Opportunities to Advance Heat Island Mitigation Policy

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ABSTRACT

In an ideal world, communities would understand how heat islands form, and how they impact their lives. Decision makers would consider heat island mitigation strategies amongst other options they traditionally consider when mitigating pollution, reducing energy demand, and developing or redeveloping areas. Cool roofs and cool pavements would have a larger share of the market, and more shade vegetation would be planted.

While heat island mitigation research and implementation has progressed, significant advancements have yet to be realized. This lack of advancement may be due to the following barriers: (1) Heat island mitigation is interdisciplinary and technically complex. It requires partnering with multiple stakeholders to develop and implement policies and to obtain political backing to promote enforceable actions. (2) Many implementation questions still need to be addressed, and practitioners need guidance in various formats for different applications. (3) Decision makers do not have adequate information on benefits. (4) Stronger incentives need to be provided.

This paper discusses three areas where the U.S. Environmental Protection Agency (EPA) can address these barriers and advance adoption of heat island mitigation policies – making them standard practice: (1) Integrate heat island mitigation with health policy and community development; (2) Incorporate heat island mitigation into air quality planning; and (3) Build state and local capacity by providing implementation guidance, technical assistance, tools, outreach, and forums for sharing information.

Introduction

For several years, researchers have been studying heat islands in large and small, low and mid-latitude cities. Comparisons of temperature data from paired urban and rural weather stations, field campaigns, and transect studies indicate that urban temperatures have been increasing in cities around the world and that much of the recent warming trends in urban areas are due to the heat island effect.

Researchers and practitioners have identified the following actions to mitigate heat islands: developing ratings and labels for cool materials, revising building performance standards to include heat island mitigation technologies, providing utility incentive programs, and granting air quality credit for heat island mitigation strategies (Rosenfeld et al. 1998).

Researchers have published new studies on cool roof technologies (Akbari et al. 1997; Akbari & Rainer, 2000; Parker, Sonne & Sherwin 1997; Wilkes et al. 2000), cool pavements (Levinson & Akbari 2001; Pomerantz et al. 2000; Ting, Koomey & Pomerantz 2002), shade vegetation (Akbari, Pomerantz & Taha 2001; Clark, Matheny & Nelda 1998; Simpson 1998) and air quality and meteorological impacts of heat island mitigation measures (Emery, Taha & Gero 2000; Gorsevski et al. 2000; Taha, Chang & Akbari 2000).

Local, state, and national level stakeholders have also implemented actions to mitigate urban heat islands. Most of these actions have occurred within the last five years:

- The EPA and the Department of Energy (DOE) launched the ENERGY STAR® Labeled Roof products program to identify reflective roofing products that decrease heat transfer into flat and sloped-roof buildings.
- The U.S. Green Building Council incorporated landscape and exterior design criteria to reduce heat islands into its Leadership in Energy & Environmental Design (LEED) Rating System 2.0.
- The American National Standard Institute (ANSI) / American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) / Illuminating Engineering Society of North America (IESNA) Standard 90.1-1999 was modified to include reflective roofs.
- The American Society for Testing and Materials (ASTM) developed standards to measure and calculate solar reflectance of horizontal and low sloped surfaces (E1918-97 and E 1980-01) and established a subcommittee to create standards for green roofs.
- Arizona, California, Florida, Georgia, Maine, Massachusetts, and Chicago have or are modifying their energy codes to consider or require cool roofs.
- The California Energy Commission (CEC) launched the “Cool Savings Program,” a $24.5 million cool roof rebate program.
- Utilities, including the Sacramento Municipal Utility District (SMUD), the Los Angeles Department of Water and Power (LADWP), and Florida Power & Light have been offering cool roof incentive and shade tree planting programs.
- The EPA issued the “Stationary Sources Voluntary Measures Policy,” which allows states to obtain limited credit for heat island mitigation in their air quality plans.

