Building Technologies Department
Building Technology and Urban Systems Division
Lawrence Berkeley National Laboratory

United States Cool Surfaces Deployment Plan

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June 2023

doi:10.20357/B7602K

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Acknowledgements

The work described in this study was conducted at Lawrence Berkeley National Laboratory and supported by the U.S. Department of Energy Building Technologies Office under Contract No. DE-AC02-05CH11231.

This manuscript has been co-authored by UT-Battelle, LLC, under contract DE-AC05-00OR22725 with the US Department of Energy (DOE). The US government retains and the publisher, by accepting the article for publication, acknowledges that the US government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this manuscript, or allow others to do so, for US government purposes.

The manuscript was also co-authored by Arizona State University, the Smart Surfaces Coalition, and Haley Gilbert under subcontracts from Lawrence Berkeley National Laboratory, and by the Cool Roof Rating Council with in-kind support from that organization.

The authors would like to thank our program managers Sven Mumme and Marc LaFrance, interviewed stakeholders, workshop participants, and plan reviewers.

The authors thank the following experts for reviewing this report (affiliations do not imply that those organizations support or endorse this work):

- Iain Walker, Ph.D., Lawrence Berkeley National Lab
- Frank Klink, Ph.D., Chair, Education Committee, Cool Roof Rating Council

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Suggested Citation

Levinson, R., Alhazmi, M., Becce, J., Desjarlais, A., Gilbert, H., Kats, G., Miller, J., Morin, E., Sailor, D., & Schneider, S. (2023). *United States Cool Surfaces Deployment Plan*. Lawrence Berkeley National Laboratory, Berkeley, CA. https://doi.org/10.20357/B7602K

Abstract

Solar-reflective building envelope surfaces, such as cool roofs and walls, can be especially helpful in disadvantaged communities that often have poorly insulated older homes, aging or absent air conditioning units, steep utility bills, polluted air, and high vulnerability and exposure to extreme heat. With support from the U.S. Department of Energy, our project seeks to dramatically increase the climate-appropriate deployment of cool surfaces across the United States with an emphasis on their application to disadvantaged communities.

First, we sought to identify cool-surface deployment barriers, opportunities, and models by (a) reviewing the history of cool-surface deployment activities, (b) interviewing cool-surface stakeholders, (c) researching successful energy-efficiency/green building deployment models; and (d) interviewing the actors who have implemented these models. Second, we conducted a workshop to engage stakeholders in development of a deployment plan. Third, we asked six U.S. federal agencies (a) how cool surfaces and cool surface stakeholders could support their missions and (b) how agency activities could support cool-surface deployment. Fourth, we identified a set of transformative ideas that form the core of the deployment plan.

Transformative ideas include but are not limited to initiatives to (a) launch an educational campaign to make the general public and building professionals aware of how cool roofs and walls exclude unwanted solar heat; (b) create a "Cool Roof Prize" stimulating the development of affordable, high-performance cool asphalt roofing shingles; (c) conduct high-profile, large-scale demonstration programs that bring cool surfaces to disadvantaged heat-vulnerable communities; and (d) support local, regional, and state climate action (heat mitigation) plans with cool surfaces.

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1 Introduction

Solar-reflective building envelope surfaces, such as cool roofs and walls, can save energy, reduce the carbon footprint, and lower peak power demand in air-conditioned buildings. They improve comfort and safety in buildings that are not air-conditioned due to a lack of equipment or power, mitigate the urban heat island (UHI) effect, improve air quality and conserve water by lowering outside air temperature, and slow global warming.

Cool roofs and walls can be especially helpful in disadvantaged communities that often have poorly insulated older homes, aging or absent air conditioning units, steep utility bills, polluted air, disproportionately low levels of shade-providing tree cover, and high vulnerability and exposure to extreme heat. These cool surfaces are among the least-expensive ways to improve energy efficiency and lower energy costs in these communities. They also boost resilience to coincident power outages and heat waves by mitigating temperature rise during these events.

Uptake of cool surfaces has been strong in the U.S. states of California and Florida, but more limited nationally. Our project, sponsored by the Building Technologies Office (BTO) of the U.S. Department of Energy [1], seeks to bridge this gap by dramatically increasing the climate-appropriate deployment of cool roofs and walls across the U.S., with an emphasis on their application to disadvantaged communities.

2 Approach

First, we sought to identify cool-surface deployment opportunities, barriers, and models by

a) reviewing the history of cool-surface deployment activities, including code improvements, utility incentives, recognition by green-building programs and energy-efficiency labels, and demonstrations;

b) interviewing cool-surface stakeholders, such as policymakers, code officials, state energy and housing agencies, utilities, insurers, cities, non-governmental organizations, local civil society organizations, cool-product manufacturers, and researchers;

c) researching energy-efficiency/green building deployment models with successful track records; and

d) interviewing the actors who have implemented these models.

Second, we shared the literature review and stakeholder interview reports with the stakeholders, including six federal agencies. We further engaged and invested them in plan development by conducting a full-day virtual workshop in which participants provided feedback and recommended proven or novel strategies.

Third, we asked the federal agencies how cool surfaces and cool-surface stakeholders could support the agencies' missions, and how each agency's activities could support cool-surface deployment.

Fourth, based on the findings of the literature review, interviews, and workshop, we identified and elaborated a set of transformative ideas that form the core of a large-scale deployment plan.

3 Identifying cool-surface deployment barriers, opportunities, and models

3.1 Literature review

3.1.1 Overview

We explored peer-reviewed literature, conference proceedings, and grey literature[1] to assess the history of cool-surface deployment, and to seek lessons from the deployment of other energy-efficiency/green building technologies. We also researched heat action plans and programs, various codes and standards, and incentive and rebate programs relevant to cool surfaces. This effort and its findings are detailed in our literature review [2,3].

3.1.2 Outcomes

The literature review yielded the following key takeaways.

Opportunities

- Cool surface policies and programs are increasingly being pursued and adopted by city and regional governments through their climate action plans and related planning efforts. There is potential for such efforts to spread organically as governments share best-practices, and to integrate information about successful efforts into educational activities to accelerate the transfer of knowledge.
- Technology research and development is currently addressing challenges ranging from soiling (amphiphobic/self-cleaning materials and coatings) to glare (retroreflective surfaces) and condensation (use of ventilated air spaces and vapor barriers). Over time, new products resulting from these efforts will diminish concerns related to current challenges facing cool surface products. Investment in R&D is a long-term strategy for accelerating widespread adoption of cool surfaces.
- There are well-established models for implementing cool surfaces in codes and standards (e.g., California Title 24 and ASHRAE 90.1). These can form the foundation to accelerate nationwide cool-surface deployment through continued integration in codes and standards and their subsequent adoption.
- In the short-term, public incentive and rebate programs can help to expand growing markets until education, technology, and codes/standards are in place to adequately address the range of challenges and barriers facing efforts to expand use of cool surfaces.

Barriers

- Public perception of the aesthetic appeal of cool surfaces can be a barrier to individual adoption—this can include desire for uniformity in an otherwise dark-roofed neighborhood or can be associated with the visibility of soiling and microbial growth on lighter-colored surfaces.
- There is a lack of knowledge and awareness of cool surfaces and their life cycle benefits across all classes of decision-makers (e.g., general public, contractors, local officials, manufacturers,

[1] Grey literature includes institutional reports, position papers, and other resources not available from commercial or academic publishers.

researchers, and politicians). This lack of knowledge, combined with decision-making inertia, tends to favor conventional technologies and approaches.

- Financial pressures to extend the life of old or failing infrastructure can impede the deployment of cool surfaces, particularly in lower-income neighborhoods where the need for cool surfaces may be the greatest, but current practice favors frequent patching of existing infrastructure rather than replacement or resurfacing.

Challenges

- Cool surfaces can lead to increased heating demand in winter.
- Shading from other structures and vegetation can limit the benefits of cool surfaces in some applications.
- Application of very bright materials to vertical or steep-sloped surfaces can introduce glare associated with the reflected solar radiation.
- Cool surfaces can create condensation that can in some circumstances lead to degradation of construction materials and growth of mold.
- The long-term performance of some cool surfaces is adversely affected by weathering, potentially requiring periodic cleaning.

