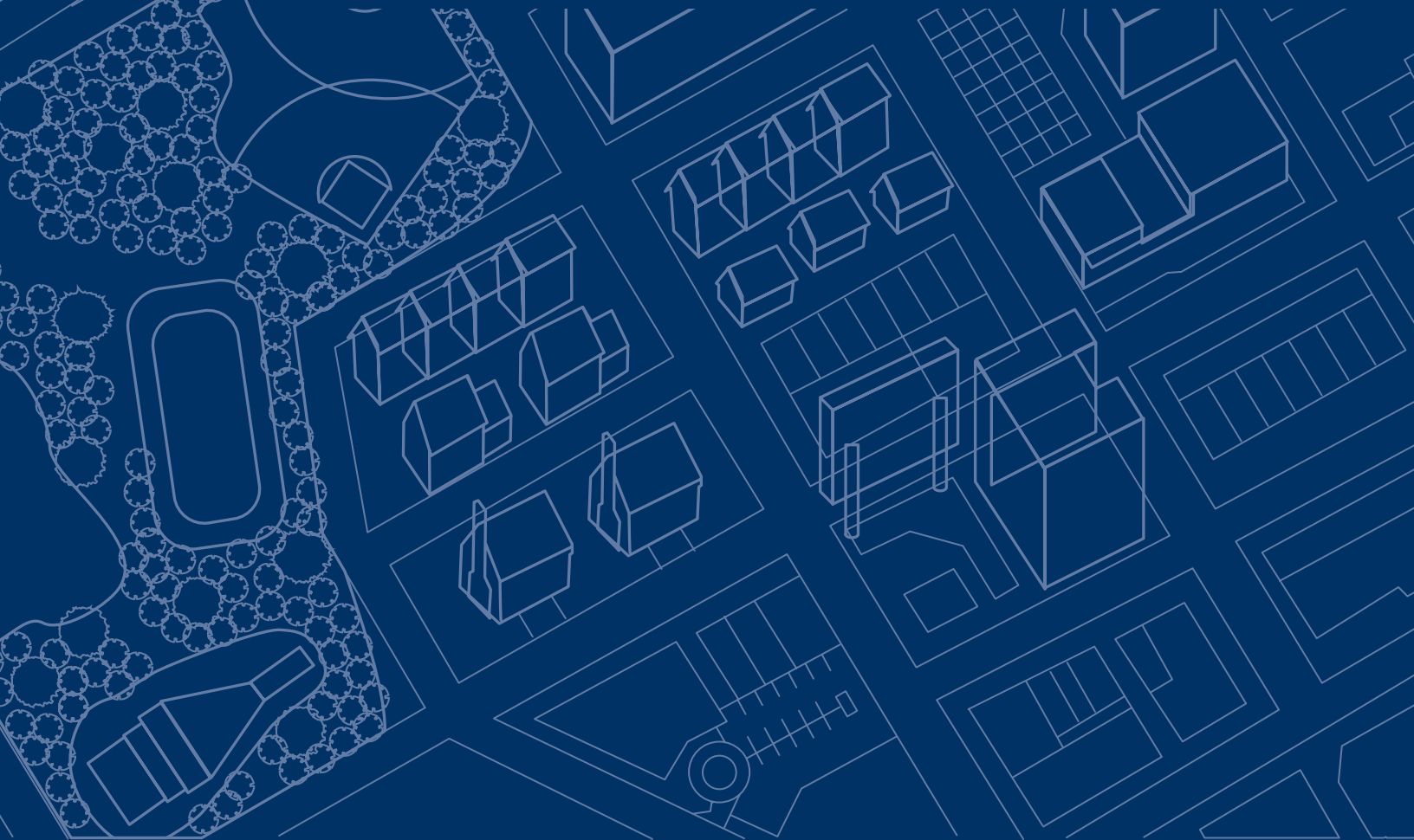




Reducing Urban Heat Islands: Compendium of Strategies

Heat Island Reduction Activities



Acknowledgements

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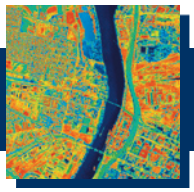
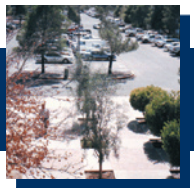




Heat Island Reduction Activities

Across the United States, a diverse group of stakeholders, from government agencies to corporations, have advanced urban heat island reduction strategies—urban forestry, green and cool roofs, and cool pavements—to lower summertime temperatures and achieve many energy and environmental benefits. Typically heat island mitigation is part of an energy, air quality, water, or sustainability effort,[1] and activities range from voluntary initiatives, such as cool pavement demonstration projects, to policy actions, such as requiring cool roofs via building codes. Some communities have elected to implement both voluntary and policy initiatives. These efforts can complement each other, and sometimes an initiative that begins as a voluntary activity becomes required over time.

This chapter draws from the experience of many different groups and covers a range of initiatives to highlight a variety of urban heat island reduction activities around the country. Examples for the following types of activities are included:

- Demonstration projects
- Incentive programs
- Urban forestry programs
- Weatherization
- Outreach and education
- Awards
- Procurement
- Resolutions
- Tree and landscape ordinances
- Comprehensive plans and design guidelines
- Zoning codes
- Green building standards
- Building codes
- Air quality standards.

Heat Island Mitigation Strategies

For more information on heat island reduction strategies, see the corresponding chapters of this compendium: "Trees and Vegetation," "Green Roofs," "Cool Roofs," and "Cool Pavements."

1. Voluntary Efforts

Most community strategies to reduce heat islands have relied on voluntary efforts, which can generally be grouped into the following categories:

- Demonstration projects
- Incentive programs
- Urban forestry programs
- Weatherization
- Outreach and education
- Awards.

Many groups choose to conduct just one kind of activity; others combine approaches. For example, some utilities have focused on cool roof rebates to encourage consumers to install reflective roofing products. Some local environment departments have sponsored demonstration projects, conducted outreach and education efforts to publicize results, and have provided grants to support use of mitigation technologies by residents and industry.