Despite this progress in research and implementation, heat island mitigation policy has not advanced significantly. For EPA, significant advancement would include the following: (1) Communities would have a broad understanding of how heat islands form, and how they impact air quality, energy demand, and health. (2) Decision makers (e.g., local, regional, and state officials from Departments of Energy, Environment, Public Works, Planning, Health, Air Quality, and Transportation) would consider heat island mitigation strategies amongst other traditionally considered options. For example, energy officials would consider cool roofs, cool pavements, and shade trees among the other energy saving options available, and air quality planners would consider heat island mitigation among other pollution control/prevention measures. (3) Heat island mitigation technologies, cool roofs and pavements, would have a larger share of the market, and more shade vegetation would be planted.

This lack of advancement may be due to these barriers: (1) Heat island mitigation is interdisciplinary and technically complex. It requires partnering with multiple stakeholders to develop and implement policies and to obtain political backing to promote enforceable actions. (2) Many implementation questions still need to be addressed, and practitioners need guidance in various formats for different applications. (3) Decision makers do not have adequate information on benefits. (4) Stronger incentives need to be provided.

To address these barriers, EPA proposes three courses of action to advance the adoption of heat island mitigation policies – making them standard practice: (1) Integrate heat island mitigation with health policy and community development; (2) Incorporate heat island mitigation into air quality planning; and (3) Build state and local capacity by providing implementation guidance, technical assistance, tools, outreach, and forums for sharing information.

Making Heat Island Mitigation "Standard Practice"

Heat Island Mitigation, Health Policy, and Community Development

Integrating heat island mitigation with health policy and community development can bring multiple stakeholders together. In addition, providing state and local officials with information on lives saved by reducing heat island effects can provide strong incentive to address heat islands.

Heat is the leading weather related killer in the United States. In an average year, approximately 1,100 Americans die from extreme heat (Kalkstein 1993).[1] Heat islands negatively impact health not only by contributing to extreme heat events, but also by contributing to elevated ozone concentrations.

Since it is apparent that hot weather contributes to increased morbidity and mortality in large urban areas, state and local governments have long been concerned and aware of the debilitating effects of heat on health. Several state and local health departments monitor temperatures and humidity across their states, develop heat crisis procedures, and educate and advise citizens to prevent heat-related illness and death. Several cities including Philadelphia, New Orleans, Phoenix, Dayton and Cincinnati, and Toronto have developed adaptation actions (e.g., Heat Health Watch Warning Systems (HHWWS)) that include sophisticated response systems to reduce heat-related deaths (Kalkstein et al. 1996). State and local governments' strong interest in heat adaptation provides an opportunity to promote heat island mitigation to these stakeholders.

Heat island mitigation also needs to be firmly placed on the agenda of community development and urban planning officials. The Smart Growth movement, which has gained much momentum, often indirectly addresses heat island mitigation because many recommendations to mitigate heat islands fall within the purview of and are in agreement with Smart Growth policy. Examples include promoting infill development, reducing the amount of permeable surfaces, and greening.

To encourage collaboration between these groups, which can help overcome the barrier of partnering with multiple stakeholders, and to add valuable information to the dialogue needed to develop sound policy, the EPA initiated a study with Tulane University and the University of Delaware to determine the potential for heat island mitigation to alleviate heat-related mortality. The University of Delaware has developed a method for identifying oppressive air masses in urban areas that are historically associated with elevated human mortality (Kalkstein 2000). Fifth-Generation National Center for Atmospheric Research/Penn State Mesoscale Model (MM5) outputs that estimate the impacts of heat island mitigation strategies on meteorology will be fed into a heat-related mortality analysis

[1] Temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks.

to determine (1) if the number of oppressive air mass days is decreased, (2) if the severity of the remaining oppressive days is generally diminished, and (3) if there's a marked reduction in estimated heat-related mortality. (Sailor, Kalkstein & Wong in press).

This research will be conducted in various cities to determine how large-scale mitigation of urban heat islands might impact the frequency of oppressive air masses and associated heat-related mortality rates. Tulane University, the University of Delaware, and the EPA selected Philadelphia to be the first city to study.