3.2 Stakeholder interviews

3.2.1 Overview

We planned the stakeholder interviews by drawing upon the team's experience in the cool-surface field to diagram both opportunities and barriers to widespread cool surface deployment. Opportunity categories included policy, product development, climate drivers, aesthetic drivers, education/awareness, programs, and benefits (Figure 1), while barrier categories included supply (distribution), labor shortages, costs of materials, regulations and enforcement, climate, aesthetic, side effects, and education/awareness (Figure 2). Each category or subcategory of opportunity or barrier was linked to groups of stakeholders to interview, such as but not limited to government officials, manufacturers, developers, contractors, utilities, and building owners.

In April and May 2022, we interviewed a diverse set of over 50 stakeholders to inform the development of a cool-surface deployment model for the U.S. Among these stakeholders were cool product manufacturers, city officials, federal employees, private consultants, and more. This effort and its findings are detailed in our Stakeholder Interviews Report (Appendix A).

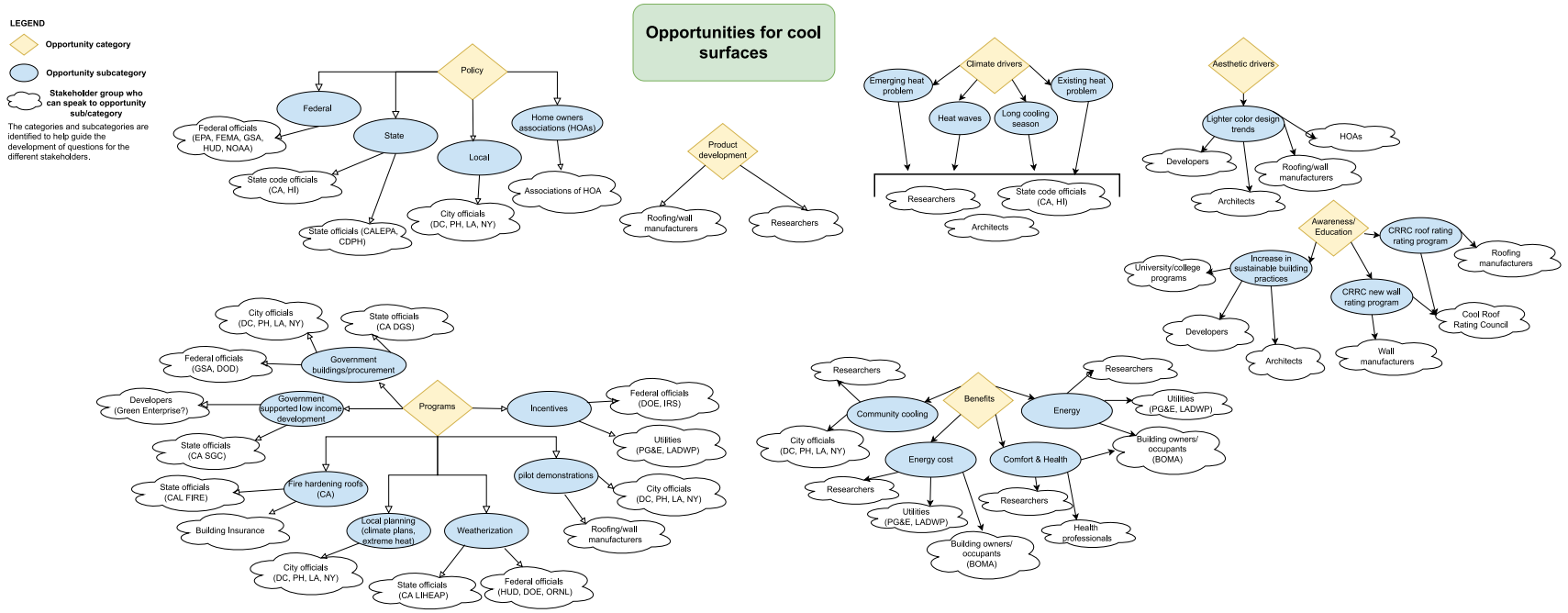

Figure 1. Diagram categorizing *opportunities* for cool surface deployment and identifying groups of stakeholders to be interviewed about them.

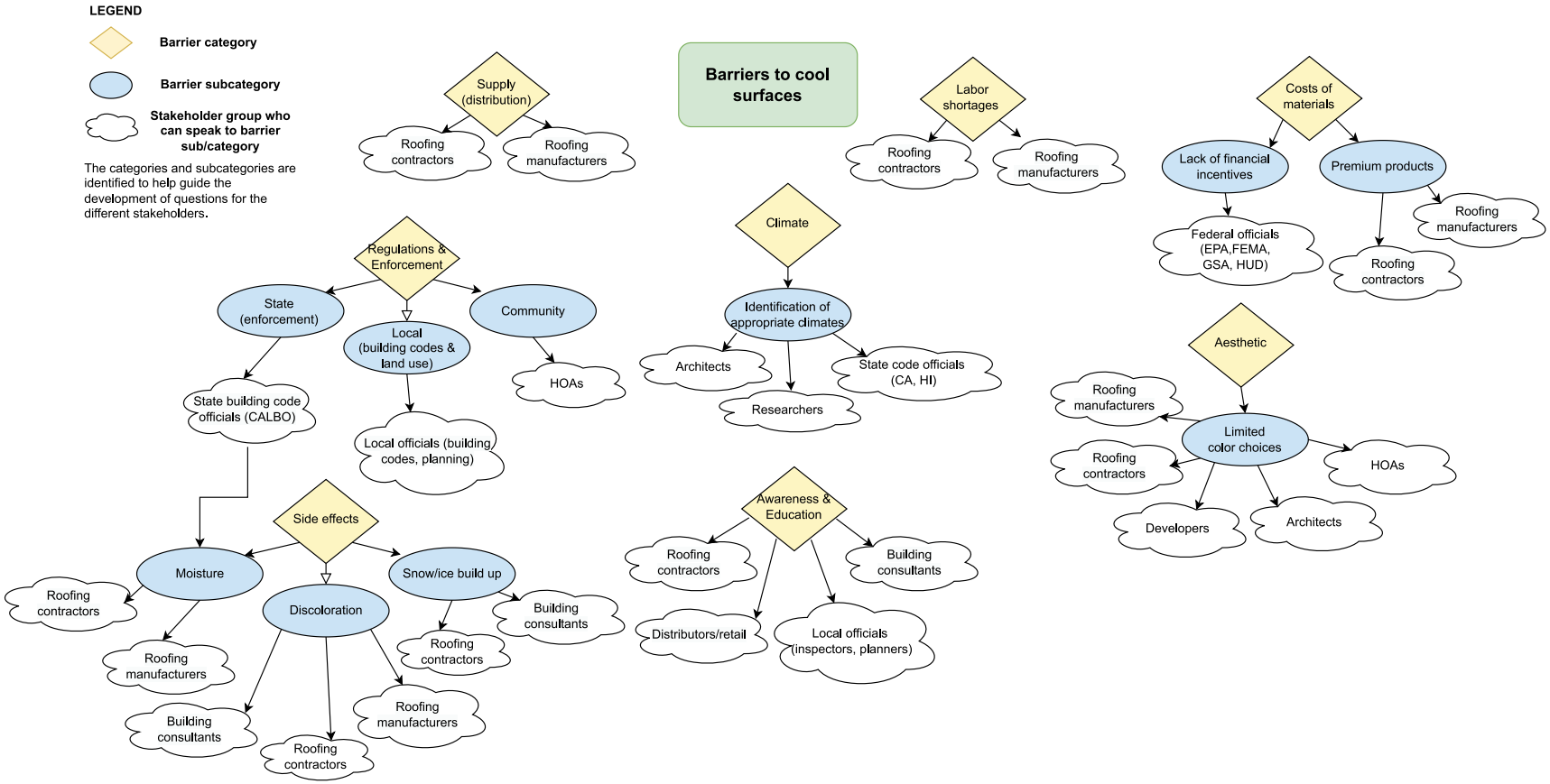

Figure 2. Diagram categorizing *barriers* to cool surface deployment and identifying groups of stakeholders to be interviewed about them.