1.1 Demonstration Projects

Local governments, universities, and other organizations have used projects to demonstrate a specific heat island mitigation strategy and quantify its benefits in a controlled environment. Documenting the project and its results can provide the data and publicity needed to develop larger initiatives, promote new technologies and help get them to market, and sometimes even encourage local economic development. (See the "Stimulating Local Economies and Businesses" textbox.)

Communities have found heat island demonstration projects to be most effective when they:

- **Target high-visibility projects.** Focusing efforts on a prominent building or site helps attract attention to heat island mitigation efforts.
- **Measure benefits.** Highlighting anticipated benefits and collecting data on actual impacts provides useful information for planning future activities. These benefits also illustrate to others the reasons and means to act.
- **Convey lessons learned.** Documenting how demonstration projects are conducted makes them easier to replicate and improve.

Lead By Example

"Lead by example" programs involve implementing strategies within local and state government facilities, operations, and fleets, where appropriate. These programs offer energy, environmental, and financial benefits while creating an important opportunity for governments to demonstrate the economic feasibility of the strategies they are promoting. This leadership can raise public awareness of the benefits of urban heat island reduction strategies, which can lead to increased public and private sector support for advancing them.

A variety of organizations can be the chief agents of change and the first to test alternative technologies, often in highly visible, public facilities. Demonstration projects have taken place in parks, schools, and municipal buildings like city hall. These projects often also monitor costs and benefits, such as energy savings. Examples include:

- **Chicago installed a green roof on its city hall** that includes 20,000 plants, shrubs, grasses, vines, and trees. The city expects to save directly more than 9,270 kilowatt-hours (kWh) per year of electricity and nearly 740 million British thermal units (Btu) per year of natural gas for heating. This energy savings translates into about $3,600 annually, and savings will increase with higher energy prices. In addition to assessing energy impacts, the green roof has been designed to test different types of rooftop garden systems, success rates of native and non-native vegetation, and reductions in stormwater runoff. This city hall green roof has helped to raise the visibility of green roofs and to increase public understanding of them. Chicago's Department of Environment staff has frequently given presentations about the roof, which has won numerous awards. For further information, go to <http://egov.city ofchicago.org> and look under the Department of Environment's City Hall green roof project.
- A demonstration project for **Tucson documented how a cool roof reduced temperatures** inside and on the roof of the building and saved more than 400 million Btu annually in energy. A white elastomeric coating was installed over a 28,000-square foot (2,600 m^2), unshaded metal roof on one of the city's administration buildings. Following the installation, energy savings were calculated at 50 to 65

Figure 1: Chicago City Hall Green Roof

Katrin Barth-Scholz/Department of Energy

Chicago's commitment to green roofs includes demonstration projects, such as on its City Hall, education, incentives, and policy actions.

Stimulating Local Economies and Businesses

The non-profit group Sustainable South Bronx has developed several goals for the green roof/cool roof demonstration project on top of its office building in Hunts Point. These goals include gathering research on local benefits, establishing a resource for the community, educating New Yorkers on the value of green roofs, and advocating sustainable building practices. The demonstration project has become a springboard for developing a local green and cool roof installation company to provide employment opportunities in the South Bronx area. The group's business is called SmartRoofs and includes a job-training program for local residents. See <www.ssbx.org/greenroofs.html#> for more information.

percent of the building's cooling energy—an avoided energy cost of nearly $4,000 annually. See <www.swenergy.org/casestudies/arizona/tucson_topsc.htm> for more information.

1.2 Incentives

Incentives have proven to be an effective way to spur individual heat island reduction actions. Incentives from governments, utilities, and other organizations can include below-market loans, tax breaks, product rebates, grants, and giveaways. For example:

- Since 2006, **Baltimore County's Growing Home Campaign has provided $10 coupons** to homeowners toward the purchase of most trees at local nurseries. Each coupon represents $5 of public funds and $5 of retail funds. In order to validate their coupons, homeowners provide information including tree type and location planted, which allows the county to integrate the data with future tree canopy studies. The county began the program as an innovative way to increase tree canopy cover as part of its larger "Green Renaissance" forest conservation and sustainability plan. In the first two months of the program, 1,700 trees were planted. See <http://fpum.org/pdf/MD%20managing_forest_resources.pdf> and <www.baltimorecountymd.gov/Agencies/environment/growinghome/index.html> for further information.
- Since 1990, the **Sacramento Municipal Utility District (SMUD) has partnered with the Sacramento Tree Foundation to provide more than 350,000 free shade trees** to residents in the Sacramento area. This program encourages residents to strategically plant vegetation around their homes to reduce energy consumption. Homes with an eastern, western, or southern exposure that heats up during the summer are eligible for this program. SMUD provides trees between four and seven feet tall (1.2-2.2 m), as well as stakes, ties, fertilizer, tree delivery, and expert advice on tree selection and planting techniques free of charge. Homeowners must agree to plant and care for the trees. See <www.smud.org/residential/trees/index.html> for more information. SMUD also offers rebates to residential customers who use cool roofing technologies. The utility offers a 20-cent-per-square-foot (0.09 m^2) rebate to customers who own single-family, multi-family, or mobile homes with flat roofs and who install ENERGY STAR® cool roof products.
- After the success of its green roof demonstration project, **Chicago established green and cool roof grant programs.** The green roof program cites the ability of green roofs to "create energy savings for building," "lower surrounding urban heat temperatures," and "reduce storm water runoff, improve water quality, and create conditions for longer-lasting roof systems." Similarly, the city recognizes cool roofs "not only help reduce cooling costs, but can also have a positive environmental impact by reducing the urban heat island effect." In 2005, its first year, the program supported 20 green roof installation projects; in 2006, it helped fund 40. In the fall of 2007, the city announced that it was expanding the program to include cool roofs and expected to provide about 55 $6,000 grants. Recipients can use grants for residential, commercial, or industrial buildings. See <http://egov.cityofchicago.org/>, under the Department of Environment portion of the website, for more information.