Philadelphia has begun to move from heat adaptation actions to mitigating heat islands. For example, the Energy Coordinating Agency (ECA) of Philadelphia launched a Cool Homes program to help senior citizens, who are at-risk of experiencing health problems or death from extreme heat, to maintain a safe and comfortable home environment, while minimizing the utility costs required to accomplish this. ECA provides summer cooling treatments to blocks of low-income homes. These treatments include applying white, acrylic, elastomeric roof coatings that have an initial solar reflectance greater than 80% and are highly emissive. ECA is monitoring indoor and outdoor (comparing a test and control block) temperature differences to determine the impacts of these measures. This field data will be compared to the modeling work by Tulane and the University of Delaware and will provide other cities with an indication of the magnitude of the impacts heat island mitigation can have on local meteorology and heat-related health.

Salt Lake City has begun connecting heat island mitigation and urban development policy. The EPA's Salt Lake City Urban Heat Island Pilot Project (UHIPP) Coordinator has been working with Envision Utah, a nongovernmental organization focusing on growth issues, to develop a second edition of a "toolbox" that informs state and local decision makers of community development options. This second edition will address energy efficiency and urban heat island mitigation. This toolbox and cooperative effort demonstrate how heat island mitigation policy can be integrated with smart growth and energy savings.

To accelerate actions such as these taken in Philadelphia and Salt Lake City, the EPA will build and strengthen its existing network by reaching out to public health officials, emergency service providers, the medical community, utilities, insurance providers, non-governmental groups, advocates for vulnerable populations (e.g., the elderly), and urban planners. Results from the EPA-supported heat-related mortality research, and additional work to determine the costs and benefits associated with heat island mitigation and reduced incidence of heat-related illness and mortality will inform decision makers of the risks, costs, and options available to them. Forums, such as the National Governors Association (NGA) Emerging Growth workshop, provide opportunities to distribute this information and describe its value in shaping public policy.[2]

One unintended benefit of researching the impacts of heat island mitigation on heat-related health is that additional cities have become interested in mitigating heat islands. In the past, heat island mitigation has appealed more to southern U.S. cities due to the longer cooling season. Mitigating heat islands to reduce heat risk, however, may be a larger concern for Northeastern and Midwestern cities because weather variability seems to be more important than heat intensity (Kalkstein 1997).[3] Thus, in addition to providing information

[2] The NGA Emerging Growth Issues Conference was held June 26-27, 2001, in Washington DC.

[3] A regional ranking of heat vulnerability, from most to least vulnerable, follows: (1) Northeast US (north and east of Maryland and Delaware); (2) Midwest (Illinois, Missouri, Indiana, Ohio); (3) Mid-Atlantic (Virginia, the Carolinas, Kentucky, Tennessee); (4) Upper Plains (Minnesota, the Dakotas, Nebraska); (5) Southern Plains

needed to integrate heat island mitigation with public health and urban development policies, the EPA has expanded the interest in heat island mitigation, which is a first step to advancing policy adoption.

Air Quality Planning

Another course of action the EPA is taking to overcome barriers is to assist states with incorporating heat island mitigation into air quality planning. The EPA has been working with multiple stakeholders to incorporate heat island mitigation into air quality plans. Results from this effort have potential to create important incentives for state and local policymakers to adopt heat island mitigation strategies.

Meteorological and air quality modeling of three UHIPP cities, from a research perspective, suggest that implementing heat island mitigation measures can contribute to temperature reductions and air quality improvements. The EPA has initiated changes in its modeling analyses to address issues concerning how heat island reduction measures can be incorporated into air quality plans and create a screening tool that provides local policy makers an efficient and reasonable assessment of the potential meteorological and air quality impacts from heat island reduction measures. In addition, should the modeling analyses demonstrate air quality benefits, the EPA expects to include a sample guideline on how heat island reduction measures can be incorporated in air quality plans in its draft "Stationary Source Innovative Measures Policy."