3.2.2 Outcomes

Interviews with various stakeholder groups yielded the following key takeaways.

City/federal government employee stakeholders

- Given the size and complexity of heat issues in cities and limited available funding, it is difficult to target and prioritize funding for cool surfaces.
- Offering building owners multiple pathways to meet cool-roof requirements is favored. These include exceptions to these requirements for rooftop solar equipment and vegetative roofs.
- Educating agencies and homeowners through outreach and the development of data-driven tools to measure costs and benefits of cool surfaces will help reduce perceived risks.
- Cool roofs or walls could lower urban air temperatures and save building owners money on energy bills, but the magnitude of potential savings is not widely known. The greatest need among city and federal employees is an effective way to conduct detailed analyses of the energy savings and air temperature reduction benefits that will result from investment in cool surfaces. According to many stakeholders, the current palette of tools is inadequate at accomplishing this need.
- Some cool-surface technologies no longer require pilot experiments—they are ready to scale up. Regulations and financial incentives help with the implementation of cool surfaces. Concerns remain related to longevity, durability, and maintenance of cool-surface products.

Industry association/product manufacturer stakeholders

- Regulations and consumer demand drive innovation and control the scale of the market.
- There is little desire to expand the market to places where there is not a direct call or promise of business for more cool-surface materials.
- Cool roofing has been around for long enough to be seen as an established solution that does not get much media attention and is not viewed as an innovative technology or an exciting solution.
- Manufacturing stakeholders were concerned with the current supply chain issues that affect getting raw materials for cool surfaces. They are also seeing a growing demand in the market from cities for cool-surfaces products, as these cities become hotter, and because of recent regulations. There were some concerns from cities related to awareness of cool-surface products (including the benefits) and costs.

Non-profit stakeholders

- There is a general feeling that either cool-surface case studies are not easily accessible or that too few such studies have been conducted.
- Pilot projects also provide an opportunity to create cross-departmental relationships in cities that can lead to more administrative efficiency in the future, but those pilots take time and effort to get off the ground.
- Cool roofing products are too “old” and established to be in conversations as an exciting emerging technology, but too “new” to be the industry standard.

- Cool roofs and/or vegetated ("green") roofs should be mandated because incentives alone are insufficient.

Research stakeholders

- Contractors are often aware of the benefits of cool roofs but choose not to advertise them to customers as other motivations drive what they are promoting. Implementing new codes is crucial so that there is an inherent cost for the contractor in not advertising cool roofing products.
- Widespread cool-roof adoption is not the silver bullet that will end human caused climate change or allow us to perfectly adapt, but it is a good step—one strategy in a multi-faceted approach to addressing climate change .

Utility stakeholders

- Cities need a better understanding of the roofing market so they can address issues like non-compliant products and drive roofing supply chains to adapt to the production of cool roofing products.
- Finding ways to make products more economical and that demonstrate cost effectiveness is crucial in proliferating cool-surface products.
- While some utility stakeholders did not directly work with cool surfaces, they had concerns about product costs and financing.

3.2.3 Other broad observations from stakeholder interviews

- How we label the impacts of different solutions matters. If we are to encourage the use of cool roofs because they mitigate heat and lower air temperatures city-wide, communities or funding sources may only look at cool roofs from an adaptation perspective, when in fact the energy reduction benefits and increased solar reflection from cool roofs also make them a climate change mitigation solution.
- Cost-effective and market-acceptable cool surface solutions for steep-slope roofing utilizing asphalt shingles remains an elusive target. The development of an acceptable cool alternative would bolster cool surface adoption in the residential sector.
- Successful deployment programs have included elements that increase the probability of a quality application—for example, the use of roofing professionals to assess the individual projects to develop an application plan and to verify that there are no other life/safety issues associated with the planned retrofit. Certification of applicators and the use of independent application observers increase the likelihood of a quality retrofit.
- Many stakeholders expressed the need for more education on cool surfaces for the public, building construction stakeholders (e.g., developers, roofing contractors), and policymakers.
- There is still an aesthetics perception problem mostly caused by the discoloration of a white roof from soiling/aging.

3.3 Stakeholder workshop

3.3.1 Overview

Our stakeholder workshop was a six-hour online meeting held on September 8, 2022 to solicit feedback on an effective cool-surface deployment model. Over 120 stakeholders from a wide range of backgrounds, including city and federal employees, industry associations, manufacturers, non-profits, state energy offices, researchers, utilities, and consultants were invited to the workshop, with 62 in attendance.

First, the research team introduced the project, presented the findings of the literature review and stakeholder interviews, and led an open discussion about these results. Second, a series of federal agencies and non-federal stakeholders spoke about their interest in cool-surface deployment. Third, participants split into small groups to answer a series of questions related to best practices for cool-surface deployment, then rejoined the larger group to share takeaways from the breakout groups.

The workshop's participants, activities, and findings are detailed in our Stakeholder Workshop Report (Appendix C).

3.3.2 Key deployment objectives derived from workshop

We analyzed input from the workshop participants to generate the following list of top 10 objectives for a cool-surface deployment plan. These represent where we seek to be rather than the current state of affairs.

1. Scalable pilot deployments across varying regions (with different climate, regulatory and program environments) are pursued to provide "local" examples and data regarding the performance of cool surfaces while explicitly addressing concerns.
2. There are better solutions for steep-slope roofs and more incentives for cool surfaces in the residential roofing sector. A possible avenue for this goal could be a manufacturers' innovation challenge for steep-slope roof products. The competition would demonstrate the value of cool surfaces in the residential sector, while also spurring innovation from manufacturers to develop more cost-effective and impactful products.
3. Guidance materials are available for consumers, contractors, and political policy and decision makers to make better-informed choices.
4. The non-energy benefits of cool surfaces, such as lowering urban air temperatures, peak power demand reduction, carbon savings, global cooling (negative radiative forcing), comfort during periods of time without air conditioning, life/safety improvements, and equity are incentivized and serve to help justify the cost of retrofit applications.
5. There are effective tools and calculators to provide actionable information (reliable quantitative outputs) about these non-energy benefits of cool surfaces.
6. Steps are taken to develop a cool-surface standard that will be inserted into policy regarding roof and wall retrofits.
7. Local, state, and federal government programs seek input from stakeholders to better understand the highly variable needs across the communities they serve, and to incorporate this information in the development of mechanisms to deploy cool surfaces—e.g., grant programs, incentives, and financing.

8. Building codes incorporate information about anticipated future climates (as opposed to past climate) so that the benefits of cool-surface technologies can be more accurately assessed vis-à-vis the climate conditions under which the building will operate.
9. CO_2 offsets provided by cool surfaces are quantified and used in carbon trading programs.
10. Partnerships and training facilitate the incorporation of cool surfaces into climate action plans across the U.S.

3.4 Federal agency engagement

We engaged six U.S. federal agencies—Department of Energy (DOE), Environmental Protection Agency (EPA), Department of Housing and Urban Development (HUD), Federal Emergency Management Agency (FEMA), National Oceanic and Atmospheric Administration (NOAA), and General Services Administration (GSA) —and the White House Office of Science and Technology Policy (OSTP) before, during, and/or after the stakeholder workshop to (a) introduce them to the project; (b) let non-federal stakeholders, such as state energy offices, city officials, energy utilities, and roof/wall manufacturers, learn about federal interests in cool-surface deployment; and (c) assess how cool-surface deployment could bolster the mission of each agency or office, and how each agency or office could in turn advance the deployment of cool surfaces.

We received federal feedback via one-on-one meetings, workshop presentations, and workshop discussions. We were able to distill it down to respond to three key questions of how we could leverage and support their missions, as well as how federal collaborators could contribute to the project's mission.

1. Benefit from deployment: How can cool-surface deployment help the agency achieve its mission?
2. Support for deployment: How can the agency's activities (current and planned) support the deployment of cool surfaces?
3. Support from stakeholders: How can cool-surface stakeholders support help the agency achieve its mission?