- The **Pennsylvania Department of Environmental Protection's Energy Harvest Program has been providing grants for specific energy saving projects** since 2003. In 2007, it dispensed more than $500,000 to green roof projects across the state. The Energy Harvest Program overall aims to deploy innovative technologies and encourages "proposals that are market-driven, create jobs, and produce economic development within the Commonwealth." See Energy Harvest Program information available at: <www.depweb.state.pa.us/energy/site/default.asp>.
- In addition to green roofs, building owners can also install vertical gardens—sometimes referred to as green or living walls—on exterior walls to shade buildings and provide evapotranspiration.[2] The **Houston Downtown Management District (HDMD) Vertical Gardens Matching Grant initiative first gave grants in 2007 to encourage plantings that cover walls.** The grants also support exceptional landscaping that adds significant evapotranspiration and shade for blank walls, parking garages, and sidewalks. The program goals include improving overall aesthetics, pedestrian comfort, air quality, and reducing the heat island effect. Grants cannot exceed half of the total project cost or $20,000, and contributions can be in kind. Tenants, property owners, and registered non-profits can all apply. See <www.houstondowntown.com/Home/Business/DoingBusiness/ DevelopmentAssistance/Development%20Assistance.PDF>.
- Since 2002, **Austin Energy has given 10-cent-per-square-foot rebates for cool roof installations**. Customers must use cool roof products that have a minimum reflectivity of 75 percent, and the project must pass a cost-benefit analysis. The utility has been promoting cool roof products as a cost-effective and low-risk approach to reducing cooling loads and peak demand. As of 2005, Austin Energy had awarded more than $164,000 as rebates, representing more than 1.5 million square feet (140,000 m^2) of roof area and saving an estimated 1.25 million kWh of energy. See <www.austinenergy.com/Energy%20Efficiency/Programs/Rebates/index.htm> for more information.

Energy Incentives

The Database of State Incentives for Renewables and Efficiency (DSIRE) provides current information on state, local, utility, and select federal incentives that promote renewable energy and energy efficiency. Some of the incentives listed, particularly those that involve energy efficiency and green building practices, include heat island reduction strategies. See <www.dsireusa.org>.

1.3 Urban Forestry Programs

Urban forestry or tree planting programs exist in most large cities and counties in the United States. These programs generally have broad goals that emphasize the multiple benefits trees can provide, including helping to cool cities. Most of these programs unite diverse stakeholders, and their efforts range from short-term, one-time projects to long-term community revitalization. Moreover, many states give grants to communities and organizations that promote or maintain urban forests. For example, Wisconsin will disburse $530,000 in roughly 40 grants in 2008 as part of a program it has operated since 1993; South Dakota has run a similar program since

1991.[3,4] As of early 2008, the Washington State legislature was working on several bills that would support and expand local urban forestry efforts in recognition of how urban trees and vegetation improve air quality, reduce temperatures, enhance quality of life, and reduce and filter stormwater runoff.[5]

Frequently, urban afforestation focuses on low-income communities, where tree cover is sparse. For example:

- The **Pennsylvania Department of Conservation and Natural Resources oversees a project called TreeVitalize,** which brings together county and local governments, foundations, trade associations, and private industry to restore tree cover in the southeastern part of the state. TreeVitalize aims to plant more than 20,000 trees in approximately 40 neighborhoods in Bucks, Chester, Delaware, Montgomery, and Philadelphia counties. The $8 million program targets neighborhoods in older cities, boroughs, and townships in which tree cover is below 25 percent. See <www.treevitalize.net/> for more information.
- **Groundwork Elizabeth,** a nonprofit group in Elizabeth, New Jersey, **works to involve neighborhood residents** in community revitalization projects,

Tree Maintenance and Education

Many urban forestry programs explain that it is easy to plant trees but difficult to maintain them, particularly until they become well established. In order to ensure most trees survive, programs have enlisted and empowered volunteers to care for trees until they are established. Community participation is important because most urban trees are not under public jurisdiction.

Often tree planting programs train participants in proper tree planting techniques and care. In Pennsylvania, TreeVitalize provides nine hours of classroom and field training to community residents who want to become urban forestry leaders. The classes cover tree identification, planting, pruning, mulching, tree biology/physiology, proper species selection, community tree care, and proper pruning. Residents also can learn how to organize community-assisted tree planting projects. Graduates are eligible to participate in advanced training and other events.

Other programs require community members to pledge to maintain and protect the trees that are planted. For example, Los Angeles residents interested in free trees from the Trees for a Green LA program first participate in an online or neighborhood workshop. Then, they complete a site plan and apply for their free trees. Residents pledge on their applications to plant and care for the trees in a proper manner and allow the city to inspect their work for overall program evaluation and quality assurance. See <www.ladwp.com/ladwp/cms/ladwp000744.jsp>.

Please see the "Trees and Vegetation" chapter of this compendium for more information about urban forestry benefits and implementation considerations.

including tree planting at local schools and parks. The organization was instrumental in getting Elizabeth involved in New Jersey's Cool Cities Initiative, which aims to plant trees primarily in the large cities of New Jersey with low tree coverage. See <www.groundworkelizabeth.com> for more information.

1.4 Weatherization

Communities have used weatherization programs as an opportunity to mitigate heat islands, protect public health, and save energy. Weatherization usually involves making the homes of qualifying residents, generally low-income families, more energy efficient at no cost to the residents. States use weatherization funds provided by the U.S. Department of Energy (DOE) Weatherization Assistance Program to help recipients cover heating bills and invest in energy efficiency actions that lower costs. States can also use the funds to install cooling efficiency measures, such as screening and shading devices.

The **Energy Coordinating Agency (ECA) of Philadelphia,** which administers the city's weatherization services, **has applied cool roof coatings** as part of its package of energy efficiency treatments. Through its Cool Homes Program, more than 550 residences in the Philadelphia area have had their roofs coated. ECA commissioned a study that found the cool coatings and increased insulation eliminated 90 percent of the heat gain through the ceiling, reducing top-floor ceiling temperatures by an average of 4.7°F (2.6°C) and chest-height temperatures by 2.4°F (1.3°C). These reduced temperatures lowered air conditioning loads by about one-third in a typical rowhouse.[6] See <www.ecasavesenergy.org/ses/whiteroof/roof-coolhomes.html> for more information.