Meteorological and air quality models are used to simulate historical air pollution (ground-level ozone) measurements and forecast expected measurements once control measures in an air quality plan are implemented. The models use projected emission levels that may result from implementing control measures and assume that a weather pattern conducive to ground-level ozone formation, called an ozone episode, may occur. Actual weather data from an ozone episode is used as input to the meteorological model. Other inputs to the model include the amount of air pollution transported into the non-attainment area from other locations and photochemical equations that simulate the formation of ground-level ozone under different weather patterns. The models are best suited to determine if control measures in an air quality plan are "directionally correct" because they can routinely over- or under-predict the formation of ozone. Despite their shortcomings, these models are the best tools available to assist decision makers in developing policies that will result in air quality improvements (EPA 1999).

The analysis to determine the impact of heat island reduction strategies on air quality is innovative in itself. Traditionally, a reduction strategy's direct impact is determined by the amount of emissions reduced or prevented. Heat island reduction strategies may influence emissions and weather patterns, two important factors in the formation of ground-level ozone. The strategies also reduce energy use and greenhouse gas emissions.

Lawrence Berkeley National Lab (LBNL)'s meteorological and air quality modeling of the first three UHIPP cities (Sacramento, Salt Lake City, Baton Rouge) indicated up to

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(Oklahoma, Texas, Arkansas) (6) Mountain states (Colorado, Wyoming, New Mexico, Montana); (7) Pacific (California, Washington, Oregon); (8) Southeast, excluding Florida; (9) Southwest; (10) Florida (Kalkstein 2001).

6.5% reduction from peak ozone measurements resulting from implementing heat island reduction strategies (Gorsevski et al. 2000). Although local decision makers provided input data in this three-city study, the air quality modeling did not follow prescriptive protocols required in developing air quality plans. LBNL also used the Colorado State University Mesoscale Model and the Urban Airshed Model-IV, which are no longer current models. State and local policy makers are now using more advanced models, such as MM5 for meteorological modeling, and Environ Corporation's Comprehensive Air Quality Model with extensions (CAMx), the Systems Application International's Urban Airshed Model-V, or EPA's Third Generation Air Quality Modeling System for air quality modeling. These models improve the assessment of weather pattern modifications and air pollution transport from other geographical areas.

Due to advancements in models and a desire to determine if heat island mitigation strategies can be included in air quality plans, LBNL is using a different approach to model the next UHIPP city – Houston, Texas. This modified approach considers:

- **Incorporating heat island reduction strategies into air quality plan for the Houston-Galveston Area (HGA).** In 2001, the EPA approved the air quality plan for the HGA. As part of its air quality plan, Texas is currently working on improving its meteorological and air quality modeling for the HGA. Texas expects to include many of its findings in a revised air quality plan by the summer of 2002. The EPA expects to provide Texas with data resulting from beneficial findings of the meteorological and air quality modeling and the opportunity to use this information in the HGA air quality plan revision. In addition, this approach can provide valuable lessons on how to integrate heat island reduction measures into state air quality plans.
- **New meteorological and air quality models.** MM5 and CAMx models were selected to (1) use the latest modeling tools to improve the simulation of weather patterns and air pollution transport, and (2) allow consistency with current modeling efforts for the HGA. The EPA expects to incorporate its findings into its innovative measures policy. This may include an example or guidelines to states on how to integrate heat island reduction measures into the modeling efforts carried out as part of a state's air quality planning.
- **EPA multi-office collaboration.** Since 1997, the EPA's Office of Atmospheric Programs (OAP) has managed the EPA's Heat Island Reduction Initiative (HIRI) Program. Recently, the EPA's Office of Air Quality and Planning Standards (OAQPS) has started collaborating with OAP on developing EPA policies that can provide credit to a state's air quality plan for incorporating heat island reduction measures. In addition, EPA Regions are also collaborating with OAP, which is also important because the EPA Regions must review and decide whether a state's air quality plan includes the necessary measures and documentation to attain the air quality standards. Should the modeling efforts in Houston indicate that heat island reduction measures are beneficial, the EPA expects to provide Texas decision makers with the necessary data to incorporate these measures in their air quality plan (translating the modeling results into equivalent emission reductions and discussing issues concerning incorporating heat island reduction measures into the modeling assessment). In addition, the EPA could include these findings in its development of a policy for innovative measures.