3.4.1 U.S. Environmental Protection Agency

Benefit from deployment	The mission of EPA is to protect human health and the environment. Therefore, cool-surface deployment closely aligns with and enables EPA to: • Reduce heat deaths • Mitigate climate change • Conserve energy • Improve air quality
Support for deployment	EPA is actively engaged in cool-surface deployments and can further leverage current activities by: • Co-leading the Interagency Working Group on Extreme Heat [4] to coordinate federal agencies to reduce risk to heat hazards • Participating on the National Integrated Heat Health Information System (NIHHIS) [5]; engagement during strategic plan development to ensure a focus on the built environment

	• Implementing the "Let's Talk about Heat Challenge" [6] to identify innovative and effective communication strategies that inform people of the risks of extreme heat and offer ways to keep safe during the hottest day • Managing the Heat Island Reduction Program [7] for local officials, community groups, researchers, and other stakeholders to identify opportunities to implement heat island reduction programs and policies that create comfortable and sustainable communities • Leveraging additional support and interest in EPA's Children's Health Office, Office of Environmental Justice and External Civil Rights, Office of Research and Development, and regional offices
Support from stakeholders	Cool-surface stakeholders can support EPA by: • Convening and sharing resources and soliciting feedback on program development • Developing and reviewing technical assistance resources, such as tools to guided local government implementation and quantifying the benefits of heat island mitigation projects • Developing key targets for cool-surface deployment and expected benefit effects

3.4.2 National Oceanic and Atmospheric Administration (NOAA)

Benefit from deployment	Cool surfaces can be leveraged to support the NOAA-managed NIHHIS [5] which aims to build societal understanding of heat risks, develop science-based solutions, and improve capacity, communication, and decision-making to reduce heat-related illness and death.
Support for deployment	NOAA is indirectly engaged in cool-surface deployment and can further leverage current activities by: • Participating on the Interagency Working Group on Extreme Heat [4] to coordinate federal agencies to reduce risk to heat hazards • Co-leading the NIHHIS website, Heat.gov [5] • Managing the Urban Heat Island Mapping Campaigns [8], a volunteer-based community science field campaign to map and understand how heat is distributed in communities • Running the "Building Equitable Resilience to Extreme Heat" [9] project to support state and local initiatives designed to reduce the negative health effects of extreme heat events, especially for disproportionately affected populations
Support from stakeholders	Cool-surface stakeholders can support NOAA specifically by: • Providing cool-surface technical assistance to NOAA's community urban heat island mapping campaigns • Improving and providing cool-surface content to the Heat.gov website

	• Partnering on long-term in situ and remote monitoring and evaluation approach for cool-surface deployment • Co-sponsoring cool-surface scientific studies using empirical observations, meta-analyses, and collaborate on the translation of research into quantitative evidence for use in applications for federal funding

3.4.3 U.S. Department of Housing and Urban Development (HUD)

Benefit from deployment	HUD's mission is to "create strong, sustainable, inclusive communities and quality affordable homes for all." HUD's 2022-2026 Strategic Plan includes a goal to Advance Sustainable Communities by "invest(ing) in climate resilience, energy efficiency, and renewable energy across HUD programs" and "advanc(ing) policies that recognize housing's role as essential to health." This focus of HUD's activities is clearly aligned with the project's goals to increase cool surfaces, especially in disadvantaged communities.
Support for deployment	HUD is engaged in cool-surface deployment and further leverages current activities by: • Developing the Climate Resilience Implementation Guide which supports communities in implementing a resilient public facilities project or program with Community Planning and Development (CPD)-funded programs. One of several guides focuses on cool roofs and describes how community planning & development funds can be used to address heat [10] **Public facilities and infrastructure improvements** with Community Development Block Grant (CDBG) or Section 108, under certain circumstances **Housing rehabilitation** with CDBG, Investment Partnerships Program (HOME), or Section 108 **New housing construction** with HOME (as part of an eligible rehabilitation project, not a CPD-funded program) **Economic development** with CDBG or Section 108 • Using Inflation Reduction Act funding to develop a new grant and loan program, Green and Resilient Retrofit Program [11], to aid multi-family buildings retrofits to make them "more energy efficient, healthier, and resilient in the face of natural disasters and climate change."
Support from stakeholders	Cool-surface stakeholders can support HUD specifically by: • Sharing HUD's Cool Roof Climate Resilience Implementation Guide [10] with eligible participants (communities, cities, states) to help develop project ideas, aid proposal development, and promote the installation of cool roof funding through HUD programs • Providing comments and feedback on program development for the Green and Resilient Retrofit Program [11]

3.4.4 Federal Emergency Management Agency (FEMA)

Benefit from deployment	Cool surfaces can be leveraged to support FEMA's efforts to prepare for community climate resilience and to rebuild post disaster to safeguard against future disasters.
Support for deployment	The following FEMA programs and resources can indirectly support cool-surface deployment and be targeted to leverage increases in deployment: • Building Resilient Infrastructure and Communities [12] which provides grants for hazard mitigation projects, including extreme heat • Building Codes Adoption Playbook [13] is used to communicate to latest editions of model building codes to increase community resilience and reduce loss from natural hazards
Support from stakeholders	Cool-surface stakeholders can work with FEMA to better account for extreme heat disasters which federal disaster law excludes from disaster aid programs since it does not cause property damage. This could be through expansion of FEMA programs to consider casualties and other nonstructural losses.

3.4.5 General Services Administration (GSA)

Benefit from deployment	GSA's Public Buildings Service manages new construction, leasing, and maintenance of federal properties nationwide. GSA owns or leases more than 8,800 assets.
Support for deployment	Through its direct management of building assets, GSA can further leverage current activities by: • Implementing the Green Proving Ground [14] program which aims to lower operational costs in federal buildings and support market transformation through the deployment of new technologies • Providing broad support of sustainable design across their portfolio of building assets • Following Executive Order 14057 on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability [15] to leverage public procurement to reduce greenhouse gases and other forms of pollution • Previous deployments of cool roofs using American Recovery and Reinvestment funds
Support from stakeholders	Cool-surface stakeholder can encourage GSA to incorporate cool-surface measures, like cool walls, into the Facilities Standards for the Public Buildings Service (P100) [16] which guides design standards and performance criteria for GSA.

3.4.6 U.S. Department of Energy Weatherization Assistance Program (WAP)

Benefit from deployment	Increasing the measures being evaluated for site specific dwellings helps the WAP to ensure that the most cost-effective comprehensive package of measures is being completed on low-income dwelling units.
Support for deployment	(This space left blank.)
Support from stakeholders	• Demonstrating/illustrating through currently utilized Energy Audit Tools how cool surfaces when evaluated with traditional energy conservation measures (e.g., air sealing, insulating) can be completed as part of a comprehensive package of installed measures • Identifying where/how the WAP network can procure cool-surface materials • Highlighting where cool surfaces have been part of weatherization projects, even if not funded by DOE, and any post installation savings metrics

3.4.7 White House Office of Science and Technology Policy (OSTP)

Benefit from deployment	The mission of OSTP is to maximize the benefits of science and technology to advance health, prosperity, security, environmental quality, and justice for all Americans.
Support for deployment	As directed by President Biden's Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability [15] (2021-12-08) to achieve net-zero emissions economy-wide by no later than 2050, including a net-zero emissions building portfolio by 2045, the White House could direct federal agencies to specify cool surfaces for federally owned or maintained buildings. This would be analogous to former Energy Secretary Steven Chu's 2010 memorandum specifying cool roofs for DOE buildings [17]. OSTP could communicate the benefits of cool surfaces to the general public and to federal agencies.
Support from stakeholders	Cool-surface stakeholders, especially researchers, can provide techno-economic analyses and educational materials to help OSTP include cool-surface deployment in its net-zero-emission messaging and directives.