Heat Health—An Opportunity to Advance Heat Island Mitigation Strategies

Several large cities have developed programs to minimize health impacts from excessive heat events. These efforts provide an opportunity to educate communities about urban heat islands and promote heat island reduction strategies, particularly shade tree planting and cool roof applications, as a long-term mitigation or adaptation strategy. For example, Philadelphia has long been concerned with reducing heat-related mortality. The city was the first in the United States to implement a Heat Health Watch-Warning System, which has become a worldwide model for heat wave forecasting.

When the Philadelphia Public Health Department educates citizens about excessive heat events and immediate counter-measures, such as using telephone heat hotlines and taking advantage of public air-conditioned buildings, or "cooling centers," it also provides them information about longer-term heat island reduction strategies.

EPA's *Excessive Heat Events Guidebook* explains how local public health officials and others can assess their vulnerability and develop and implement notification and response programs. See <www.epa.gov/heatisland/about/heatguidebook.html>.

1.5 Outreach and Education Programs

Almost all communities have found that heat island reduction efforts involve some element of outreach and education. For example, **TreeUtah has launched a comprehensive initiative, the MetroGreening Program, that uses advertising, outreach, and educational workshops** to help promote proper planting and maintenance of trees to reduce heating and cooling costs, diminish the heat island effect, and achieve other benefits in Utah's most densely-populated regions. See <www.treeutah.org/statewide.htm> for more information.

Further, the Utah State Energy Program, Utah Department of Natural Resources, and the National Energy Foundation worked together to create the **Utah Kool Kids program to teach elementary and secondary age students about urban heat islands,** their impacts on energy and air quality, and heat island reduction strategies. The program gives teachers lesson plans, overheads, test questions, experiments, and research tools to engage students. See <http://www.nef1.org/ea/kool.html> for more information.

Some outreach and education programs focus specifically on reaching students. The **Cool Schools program in Los Angeles teaches students to become environmental stewards** through hands-on and classroom experience. Through the project, students have helped plant hundreds of trees around Los Angeles schools. Cool Schools creates an opportunity to teach lessons on biology, botany, horticulture, and related topics. See <www.ladwp.com/ladwp/cms/ladwp001087.jsp>.

1.6 Awards

Governments, community groups, and corporations have rewarded exemplary work as a way to highlight innovation and promote solutions to mitigate heat islands across the public and private sectors. Examples of award programs include:

- **Home Depot Foundation's Awards of Excellence for Community Trees.** Since 2005, this foundation has recognized public/private collaborations for their leadership and development of successful tree planting initiatives. Winning projects in large and small city categories receive $75,000 and runners-up receive $25,000. Though the city and nonprofit winners are both recognized, the award money is given to the nonprofit for continued tree planting work.
- **Green Roofs for Healthy Cities' Green Roofs Awards of Excellence.** Since 2003, this nonprofit has recognized a variety of green roof projects for integrated design and implementation. The program rewards extensive and intensive green roof projects, as well as research teams and citizens who have advanced the implementation of green roofs though public policy.
- **ENERGY STAR Awards.** Since 1993, EPA has hosted the ENERGY STAR Awards to recognize outstanding participants in the ENERGY STAR Program. National Coatings Corporation, a manufacturer of cool roof materials, was recognized in 2000. The San Diego Unified School District (SDUSD) won an award in 2007 because more than 140 of its 200 buildings met ENERGY STAR criteria. Some of those buildings included cool roofs combined with photovoltaic cells that could produce more than 3.5 MW of electricity.[7]

Figure 2: Cool Roofs with Solar Panels in San Diego

SDUSD

The San Diego Unified School District won an ENERGY STAR award in 2007 because almost 70 percent of its buildings, including this elementary school with a cool roof and solar panels, met ENERGY STAR specifications.

- **EPA's Regional Office in New England's Environmental Merit Award Program.** For more than 30 years, EPA Region 1 has honored teachers, citizen activists, business leaders, scientists, public officials, and others who have made outstanding contributions to public health and the natural environment. Awards are given across environmental disciplines and have highlighted heat island reduction strategies, such as cool roofs. In 2005, Sarnafil Roofing Systems, Inc., received a Merit Award for its highly reflective roofing products.[8]

2. Policy Efforts

Some local and state governments have included urban heat island mitigation strategies in policies or regulations, which range from purchasing guidelines to building codes. A number of these actions have helped remove barriers or provide incentives for implementing mitigation strategies. Others have prescribed minimum requirements, especially for new construction. Policy efforts can include:

- Procurement
- Resolutions
- Tree and landscape ordinances
- Comprehensive plans and design guidelines
- Zoning codes
- Green building standards
- Building codes
- Air quality standards.

2.1 Procurement

Many local governments interested in mitigating heat islands started by procuring cool technologies for municipal buildings. Since state and local governments usually put construction work and material supplies out for bid, they can revise bid specifications to include cool products.

For example, **Tucson, Arizona, requires that air-conditioned city facilities use cool roofing materials** for most new construction and roof replacements. The city revised its general bid criteria to ensure that materials used are equivalent to those on the ENERGY STAR Roofing Products list. When a local government requires contractors to use cool products in this manner, it becomes easier to encourage additional use of these products on private projects.

After successfully demonstrating the use of permeable pavements, Chicago began a Green Alley initiative that encourages use of porous paving whenever an alley needs to be re-paved. Forty-six alleys were renovated under this initiative in 2007, and ultimately, almost 2,000 miles of alleyways will be made permeable. The "Chicago Green Alley Handbook" can be found through the website < http://egov.cityofchicago.org/> under the City Department of Transportation programs.

Figure 3: Permeable Pavement in Chicago Alley

City of Chicago

Raking gravel into a Gravelpave2 system.

2.2 Resolutions

A resolution is a document stating a group's awareness of and interest in an effort, such as a heat island mitigation project. Generally, a city or county council, or organizations such as air quality boards or planning commissions, issue resolutions. A resolution does not necessarily indicate that a program will be supported financially, but it can be the first step in getting an initiative started.

In May 2001, **the Austin City Council adopted a heat island mitigation resolution** that committed the city manager to review recommendations for a variety of activities to diminish heat islands. In September of that year, the city council awarded $1 million toward implementing the recommendations, which ranged from developing a cool roof strategy to increasing enforcement of the city's tree-saving ordinance. See <www.ci.austin.tx.us/trees/res_985.htm> for more information.