- **Local decision makers.** One of the most important aspects of this project is the involvement of state and local decision makers. Representatives from the City of Houston, Texas Natural Resource Conservation Commission, EPA Region VI, and other groups regularly meet to collect necessary information, discuss the meteorological and air quality modeling of heat island mitigation measures, and determine the potential benefits and feasibility of implementing heat island reduction measures. This includes identifying where and to what degree implementing heat island reduction measures is feasible based on current land use, vegetative cover, pavement and roofing technologies, costs, and other location-specific information. In addition, any heat island measure-related codes or ordinances currently available in Houston, and the process necessary to modify codes and ordinances, will also be collected. This is an important aspect of the project as codes and ordinances create an "enforceable" mechanism, a necessary element in an air quality plan.

LBNL has recently performed model-based sensitivity analyses of the HGA to provide local decision makers with information assessing the independent effects of modifying albedo versus vegetative cover. In terms of temperature changes, the analyses suggest that changes in total albedo (the combined effect from reflective roofs and pavements) appear to be more significant than modifications of vegetative cover only. However, when the albedo changes are considered individually, roof-only or pavement-only, the effects from vegetation-only changes are more prevalent. Additional sensitivity analyses may be required to confirm these results and to determine the effects of different levels of albedo and vegetative cover modification. Although these relative effects in meteorology (e.g. temperature) will not necessarily translate into similar air quality modeling results, it may provide a "direction" to local decision makers concerning the level and measures of heat island reduction that should be considered.

The EPA Voluntary and Innovative Measures Policies

On January 19, 2001 the EPA issued the "Stationary Sources Voluntary Measures Policy" (Seitz 2001). This policy allows states to include reductions in their air quality plans for "voluntary" control measures applied to non-mobile sources, including heat island reduction measures. Control measures under this policy must follow the requirements under the Clean Air Act applicable to emission reductions. That is, a state including a control measure in its air quality plan must demonstrate that the emissions are quantifiable (emission reductions can be measured and verified), surplus (not already required under another provision), enforceable (ensure that the emission reductions occur), and permanent. This unprecedented EPA policy has two limitations for incorporating heat island measures in air quality plans. First, the policy limits the amount of emission reductions creditable in an air quality plan to three percent of the required reductions. For example, if a state demonstrates that 100 tons of emission reductions are necessary, it may only incorporate up to three tons from stationary source voluntary measures. Second, the policy only provides a framework on the elements necessary for incorporating voluntary measures in an air quality plan. The policy does not include details on how emission reductions from heat island reduction measures can be determined (i.e. using meteorological and air quality modeling) and how these measures can meet the enforceability requirements, through incorporating heat island reduction measures in codes, ordinances or other policy mechanisms.

The EPA is currently developing a Stationary Source Innovative Measures Policy. Similar to the voluntary measures policy, this policy would allow states to include control measures that have not been traditionally allowed in an air quality plan. Some differences in the innovative measures policy may provide advantages for including heat island reduction measures. First, this policy could allow a higher percentage (EPA's voluntary measures policy limits emissions reductions to three percent) of emission reductions from the adoption of control measures. Second, this policy would allow any source to obtain credit for the emission reduction. The voluntary measures policy allows only states to use the emission reductions in their air quality plans. Finally, EPA expects to incorporate "lessons learned" from the HGA efforts into this innovative measures policy. This may include a discussion on modifying model input using current land use data and altering it to represent various heat island mitigation scenarios. In addition, mechanisms for implementing heat island reduction measures, including codes, ordinances, financial incentive programs, or other programs, may be included. As mentioned previously, the modeling process and implementing heat island reduction measures through codes or ordinances are important aspects for incorporating heat island reduction measures in an air quality plan.