4 Synthesis of the deployment plan

4.1 Overview

The research team considered the findings of the literature review, stakeholder interviews, stakeholder workshop, and federal agency/office engagement to develop top transformative ideas and a multi-year deployment plan to implement these ideas. In this iterative process, the federal agencies, non-federal stakeholders, and research team each contributed and helped shape the deployment plan.

4.2 Top transformative ideas

As detailed in the Stakeholder Workshop Report (Appendix C), workshop participants were asked to propose the most effective mechanisms for cool-surface deployment, and to discuss the top cool-surface benefits, opportunities, and barriers for their own organizations or industries.

The research team supplemented these answers with findings from the literature review and stakeholder interviews to generate the following transformative ideas whose execution could substantially accelerate the adoption of cool roofs and walls across the U.S.

Technical support for government regulations and specifications

1. Provide technical assistance to federal, state, and local officials (e.g., HUD, GSA, and analogous state and city housing programs) to incorporate cool roofs and walls into their program guidance and into specifications for constructing, retrofitting, and maintaining their building stock.

2. Leverage the Bipartisan Infrastructure Law and Inflation Reduction Act programs and incentives to increase deployment of cool surfaces (e.g., within HUD's Green and Resilient Retrofit program) by providing technical input on program design and implementation for federal agencies, local government, and stakeholder implementers.

Education and communication

3. Launch "Keep Your Cool," a government/utility/industry-sponsored educational campaign to inform all levels of stakeholders and the general public how cool roofs and walls keep unwanted solar heat out of our homes, workplaces, and communities, and of the many ways this is helpful. Position selection of cool roofs and walls as no-regret choices whose benefits will grow as the climate warms.
4. Create a training program for roof/wall contractors to (a) understand cool surface benefits and (b) locate and apply/install/maintain products.
5. Hold an annual "Cool Surfaces Workshop" to engage thought leaders around cool surface deployment. This would include researchers, manufacturers, cities, regional climate collaboratives, federal agencies, adaptation practitioners, environmental nonprofit organizations, construction trade associations, and more to promote best practices and close the gap between regions that have high versus low penetration of cool surfaces.

Research, development, and demonstration (RD&D)

6. Create a DOE Cool Roof Prize ("CR-Prize" similar to the L-Prize for solid-state lighting), a competition to stimulate, fund, and reward development of truly cool asphalt shingles (e.g., initial solar reflectance ≥ 0.40) that are cost competitive with otherwise equivalent to traditional asphalt shingles (e.g., cost premium $\leq \$0.20/ft^2$). The figure of merit would involve initial solar reflectance and cost premium. This would demonstrate the value of cool surfaces in the residential sector while incentivizing manufacturers to develop more cost-effective and impactful products for steep-slope roofs. It would also be key to advancing residential cool roofs in disadvantaged communities where first-cost premiums may otherwise present a serious barrier. DOE could seek co-funding from the California Energy Commission, which has prescribed the use of residential cool roofs since 2008.

7. Initiate high-profile, scalable demonstration programs that bring cool surfaces to disadvantaged communities. These deployments, located in varying geographic regions, will provide "local" examples and data regarding performance of cool surfaces in their communities.
8. Support the development of a cost-benefit analytic engine that includes energy and non-energy benefits for cool surfaces (heat mitigation and associated health benefits, peak energy demand reduction, CO_2e reduction benefits, comfort during periods of time without air conditioning, indoor thermal safety, and equity) that could be easily adopted by federal agencies (WAP, FEMA, HUD, DOT) as well as local officials and utility stakeholders. Analysis should be integrated into a user-friendly cost-benefit analytic engine so users can understand the costs and benefits of a cool surfaces project.
9. Use cost-benefit analysis of existing incentive programs to inform the development of best practice guidelines that can be shared with decision makers.
10. Develop/modify evaluation tools and calculators for the general public and building professionals that provide actionable information on the impact of cool surfaces at building to neighborhood to city scales with respect to multiple outcomes (not just energy).

Building codes and standards

11. Introduce prescriptive requirements or performance credits for the use of cool roofs and walls into all green-building standards used in the U.S.
12. Codify retrofits so that substantial modifications to the building envelope must include some improvements in energy efficiency. Promote the use of cool roof and cool wall technologies in these code updates.
13. Develop a cool surface "standard" boilerplate language that can be inserted into different policy and standards documents, incentive programs, and local codes to simplify the development of these documents and to homogenize the cool surface requirements.
14. Expand building standards and programs that incorporate cool roofs to include cool walls, accounting for roof-wall differences in materials and physics.

Incentives

15. Create competitions with prizes to increase deployment at the community, city, and regional level (e.g., Million Cool Roofs Challenge).
16. Provide upstream rebates to manufacturers of cool roof and wall products to eliminate cost premiums.

Government actions, including climate action and heat mitigation plans

17. Create partnerships and training between city and regional governments to facilitate incorporation of cool surfaces into climate action plans and initiatives, and into urban planning.
18. Integrate cool-surface specifications and city-wide reflectance targets into local climate action and/or heat mitigation plans. A city would need to gather heat maps and surface reflectance estimates to get a baseline albedo of its urban area, then set targets for how to increase reflectance city-wide.

19. Motivate local, state, and federal government programs to seek input from stakeholders to better understand the highly variable needs across the communities they serve, and to incorporate this information in the development of cool-surface deployment mechanisms—e.g., grant programs, incentives, and financing.

4.3 Support for Justice40 Initiative

These transformative ideas for cool surface deployment support the U.S. Government's Justice40 Initiative [18] goal that "40 percent of the overall benefits of certain Federal investments flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution." Cool surfaces deployment will benefit disadvantaged communities (DACs) in at least four of the seven areas[2] targeted by Justice40: energy efficiency; affordable and sustainable housing; climate change; and training and workforce development. Ties to Justice40 are included in the transformative idea details in Section 5.2.

5 Multi-year deployment plan

5.1 Overview

The plan is divided into three sections. The first section expands on the what, why, who, how, when, and where for each transformative idea. That is, *what* will be done, *why* should it be done, *who* will do it, *who* will benefit, and *how/when/where* will it be done?

The second section is a timeline of the transformations (Gantt chart) and an estimation of what could be accomplished in the short term (< 2 years), medium term (2 – 5 years), and long term (>5 years) if these ideas are executed.

The third section maps the interactions between stakeholders to consider how they can work together to advance the deployment of cool surfaces.

5.2 Transformative ideas, detailed

5.2.1 Provide technical assistance to government officials responsible for housing

Summary	Provide technical assistance to federal, state, and local officials (e.g., HUD, GSA, and analogous state and city housing programs) to incorporate cool roofs and walls into their program guidance and into specifications for constructing, retrofitting, and maintaining their building stock.
What	Provide technical assistance to various government officials to increase deployment of cool surfaces in funding programs.
Why	To significantly increase deployment of cool surfaces, it is critical to leverage government spending that could be utilized to support installation activities.
How	Technical assistance would support government agencies in aligning synergistic policies and programs that are developed or under development where cool

[2] The seven targeted areas are climate change, clean energy and energy efficiency, clean transit, affordable and sustainable housing, training and workforce development, remediation and reduction of legacy pollution, and the development of critical clean water and wastewater infrastructure.

	surfaces could easily be incorporated to achieve policy and program goals while increasing their beneficial deployment. Technical assistance might be in the form of specification development, impact assessments, market analysis, proposal development, monitoring, program evaluation, cost-benefit assessments, or stakeholder coordination.
Who will implement	Researchers, non-profits, industry trade groups, and building consultants would provide technical assistance, ideally coordinated through one organization to maximize synergies among activities.
Who will benefit	All building residents and occupants that benefit from various government funded policies and programs.
Where	National activities with focus on all levels of government (local, regional, state, federal).
Implementation timeline	Short
Cost	Low
Justice40 link	Assists federal/state/local programs that provide affordable and sustainable housing to DACs.
Undesirable side effects	None
Model to follow	Technical assistance provided to U.S. Department of Energy's Climate Action Champions [19].