In October 2006, **Annapolis, Maryland, adopted a comprehensive energy efficiency resolution** that included general goals and specific long-term targets for adopting a range of energy efficiency measures. One recommendation was to increase tree shading so that the city could sequester carbon dioxide (CO_2), reduce the urban heat island effect, and lower ozone levels. In 2007, the city adopted a new tree protection ordinance as one step towards protecting existing shade trees, discussed below. See <www.annapolis.gov/upload/images/government/council/Adopted/R3806.pdf> for more information.

Model Resolutions and Policies

The International Council for Local Environmental Initiatives (ICLEI), a nonprofit organization, runs an Urban Heat Island Initiative program that provides assistance to local governments. ICLEI hosts a website <www.hotcities.org> that provides policy information, such as sample language for developing a heat island resolution and a model policy framework.

ICLEI works with local governments to coordinate workshops throughout the United States to help understand heat island impacts and mitigation strategies. These workshops can help communities develop a heat island mitigation project or program. See <www.hotcities.org/Workshops/index.htm> for more information.

2.3 Tree and Landscape Ordinances

Many local governments have enacted tree and landscape ordinances, which can ensure public safety, protect trees or views, and provide shade. Three types of ordinances, in particular, are most useful from a heat island perspective: tree protection, street trees, and parking lot shade.

Tree Protection

Tree protection ordinances prohibit the removal or pruning of trees without a permit. Often, these ordinances apply only to native trees or trees with historical significance. The effectiveness of this type of provision depends on enforcement and how strict the requirements are for granting tree removal permits.

Some ordinances protect not only trees but also the ground under the crown area of a tree to prevent root damage. An ordinance in **Atlanta, Georgia, for example, requires that at least 16 square feet (1.5 m^2) of soil around the tree must remain unpaved** and open to the air. Toxic chemicals also must be kept away from the trees. These ordinances are less common than those that simply restrict removal.

Another approach, often linked to a local government's subdivision or development code, is protecting tree stands during new construction. In this case, developers are required to preserve tree stands during site design and protect them once construction commences. The ordinances can require protection based on the percentage of a site, or a minimum point value, with larger, mature trees earning more points.

Annapolis, Maryland, explicitly recognized the environmental value of trees and acted to protect them during construction. The "Tree Protection Ordinance" requires a survey of trees on a proposed development site and fences or other means to mark and protect designated trees during construction. The ordinance also prohibits certain activities, such as trenching or grading, within the dripline of trees, unless specific precautions are followed. More information on this ordinance is available under §17.09 City Code at <http://bpc.iserver.net/codes/annapolis/>.

Figure 4: Fences Protect a Tree During Construction

TLCforTrees

Fences can protect not just a tree's trunk and branches, but also its root system during construction.

San Antonio, Texas, requires different levels of tree protection based on tree class or location. The ordinance classifies significant trees, heritage trees, and trees within the 100-year floodplain. For example, heritage trees (defined, for most species, as trees 24 inches [60 cm] or greater in diameter at breast height [DBH]), must be preserved. The ordinance, however, generally counts total tree diameter-inches at a site, not individual trees, and gives flexibility in preservation: up to 90 percent of the tree-diameter-inches can be considered preserved if the developer plants an equal or greater number of tree-diameter-inches elsewhere. Developers can also fulfill the preservation requirement by contributing to the city's tree fund. For details, see the ordinance and its amendments at <http://epay.sanantonio.gov/dsddocumentcentral/upload/2003%20Tree%20Preservation%20Ordinance.pdf> and <http://epay.sanantonio.gov/dsddocumentcentral/upload/Revised%20Tree%20Amend%2011-06.pdf>.

Street Trees

Street tree ordinances generally govern how to plant and remove trees along public rights-of-way and land that is privately

owned but accessible by the public. At a minimum, these ordinances designate the numbers or types of trees that should be planted. More effective street tree policies include guidelines on tree selection, installation, and maintenance to lengthen a street tree's life and minimize problems with pavement, electrical wires, and buildings.

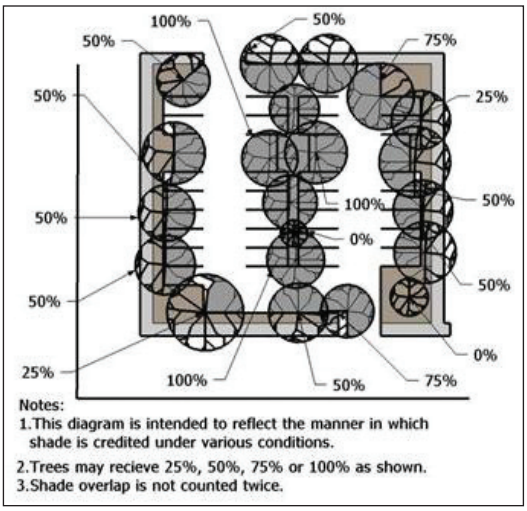
For example, **Orlando, Florida, specifies that trees must be planted along both sides of a street,** with one tree every 50 to 100 feet (15-30 m). The selected trees must eventually be capable of reaching a minimum height of 40 feet (12 m) and a crown spread of 30 feet (9 m). The ordinance is available at <www.municode.com/resources/gateway.asp?sid=9&pid=13349>.

Seattle requires a street use permit before landscaping in a planting strip in a public right-of-way. For street trees, the strip must be at least 5 feet (1.5 m) wide, unless specific approval from the city's arborist is received. Five feet is generally recommended as the minimum width for planting most trees. A guide is available to help property owners select and plant trees in accordance with the city's requirements. See <www.seattle.gov/trasportation/treeplanting.htm> for further information.