Capacity – Tools and Guidance

Finally, the EPA provides tools and outreach materials and issues guidance to help state and local decision makers adopt policies that protect public health and the environment. To help address implementation questions and provide practitioners with needed guidance, EPA is developing the following:

- **Heat-Related Health Analyses.** (Discussed above.)
- **Stationary Source Innovative Measures Policy.** (Discussed above.)
- **Land Use Analyses.** LBNL has been evaluating surface characteristics, or baseline conditions, and identifying the potential for albedo (solar reflectance) and vegetative modifications in various cities (Akbari, Rose & Taha 1999; Akbari and Rose 2001a; Akbari and Rose 2001b). Results from these studies can be applied to other cities and used to assist practitioners and air quality modelers with implementing and modeling heat island reduction strategies.
- **Energy Savings Streamlining Tool.** This research, conducted by LBNL, involves developing correlations between energy savings and climate for different regions in the U.S. Cities can use this information to determine city-specific energy saving potentials for each heat island mitigation measure. Cities can also use this information to develop codes, regional standards, and ordinances.
- **Air Quality Streamlining Tool.** This analysis will provide policy makers with a quick, low-cost assessment of the potential air quality benefits that may result from implementing heat island mitigation measures. Cities may use this information as a screening tool to determine if the air quality benefits from heat island mitigation are sufficient to merit action. Because traditional modeling, which LBNL is using in the HGA, is resource-intensive (timing and funding), the EPA is collaborating with LBNL and Tulane University to develop a streamlined modeling approach to be

applied in over 20 U.S. metropolitan areas. Factors considered in selecting these cities include current ground-level ozone readings and local involvement with the International Council for Local Environmental Initiatives (ICLEI) Policy Adoption and Peer Exchange Initiative (PAPEI). Should the screening tool demonstrate potential air quality benefits, policy makers may further study the impact of heat island reduction measures using traditional meteorological and air quality models and processes.

The EPA will work with communities to tailor information from these analyses into area-specific information to guide policy development. Some of this work has already begun. For example, through the PAPEI, ICLEI, the EPA, and national experts are providing technical assistance to six local governments, who have committed to adopting heat island mitigation policies.

Over a decade ago, EPA published one of the only heat island mitigation guidebooks (EPA 1992). This guidebook defined an urban heat island, described basic heat island mitigation concepts and technologies, discussed tree planting procedures, and promoted implementation through ordinances. Many heat island mitigation stakeholders have found this guidebook a useful tool and are still turning to it for guidance.

Since 1992, however, several new products and information regarding their costs and benefits have become available, and many communities have implemented heat island mitigation projects and policies, generating field experience and replicable approaches. This new information needs to be collected, summarized, converted into lessons learned and guidance, and widely distributed.

In response to this need, the EPA is providing an updated guidebook geared towards state and local energy, environment, planning, and health officials; community groups; utilities; and industry representatives (mainly cool paving and cool roofing manufacturers and distributors). This guidebook will provide a summary of new technologies, case studies and lessons learned, and detailed guidance on developing and implementing coordinated, large-scale heat island reduction efforts.

More specifically, this guidebook will walk communities through the steps needed to develop voluntary actions, incentive programs like utility or the CEC's cool roof rebate program, and policy options for implementing heat island mitigation strategies. These steps will include: gathering product information – product availability, costs, and impacts on health and the environment; holding seminars that include industry partners and community leaders to introduce the topic of heat islands and address new technologies and practices; obtaining funding to support demonstration projects or other heat island mitigation activities; showcasing demonstration projects; developing, marketing, implementing, and evaluating incentive programs; and modifying or developing codes, standards, and regulations.

Potential follow up from this guidebook includes working with communities to develop, implement, and evaluate action plans and collecting and distributing specific market information about heat island mitigation technologies and benefits of mitigation that may be needed.

Finally, EPA will serve as a central repository of information and provide a central forum for heat island stakeholders, researchers, and practitioners to share experiences and discuss heat island reduction technologies, projects, and policies through a heat island website, stakeholder conference calls, and workshops.

Conclusion

By advancing heat island mitigation policy in these three areas, the EPA hopes to see an elevated level of understanding about heat islands – their causes and opportunities to mitigate them. The Agency anticipates that strong networks comprised of stakeholders from multiple interest groups, will discuss heat island mitigation in various policy forums including air quality, public health, community development, and energy. New communities will become interested in heat island mitigation and will help advance heat island mitigation actions – by revising codes, transforming markets, and creating additional incentive programs.

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