5.2.2 Leverage new Bipartisan Infrastructure Law and Inflation Reduction Act programs and incentives

Summary	Leverage new Bipartisan Infrastructure Law (BIL), Inflation Reduction Act (IRA), and related programs and incentives to increase deployment of cool surfaces by providing technical input on program design and implementation for federal agencies, local government, and stakeholder implementers.
What	There is new federal legislation that is directing funds from the federal government to states, cities, manufacturers, homeowners, and other key stakeholders to deploy carbon emission reducing technologies and to improve climate resilience. This is a unique opportunity to provide technical input to (1) federal agencies as they design programs and (2) implementation support to local government and other key stakeholders to leverage cool surfaces to achieve the legislative objectives.
Why	The federal government is tasked with spending these new program funds. If funding programs are carefully executed with key technical input, the funds can be leveraged to make transformative advancements in cool-surface deployment to save energy, reduce carbon emissions, and improve climate resilience, mitigation, and adaption in DACs.
How	Researchers, non-profits, and other stakeholders connect with federal government agencies to provide technical assistance, share resources, share comments, and coordinate stakeholder input to align synergistic policies and

	programs that are under development where cool surfaces could easily be incorporated to achieve policy and program goals while increasing their beneficial deployment.
Who will implement	Researchers, non-profits, industry trade groups, building consultants would serve as the technical assistant providers ideally all coordinated through one organization to maximize synergies between activities.
Who will benefit	All building residents and occupants that benefit from various government funded policies and programs.
Where	National activities
Implementation timeline	Short
Cost	Low
Justice40 link	Helps BIL and IRA programs align with goals for DACs for energy efficiency, climate resilience, and affordable and sustainable housing.
Undesirable side effects	None
Model to follow	Many government agencies already work with government consulting companies to help with program development.

5.2.3 Launch "Keep Your Cool" educational campaign

Summary	Launch "Keep Your Cool," a cool-surface educational campaign for all stakeholders and the general public.
What	Government, utilities, and the cool-surface industry would jointly prepare and conduct an educational campaign that informs all stakeholders and the general public about the benefits of cool roofs and walls. Position selection of cool roofs and walls as no-regret choices whose benefits will grow as the climate warms.
Why	Stakeholder interviews and the stakeholder workshop revealed a strong need to educate consumers, government agencies, policy makers, code officials, and industry professionals about cool-surface benefits and options. There is also a need to address misinformation about cool surfaces.
How	Researchers, non-profits, utilities, and government agencies will compile existing fact sheets, guidebooks, web pages, online calculators, and other information about cool surfaces. They will develop new campaigns, supported by marketing professionals, that target specific audiences (e.g., consumers, government agencies, policy makers, code officials, and industry professionals) through city, state, and federal websites; utility websites and mailed statements; industry marketing material; and workshops for industry professionals, such as continuing education programs for architects, engineers, and building enclosure consultants.
Who will implement	Researchers, non-profits, utilities, and government agencies will prepare the information to be disseminated by city, state, and federal governments; utilities;

	manufacturers; and industry. Marketing professionals from industry and the utility sector can help design and target educational materials.
Who will benefit	Building tenants and owners (e.g., reduced cooling demand, occupant comfort, energy savings), communities (e.g., urban cooling, improved air quality), utilities (e.g., peak power demand reduction), governments (e.g., meeting energy efficiency and carbon savings coals), and cool-surface manufacturers (better educated consumers).
Where	National campaign
Implementation timeline	Short
Cost	Low
Justice40 link	Campaigns can target DACs.
Undesirable side effects	None
Model to follow	DOE Insulation Fact Sheet [20]

5.2.4 Create cool-surface contractor training program

Summary	Create a training program for roof/wall contractors to understand cool-surface benefits, locate and apply/install cool products, and market these products to consumers.
What	Teach roof/wall contractors about the many benefits of cool roofs and walls, how to communicate these benefits to their customers, and how to apply/install cool surface products if special practices are required.
Why	Building owners often take envelope product advice from building professionals, such roof/wall contractors, who may not know enough about the benefits of cool surfaces to recommend them to customers, and in some cases (e.g., cool exterior wall paints) may be unfamiliar with application details. This may lead contractors to recommend that their customers select warm surface materials in hot climates.
Who will implement	The training program would be created and executed by cool roof/wall industry associations with assistance from utilities and cool-surface benefit experts.
Who will benefit	Building owners that otherwise would have difficulty obtaining cool surface products.
How	With technical support from non-commercial entities such as academic researchers, government agencies, and non-governmental organizations, cool roof/wall industry associations would develop training programs to certify contractors and other vendors for sale and installation of their products. Consumers could then look for cool-surface certified suppliers.
Where	Anyone could be trained and certified, though such programs may be state specific.

Implementation timeline	Short to launch; medium to train a substantial number of certified cool-surface vendors.
Cost	Low to create and implement.
Justice40 link	Can provide job training in DACs.
Undesirable side effects	None
Model to follow	U.S. Army's National Roofing Program [21]

5.2.5 Organize annual "Cool Surfaces Workshop"

Summary	Organize an annual "Cool Surfaces Workshop" to engage thought leaders around cool-surface deployment.
What	Organize an annual workshop that brings decisionmakers and thought leaders together to address climate change impacts with the use of cool surfaces. This would include researchers, manufacturers, cities, regional climate collaboratives, federal agencies, adaptation practitioners, environmental nonprofit organizations, construction trade associations, and more to promote best practices and close the gap between climate zones that have high versus low penetration of cool surfaces.
Why	A yearly workshop focused on cool surfaces will bring stakeholders together to address the challenges and opportunities for cool-surface deployment in a multidisciplinary fashion and will help raise awareness, while providing a forum for discussion, technical research, and best practices for the development and implementation of cool-surface policies and programs at local, regional, state, and federal levels.
How	Organize a standalone workshop or hold one in conjunction with a related industry event, like Greenbuild.
Who will implement	A collaboration between a nonprofit organization(s) and academia would be well-primed to organize and implement the workshop. Workshop organizers could seek event sponsors from private sector (manufacturing, consulting firms), government, and nonprofit organizations to fund the event.
Who will benefit	Decision makers and industry would directly benefit from the ideas, research, and models that would be shared, presented, and discussed at the workshop.
Where	The workshop could be held at a different location each year to enable stakeholders around the country to attend. The workshop could also be live-streamed to maximize attendance and participation.
Implementation timeline	One year for planning and coordination. The event could take place right before the hot season starts (e.g., in April or May).
Cost	Low
Justice40 link	Workshop would prioritize that representatives from DACs are included and given speaking time.

Undesirable side effects	None
Model to follow	Workshops at conferences like Greenbuild (U.S.), National Adaptation Forum (U.S.), and International Conference on Countermeasures to Urban Heat Islands (Global)

5.2.6 Cool Roof Prize (CR-Prize) for better cool asphalt shingles

Summary	Launch a competition to stimulate, fund, and reward development of truly cool asphalt shingles that are cost competitive with otherwise equivalent traditional asphalt shingles and satisfy the aesthetic requirements of the marketplace.
What	Create the "Cool Roof Prize," a competition to stimulate, fund, and reward development of truly cool asphalt shingles (e.g., initial solar reflectance ≥ 0.40) that are cost competitive with otherwise equivalent traditional asphalt shingles (e.g., cost premium ≤ $0.20/ft²). Figure of merit would involve initial solar reflectance, cost premium, and market acceptance.
Why	This would demonstrate the value of cool surfaces in the residential sector while incentivizing manufacturers to develop more cost effective and impactful products for steep-slope roofs. It would also be key to advancing residential cool roofs in DACs where first-cost premiums may otherwise present a serious barrier.
How	DOE announces the Cool Roof Prize ("CR-Prize"), modeled after its Lighting Prize ("L-Prize") [22], establishing performance and price targets for cool asphalt shingles. Just as the 2008 L-Prize targeted the most common type of light bulb (60 W incandescent), the CR-Prize would target the common type of residential roofing –the asphalt shingle.
Who will implement	BTO would implement the competition, potentially with co-funding from the California Energy Commission because California has historically driven the adoption of cool roofs. Utilities and energy efficiency program partners would be recruited to promote and develop markets for the winning product(s), as was done in the 2008 L-Prize [23].
Who will benefit	All consumers of asphalt shingle roofing for new construction and roof retrofits, but especially DACs where first-cost premiums may otherwise present a serious barrier to adoption of cool roofs.
Where	Competition would be national, with applicants committing to manufacture products domestically.
Implementation timeline	Short (1 year) to launch the competition; medium (2-3 years) to find the winner (or winners, if more than one entrant meets the criteria). For comparison, the 2008 L-Prize announced its winner in 2011.
Cost	Low to launch the contest, with a multi-million dollar prize to the winner (or winners). For comparison, the 2008 L-Prize awarded $10M cash to its winner in 2011. The 2021 L-Prize [22] prize structure ($20K to each of four concept-phase winner; $2M prize pool for up to six prototype-phase winners; $10M prize pool for up to four manufacturing-and-installation phase winners) might be a helpful approach.