Parking Lot Shade

Some communities require parking lots be shaded to cool pavement and cars, which increases comfort, reduces the heat island effect, and lowers evaporative emissions from parked cars. For example, since 1983, **an ordinance in Sacramento's zoning code has required that enough trees be planted to shade 50 percent of new, or significantly altered, parking lots** after 15 years of tree growth. A 2001 study found that the lots were only achieving about 25 percent shading because sometimes shade was double-counted, trees did not grow to their expected size under the conditions

Figure 5: Parking Lot Shade Guidelines



City of Elk Grove, California

Shade diagrams, such as this one from Elk Grove, California, help determine if planned or actual vegetation meet the communities guidelines.

of the lot, or trees were not adequately dispersed.[9] Thus, Sacramento modified its code in 2003 to improve coverage.[10]

Chicago has a landscape ordinance that requires planting trees or shrubs on parkways and landscaping parking lots, loading docks, and other vehicular use areas, both within the sites themselves and to screen their perimeter. The ordinance applies to most new building construction, as well as to repairs, remodeling, and enlargements of a particular size and cost. The Bureau of Forestry, which maintains the standards, must inspect and approve all parkway vegetation prior to planting. The Chicago Department of Zoning reviews all building and zoning permit applications to ensure compliance with the ordinance. See <http://egov.cityofchicago.org/webportal/COCWebPortal/COC_EDITORIAL/11_Landscaping_and_Screening.pdf>.

In 2007, the city of **Baton Rouge strengthened its landscape ordinance,** which requires tree planting on all new developments, excluding single-family residences. The ordinance requires two shade trees for every 5,000 square feet (465 m^2) of site, and

one shade tree per 600 square feet (55 m^2) of street frontage. Parking lot requirements include one shade tree per 15 parking spaces for a lot with one to 25 spaces; one shade tree per 12 parking spaces for a lot with 25 to 100 spaces; and one shade tree per 10 parking spaces for a lot over 100 spaces. For example, a 10,000-square-foot (465 m^2) site with 600 square feet (55 m^2) of storefront and 150 parking spaces would require 20 shade trees (i.e., four for the square footage of the site, one for the store frontage, and 15 for the parking lot). For more information on Ordinance 12692, see the city's information bulletin at <http://brgov.com/dept/planning/udc/pdf/Chapter18.pdf>.

2.4 Comprehensive Plans and Design Guidelines

Comprehensive plans and design guidelines are another way that communities have incorporated opportunities to promote heat island reduction. Comprehensive plans, sometimes called general plans in California and other states, are adopted by a legislative body of a local government, and set forth policies, goals, and objectives to direct development and conservation that occurs within its planning jurisdiction. They generally have a broad scope and long-term vision. Design guidelines provide a connection between general planning policies and implementing regulations, such as zoning codes and subdivision regulations. Design guidelines convey a sense of the preferred quality for a place by being descriptive and suggestive.

The **"Environmental Planning Element" in the Gilbert, Arizona, general plan lists mitigating heat islands as a core goal.** Specific policies under the goal include: 1) developing criteria that will identify projects that might contribute to the heat island effect and will require an evaluation of mitigation techniques; 2) seeking sponsors such as educational institutions, utility companies, and government entities to promote heat island awareness among landowners, developers, engineers, and architects; and 3) promoting design concepts using engineered green space to maximize shading of surfaces that tend to heat up, promote education and awareness of cool roof materials and construction techniques, and promote alternative pavement technologies in parking areas. For more information see <www.ci.gilbert.az.us/generalplan/chapter07.cfm>.

Design guidelines can take a holistic approach to heat island mitigation or specific mitigation strategies. For example, **Toronto's Official Plan includes policies to reduce the urban heat island and achieve a wide range of environmental gains.** As part of that plan, the city released draft parking lot guidelines in November 2007 that call for shade trees, permeable and reflective pavements, and other design features to manage stormwater, reduce energy consumption, and lower urban temperatures.[11]

The town of **Highland, Utah, created a master plan for a 50-acre (200,000 m^2) overlay zone** to be privately developed as a town

Figure 6: Portland Eco-Roof

Portland BES

The Portland Bureau of Environmental Services (BES) has a green roof on its headquarters. The city allows denser development for projects that use green roofs, or eco-roofs as the city calls them.

center. The city design guidelines for the zone recommended several heat island mitigation elements, including reflective roofing, reflective parking lot surfaces, and landscaping. Those guidelines were then adopted into the zoning requirements for the town center.

In contrast, **Portland, Oregon, has focused on the use of eco-roofs** in the city center district, primarily for their aesthetic and stormwater management benefits. Design guidelines call for integrating vegetated roofs into central city projects. As discussed in the next section, Portland has taken specific steps in its zoning code to achieve this result.

2.5 Zoning Codes

Zoning codes implement the goals and objectives of a comprehensive plan. These regulations generally dictate function for an area, building height and bulk, population density, and parking requirements. Zoning codes can also promote heat island mitigation strategies in various ways. For example, as noted in Section 2.3, cities such as Sacramento have adopted parking lot shading requirements as part of their zoning codes.

Communities have also allowed density bonuses for construction that adopts mitigation strategies. In 2001, **Portland, Oregon, modified its zoning code to include an "eco-roof development bonus"** for developers to install rooftop gardens or "eco-roofs." In Title 33 of the Zoning Code there is a floor area ratio bonus for projects that install eco-roofs in Portland's central district. The bonus amount depends on the extent of the eco-roof coverage. If the eco-roof covers 60 percent or more of the roof surface, developers can build an additional 3 square feet (0.3 m^2) for each square foot of green roof. If the green roof covers a lower percent of the surface, the bonus is reduced. See Section 33.510 of the code at <www.portlandonline.com/shared/cfm/image.cfm?id=53363> for specific information.

Chicago also has a similar provision, with the floor area ratio density bonus based on the amount by which a green roof exceeds 50 percent of the roof surface.

2.6 Green Building Programs and Standards

Green building initiatives place a high priority on human and environmental health and resource conservation over the life cycle of a building. Many local, state, and federal governments have adopted green building programs, or standards, that capture heat island reduction strategies.

For example, local governments such as **Arlington, Virginia, and San Jose, California,**[12] are basing their municipal green building requirements on the **U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) Rating System™. Green Globes,** operated by the Green Building Initiative (GBI) in the United States, is another rating system that communities are using. The **Canadian government** requires all federal buildings to meet the Canadian version of Green Globes, **Go Green** and **Go Green Plus**. States like **Arkansas and Maryland recognize both LEED and Green Globes** in their green building initiatives. Under both rating systems, buildings can earn credits towards certification by providing shade vegetation, installing cool or green roofs, and using highly reflective and emissive pavements or permeable paving products, all measures that reduce the heat island effect.

Specific to homes, programs such as **EarthCraft House,** created by the Greater Atlanta Home Builders Association and Southface Energy Institute, award points for residences that preserve and plant trees, install ENERGY STAR cool roof products, or use permeable pavement. In addition, EarthCraft Houses must meet ENERGY STAR certification. Communities from **Virginia to Florida have constructed EarthCraft homes.**

Seattle Green Factor

Seattle has adopted minimum landscape requirements, known as the Seattle Green Factor, for new developments in commercial areas in the city. This program requires that, as of late January 2007, certain new developments in neighborhood business districts must provide for vegetative cover on the equivalent of 30 percent of the applicable property. The regulations apply to developments with more than four dwelling units, more than 4,000 square feet (370 m^2) of commercial uses, or more than 20 new parking spaces. Developers can use a menu of strategies, including planting new trees, preserving trees, and installing green roofs and green walls to meet this target. The regulations are part of the city's Commercial Code and encourage planting of layers of vegetation and larger trees in areas visible to the public. The rules also include bonuses for harvesting rain water and choosing plants that need less water. The city has developed a worksheet to help applicants calculate a "score" that indicates whether various mixes of landscaping measures meet the requirements, which will allow developers to try different combinations of features. See <www.seattle.gov/dpd/permits/greenfactor/> for more information.

Figure 7: Seattle Public Library

Green Roofs for Healthy Cities

Seattle promotes green roofs, such as this one on a city library, through its Green Factor program.

Meanwhile, since 1996, the city's Neighborhood Matching Fund program has provided more than 17,200 trees to more than 600 neighborhood groups for Seattle's streets and parks, and the city has established the Emerald City Task Force, which advises the city on incentives and policies to encourage private property owners—residential and commercial—to improve their land by preserving existing trees and planting new ones. See <www.seattle.gov/trees/> for more information.

Further, the **National Association of Home Builders** is working with the **International Code Council** to develop **a national green building standard for homes** that captures heat island reduction strategies as well.

Whereas the above efforts allow building owners to choose technologies and do not guarantee that heat island reduction strategies will be included in the mix, **some communities, such as Frisco, Texas, have gone so far as to require cool roofs in their commercial green building programs.** In late 2006, the Frisco City Council approved requirements for most new commercial construction to install ENERGY STAR labeled cool roof products.

2.7 Building Codes

Building codes are regulations adopted by local and state governments that establish standards for construction, modification, and repair of buildings and other structures. An energy code is a portion of the building code that relates to energy usage and conservation requirements and standards (see <www.energycodes.gov>). Some cities and states have begun including cool roofing in their building codes because of its potential to save energy, particularly during peak loads. For example:

- In January 2003, **Chicago amended its energy code to require roof installations on or prior to December 31, 2008, to meet a minimum solar reflectance** of 25 percent. The amendments apply to most air-conditioned buildings with low-sloped roofs. After December 31, 2008, contractors must use roofing products that meet or exceed the minimum criteria to qualify for an ENERGY STAR label.
- **Georgia was the first state to add cool roofs to its energy code,** in 1995. Georgia allows a reduced roof insulation level if a cool roof with a 75 percent minimum solar reflectance and 75 percent minimum thermal emittance is installed.[13] Note that if building owners install a cool roof and simultaneously reduce insulation, there may be no net energy savings.
- **Florida also gives cool roofs credit** in its building energy code. Buildings using a roof with 70 percent minimum solar reflectance and 75 percent minimum thermal emittance are eligible to reduce the amount of insulation needed to meet building efficiency standards, as long as a radiant barrier

The Foundation for Including Cool Roofs in Energy Codes

The American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) has developed energy-efficient design standards that provide minimum requirements for both commercial and residential buildings. The ASHRAE standards underlie most state building and energy codes. ANSI/ASHRAE/IESNA Standard 90.1-1999, *Energy Standards for Buildings Except Low-Rise Residential Buildings*, and ANSI/ASHRAE Standard 90.2-2001, *Energy-Efficient Design of Low-Rise Residential Buildings*, provide guidelines for new equipment, systems, and buildings. These standards originally were developed in response to the 1970s energy crisis and now include credits pertaining to cool roofing. For example, Addendum f to 90.2-2001 allows high-albedo roofs in hot and humid climates as part of the energy efficiency ceiling calculation for a residential building.

is not also installed in the roof plenum or attic space.

- In response to electrical power shortages, **California added cool roofs as an energy efficiency option to its building energy code** (Title 24) in 2001. The code defines a cool roof as having a minimum solar reflectance of 70 percent and minimum thermal emittance of 75 percent, unless it is concrete or clay tile, in which case it can have a minimum solar reflectance of 40 percent. This 40-percent rating incorporates new cool-colored residential products into the standard. In 2005, these cool roof provisions became mandatory requirements for all new non-residential construction and re-roofing projects that involve more than 2,000 square feet (180 m^2) or 50 percent replacement.[14] The code allows owners to meet these requirements in a variety of ways.
  - The simplest approach is to apply a cool roof that meets the minimum requirements.
  - Another alternative is to use roof products that do not meet the cool roof criteria and then offset the reduced performance levels by implementing other measures, such as insulation and window improvements, that exceed minimum requirements.
  - The third, and most flexible option, is to use whatever methods are deemed practicable as long as the code's specific performance goal is reached. In this scenario, the building owner creates a model of all the characteristics that affect the energy consumption of the building to determine the mix of measures that will meet the code criteria. The California Energy Commission provides computer software for this compliance option.

Cool Roofs in California

California has a long history of supporting cool roof research and implementation to alleviate peak energy demand. In 2001, the state passed legislation that activated emergency measures, including cool roofs, to reduce peak demand and mitigate the energy crisis. The cool roofs program was subsequently formalized as the Cool Savings Program, which provided rebates to building owners for installing roofing materials with high solar reflectance and thermal emittance. The highest rebate went to roofs on air conditioned buildings, while buildings with rooftop ducts and other non-residential buildings were eligible for a slightly lower rebate. The program was administered by the California Energy Commission but implemented by five organizations directly responsible for promoting the program, recruiting customers, verifying project completion, and paying incentives of 15 to 25 cents per square foot (0.09 m^2) of eligible roofing area. The program was so successful that California revised Title 24 to make cool roofs on certain new or renovated buildings mandatory starting in 2005.