Justice40 link	Promotes housing affordability, energy efficiency, and climate resilience in DACs by making residential cool roofs more affordable.
Undesirable side effects	None, but care must be taken to ensure that (a) the performance and cost targets are sufficient ambitious; (b) the winner(s) are prepared to manufacture at scale; and (c) there will be a market for the winning products.
Model to follow	2008 L-Prize [23] and 2021 L-Prize [24]

5.2.7 High-profile, large-scale demonstration programs

Summary	Initiate high-profile, large-scale demonstration programs that bring cool surfaces to disadvantaged heat-vulnerable communities where these materials would provide the greatest benefits.
What	Collaborative large-scale demonstrations. For example, a cool-wall (painting) demonstration in which paint manufacturers donate paint and painting supplies to be used by community members to paint their own homes, perhaps analogous to the home-building work of Habitat for Humanity, with a research team leading a community (participatory) science program to monitor the benefits.
Why	Would simultaneously raise public awareness, produce immediate benefits to residents, and produce real-world data (quantitative and qualitative) that is climate/regional specific.
How	Should be jointly supported by government, industry, and non-governmental organizations. Media coverage and a mass media communications roll-out will be important.
Who will implement	A community-based organization with support from the local government, university(s), and other nonprofit groups.
Who will benefit	Local residents, surrounding community, and municipality (i.e., could help push the needle toward meeting climate and energy goals by raising awareness and serving as a model citywide and regionally).
Where	Warm climates and urban areas in any climate zone that is experiencing extreme heat events and extended heat waves.
Implementation timeline	Short to medium to plan, coordinate, and implement.
Cost	Varies, but materials could be donated by industry or funded by the municipality.
Justice40 link	Demonstrations can be held in DACs.
Undesirable side effects	None
Model to follow	For community projects, see Chelsea Cool Block Project, Philly Coolest on the Block initiative, and Cool Community project (partnership between City of LA, GAF, and Climate Resolve). For a cool-science example, see the NOAA UHI Mapping Campaign.

5.2.8 Create cost-benefit analytic engine

Summary	Develop an in-depth cost-benefit analytic engine customized for use by America's mid- and large-sized cities, providing detailed online cost-benefit analytic capabilities for cities for large range of cool surface and smart surface interventions. Costs include initial costs, O&M, replacement costs, and training. Benefits include reduced summer temperature, reduced energy costs, reduced CO2e, as well as climate, employment, revenue, and health impacts. In addition, impact estimation would be provided on tourism revenue and city-credit rating. Analysis at the city-wide adoption level provided through a user-friendly cost-benefit analytic engine for end users to rigorously quantify the broad range of costs and benefits of cool roofs and walls.
What	Sophisticated cost-benefit analysis engine available through a user-friendly web-based platform. The customized cool surfaces engine would, when a city name is entered, automatically retrieve data about a range of key city metrics from national databases (e.g., heating degree days, cooling degree days, sunshine, rainfall, electricity cost). In addition, the tool would provide descriptions of sources and ranges for an additional 10-15 important criteria (e.g., surface attribute quantification including square footage and albedo of urban surfaces) to guide cities to further customize the analytic engine to their city. Would include online training sessions, plus training tools and videos.
Why	Would allow federal agencies, state, and city governments to gain a comprehensive understanding of cool surface costs and benefits to make better-informed surfacing decisions. This would lead to reductions in building and city-level heat, use of air conditioning, direct and indirect energy costs, and peak loads, as well as a range of health, equity, and other economic benefits.
How	With funding, this tool would build on Smart Surface Coalition's existing analytic engine to develop an online analytic engine customized for the roughly 300 U.S. cities with populations of 100,000 or more.
Who will implement	Project research team can provide support to DOE staff or help staff review of best practices and development of guidelines for new incentive programs.
Who will benefit	Federal agencies, policymakers, state, and city leaders will for the first time have the analytic capability to quantify the energy, climate, health, and other benefits from changes in city surfaces. These interventions can deliver 30% peak load reduction, 5 °F (3 °C) city-wide cooling, and 15% city-wide CO_2e reduction, along with environmental justice and health benefits. For cities, and city planners, this analytic engine would allow them for the first time to develop multiple scenarios to test and quantify a range of impacts on a cost per unit surface area modified (e.g., $/ft² roof) to determine optimum surface intervention to achieve city policy objectives. For example, the availability of this analytic engine customized for Baltimore has allowed Baltimore to run hundreds of scenarios, identify the most cost-effective cool and smart surface strategies, and implement city-wide changes in surface policies.
Where	The analytic engine would be available online nationally and be customized for the roughly 300 largest US cities—e.g., those with a population of 100K or greater where summer heat is becoming a problem.

Implementation timeline	Medium term (30 months)
Cost	Primarily for data gathering. Medium-cost depending on existing data sets.
Justice 40 link	Analytic engine will show city/state/federal governments how cool surfaces will benefit DACs.
Undesirable side effects	None
Model to follow	Smart Surfaces Coalition cost-benefit engine [24] developed for the cities of Baltimore [25], Stockton [26], etc. (For example, Baltimore is adopting Smart Surfaces city-wide.)

5.2.9 Develop guidelines for best practices in incentive programs

Summary	Develop guidelines for best practices in cool surface incentive programs
What	Comprehensive best practice guide for developing cool surface incentive programs.
Why	Until cool surfaces become standard practice, incentive programs are necessary to encourage implementation. A guideline for developing an effective incentive program can act as a reference for decision-makers proposing and developing cool-surface incentive programs.
How	Review results of cool-surface incentive programs, as well as green infrastructure incentive programs. Also review information gathered from stakeholder interviews and workshops.
Who will implement	Project research team can provide guidance to DOE staff or help staff the review and development of best practices.
Who will benefit	Decision makers designing new incentive programs and their constituents who would take advantage of the incentive programs.
Where	Review should cover cities and regions with existing cool surface incentive programs. Guidelines will be applicable nationally.
Implementation timeline	Short to medium term depending on if some incentive programs would need to be piloted to identify best practices.
Cost	Low to create, medium if pilots of incentive programs were included
Justice40 link	Guidelines will show how to design cool-surface incentive programs that benefit DACs.
Undesirable side effects	None assuming common themes can be extracted from existing cool surface incentive programs.
Model to follow	TBD

5.2.10 Develop/modify evaluation tools and calculators

Summary	Develop/modify evaluation tools and calculators for the general public and building professionals that provide actionable information on the impact of cool surfaces at building to neighborhood to city scales with respect to multiple outcomes (not just energy).
What	User-friendly web-based tools that can develop a monetary comparison between cool surfaces and other roofing and cladding choices. Tool would assess energy savings, peak demand reduction, reduced surface temperatures, carbon reduction, and environmental justice and health benefits.
Why	Cool surfaces offer numerous benefits beyond energy savings and peak demand reduction. To accurately assess the benefits of cool surfaces, simple tools that can be used by the public will facilitate accurate comparisons with other technologies.
How	Government and stakeholder investment will allow researchers to develop the needed calculators and tools.
Who will implement	National laboratories or other research institutions will undertake the development and deployment of these tools.
Who will benefit	The building industry will be able to make better decisions regarding the selection of their building envelope finishes and surface materials.
Where	The tools will be employed to assess cool surface benefits in all climate zones.
Implementation timeline	Short to plan, develop, and implement.
Cost	Medium to launch (academics) and low to implement (web-based; cost would be marketing of the website to users).
Justice40 link	Tools are likely to show that cool surfaces are especially helpful for retrofitting DAC homes that have poorly insulated envelopes with hot roofs.
Undesirable side effects	There are no undesirable side effects of having better information.
Model to follow	Existing cool roof calculators that only focus on energy benefits.