California began the process of updating Title 24 in late 2005, with final revised standards due in 2008. As part of this update, California is investigating extending cool roof requirements to houses and buildings with steep-sloped roofs. See <www.energy.ca.gov/title24/2005standards/index.html> and <www.energy.ca.gov/title24/2008standards/index.html> for further information.

2.8 Air Quality Requirements

As summertime temperatures rise, the rate of ground-level ozone formation, or smog, increases. By lowering temperatures, urban heat island mitigation strategies can help reduce ground-level ozone concentrations. Many cities and counties are struggling to attain national ambient air quality standards (NAAQS), particularly for ground-level ozone. Most of these areas have adopted a wide range of emission control strategies on traditional air pollution sources and are seeking innovative ways to further reduce air pollution levels. Communities are considering urban forestry and cool roofs, in particular, as technologies that can help them reach attainment.

Under the Clean Air Act, State Implementation Plans (SIPs) are federally approved and enforceable plans that identify how each state will meet and maintain federal air quality standards. **EPA has developed three policies that help states to include heat island reduction strategies in their SIPs.** See the "Policies to Advance Heat Island Mitigation in SIPs" textbox.

A few areas have been working to include heat island reduction strategies in their SIPs, including Atlanta, Houston, Sacramento, and the Washington D.C. metropolitan area. In 2006, **Sacramento secured a large Congestion Mitigation and Air Quality (CMAQ) Improvement Program grant to work on including urban forestry in its SIP.** The project, known as the Urban Forests for Clean Air demonstration project, involves the Sacramento Tree Foundation, the USDA Forest Service, the Sacramento Area Council of Governments, and the Sacramento, El Dorado, Placer, and Feather River Air Districts. The project includes three phases: 1) initial estimates of the effects of the urban forest on air quality; 2) development of improved models to analyze these impacts; and 3) a final report on the findings. Under the first phase, the Forest Service's Center for Urban Forest Research estimated the impacts of trees on air quality using existing models and statistical analyses. That analysis predicted that one million additional trees could lower emissions of NO_x by almost a quarter ton per day and particulate matter by over one ton per day. If trees that emitted low levels of volatile organic compounds (VOCs) were chosen, ground-level ozone could also be reduced by 1.5 tons daily. The long-term goal for the project is to develop the technical support for a SIP revision that includes large-scale, urban tree planting as a ground-level ozone reduction control strategy for the Sacramento region. See <http://www.fs.fed.us/psw/programs/cufr/products/psw_cufr696_SacramentoAirQuality.pdf> and <www.sactree.org> for more information.

Heat Island Mitigation Strategies Reduce Ground-Level Ozone

Ground-level ozone forms more readily when air temperatures rise. Strategies to mitigate the urban heat island reduce air temperatures and therefore decrease concentrations of ground-level ozone. These strategies also reduce energy demand for cooling, which reduces air pollution and greenhouse gas emissions associated with energy production. When selecting vegetation for a green roof or to plant along a street or other areas, communities in areas with poor air quality may want to consider the volatile organic compound (VOC) emissions from certain plants, because VOCs are a pre-cursor chemical for ground-level ozone. With the right choice of species, the benefits of additional trees and vegetation far outweigh the costs.

Policies to Advance Heat Island Mitigation in SIPs

Currently, three EPA policies help states to include heat island reduction strategies in their SIPs:

1. The Emerging and Voluntary Measures Policy provides flexibility for states to include in their SIP nontraditional measures, which are measures that do not directly reduce emissions at their source such as a scrubber on a utility smokestack. Heat island reduction strategies can be included under this policy.
2. The Guidance on State Implementation Plan (SIP) Credits for Emissions Reductions from Electric-Sector Energy Efficiency or Renewable Energy Measures provides state and local air quality officials with information on how to incorporate energy efficiency and renewable energy measures into their SIPs. It includes a step-by-step procedure for estimating emission reductions from these measures, a list of tools and resources for more information, and examples of proposed SIP submissions. This policy encourages cool roofs particularly. See <http://www.epa.gov/ttncaaa1/t1/memoranda/ereseerem_gd.pdf >.
3. The Bundled Measures Policy allows a state to combine many projects and programs that individually would not result in large reductions of air pollution emissions. EPA considers the performance of the entire bundle (the sum of the emissions reductions from all the measures in the bundle) for SIP evaluation purposes, not the effectiveness of any single measure. In this way, the responsible agency can include innovative strategies, such as heat island mitigation measures, that may otherwise be overlooked because they do not on an individual basis provide significant air quality benefits.

The **Washington D.C. region's SIP includes a Regional Canopy Management Plan as a ground-level ozone reduction strategy.** The plan involves working with local governments to establish goals for increasing tree canopy coverage and decreasing ground-level ozone pollution. In June 2007, Fairfax County, Virginia, set a precedent by selecting an urban forestry canopy goal of 45 percent. The county developed this target after it determined that current tree management efforts would lead to a decrease in canopy size from 41 percent to 37 percent over the next 30 years. To combat this loss, the county has proposed increasing the average number of trees planted from 21,000 to 84,000, justifying the expense of additional trees by citing the multiple benefits they provide.

Figure 8: Tree Canopy in Washington D.C.

U.S./Japan ASTER Science Team

Construction in and around Washington, D.C., has reduced tree cover (green in this image), but many efforts have formed to slow or reverse this trend.

Endnotes

1 Examples of sustainable or low-impact development (LID) initiatives are The Sustainable Sites Initiative (<http://sustainablesites.org>), a collaboration between the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center, the US Botanic Garden, and other groups; and EPA's Low Impact Development Page (<www.epa.gov/owow/nps/lid/>) and Green Infrastructure Action Strategy (<http://cfpub.epa.gov/npdes/greeninfrastructure/information.cfm#greenpolicy>).

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