5.2.11 Introduce cool surface requirements/credits into all green-building standards and programs

Summary	Introduce prescriptive requirements or performance credits for the use of cool roofs and walls into all green-building standards used in the U.S.
What	Increase the requirements of cool surfaces in standards and programs that are designed to be above-code with respect to energy efficiency and sustainability.
Why	Green building standards and programs typically promote above-code levels of energy efficiency.

How	Petition green building standard and program committees to add prescriptive requirements and/or performance credits for the use of cool surfaces into their documents. Review green building standards and programs that promote cool surfaces and then draft additional language for those standards and programs that presently do not require this feature.
Who will implement	The project research team can provide guidance to DOE staff or work directly with green building standard and program developers.
Who will benefit	Building owners and occupants in regions where cool surfaces are climate appropriate.
Where	Anywhere cool surfaces are already recognized in policies and programs.
Implementation timeline	Short to medium to create due to code cycle time and potentially long to implement due to the requirement of local jurisdiction adoption.
Cost	Low to launch and medium to implement (requires continuous maintenance).
Justice40 link	Green building standards and programs can encourage cool-surface retrofits in DACs.
Undesirable side effects	None so long as cool surfaces are promoted only in suitable climate zones.
Model to follow	CALGreen, National Green Building Standard (ICC 700), Green Globes, International Green Construction Code, U.S. Green Building Council LEED

5.2.12 Codify retrofits so that the building envelope must include some improvements in energy efficiency

Summary	Codify retrofits so that substantial modifications to the building envelope must include some improvements in energy efficiency. Promote the use of cool roof and cool wall technologies in these code updates.
What	Update building codes to require some energy efficiency improvements when undertaking a substantial retrofit.
Why	Encouragement to update the energy efficiency of existing buildings is needed to meet climate change carbon reduction goals. Updates to the building envelope are the ideal time to incorporate these energy efficiency improvements.
How	Encourage retrofit energy efficiency upgrades through economic incentives.
Who will implement	Federal agencies will petition the code bodies to include these revisions in the next round of building code updates.
Who will benefit	Building owners and occupants through reduced energy costs and a healthier environment.
Where	All climate zones where the use of cool roof and wall technologies are viable.
Implementation timeline	Short to medium to create due to code cycle time and potentially long to implement due to the requirement of local jurisdiction adoption.

Cost	Low to launch (lobby code agencies) and medium to high to implement (additional financial burden of requiring an energy efficiency upgrade).
Justice40 link	Code requirements that promote cool surfaces for retrofits help solve the split-incentive problem (owner does not pay for utilities), benefiting DAC tenants.
Undesirable side effects	Cost of retrofit improvements will increase due to the additional financial burden of requiring an energy efficiency upgrade as well.
Model to follow	Building envelope code requirements for new construction; California Title 24 requirements for retrofit energy efficiency improvements.

5.2.13 Develop cool surface boilerplate language for policies and programs

Summary	Develop a cool surface "standard" boilerplate language that can be the foundation of different policy and standards documents, incentive programs, and local codes to simplify the development of these documents and to homogenize the cool surface requirements.
What	Boiler plate language would be developed which clearly outlines cool surface specifications for technical performance, appropriate applications (e.g., climate zones, measurement standards, limitations, and other key details to implement an effective policy, program, or code.
Why	It can be challenging for government officials to accurately specify technical cool surface requirements for policies, programs, and codes. Therefore, boiler plate language would outline the technical specifications which could then be easily incorporated with minimal technical understanding from government and/or program officials.
How	A consortium of cool surface researchers, non-profits, industry trade groups, and building consultants would jointly develop boiler plate language and work through various communication and outreach channels to share it with relevant government and non-profit entities as well as post it to consortium member websites to easily locate.
Who will implement	Researchers, non-profits, industry trade groups, and building consultants would serve as the technical assistant providers ideally all coordinated through one organization to maximize synergies between activities.
Who will benefit	Any government or non-profit entity trying to develop or revise its building codes, programs, or specifications.
Where	National
Implementation timeline	Short
Cost	Low
Justice40 link	Facilitates implementation of cool surfaces in programs supporting DACs.
Undesirable side effects	None

Model to follow	TBD

5.2.14 Include cool walls in building codes, standards, and programs

Summary	Expand building codes, green building standards, and green building programs that already have provisions for cool roofs to include provisions for cool walls, accounting for roof-wall differences in materials and physics.
What	Update building codes, standards, and green building program that already incorporate cool roofs to also include cool walls.
Why	Even regions of the United States that have well-established cool roof policies and programs may lack analogous policies and programs promoting the use of cool walls.
How	Review national, state, and local policies and programs that promote cool roofs, then draft additional language to promote cool walls where climate appropriate
Who will implement	CMSP research team can provide guidance to DOE staff or work directly with codes and standards developers and program developers.
Who will benefit	Building owners and occupants in regions that do not have cool wall policies (currently, most of the United States).
Where	Anywhere cool roofs are already recognized in policies and programs
Implementation timeline	Short to medium to create due to code cycle time and potentially long to implement due to the requirement of local jurisdiction adoption.
Cost	Low to launch (academics); medium to implement (requires efforts by many stakeholders and ongoing technical guidance from researchers).
Justice40 link	Cool walls are a low-cost, do-it-yourself option that may be especially attractive in DACs.
Undesirable side effects	None so long as cool walls are promoted only in suitable climates (e.g., ASHRAE zones 1-4).
Model to follow	ASHRAE Standard 90.1 recently expanded its cool-wall provisions via Addendum s [27].

5.2.15 Create cool-surface competitions to spur deployment

Summary	Create competitions with prizes to increase deployment at the community, city, and regional level.
What	Competitions such as the "Million Cool Roofs Challenge" can be developed and conducted, with cash prizes and/or non-monetary awards and recognition.
Why	Motivated by recognition and/or cash prizes, individual communities and corporations can be incentivized to develop exemplar cool roofing projects with an emphasis on benefiting DACs.

How	Obtain funding from foundations or federal government (e.g., infrastructure funding) to establish a prize and for the design and implementation of the competition.
Who will implement	Most likely a non-profit (e.g., similar to how the Million Cool Roofs Challenge operated).
Who will benefit	DACs will locally receive direct benefit.
Where	Communities where the need and benefit are the greatest, particularly DACs in hot-weather climates.
Implementation timeline	Medium
Cost	Low to medium
Justice40 link	Competitions can target DACs.
Undesirable side effects	None
Model to follow	Million Cool Roofs Challenge as an initial model

5.2.16 Upstream rebates for cool-surface manufacturers

Summary	Develop rebates for manufacturers to offset initial cool surface product premiums that exist today and increase cool-product availability.
What	Energy utilities and government agencies in some U.S. states offer (or previously offered) rebates to building owners who buy cool roof products. This policy would create new upstream (manufacturer) rebate programs designed to offset the initial cost premium (if any) for a cool version of a roof or wall product.
Why	While many cool roof/wall products are priced the same as otherwise comparable warm products, some cool products that require specialized components or manufacturing processes may cost more to produce and sell for a higher price, especially when the cool-surface market is new and limited. Rebates that offset these cost premiums can drive both demand and supply for cool surfaces.
How	Energy utilities would use ratepayer funds and government agencies would use tax revenues to provide upstream incentives. While not yet tested, upstream incentives that subsidize the production of cool-surface materials so that they retail for the same price as otherwise-similar warm-surface materials might be cheaper to provide (no distributor/contractor markup) and easier to administer (there are far fewer manufacturers than consumers).
Who will implement	The rebate programs would be developed by regulated energy utilities that have mandates to promote energy efficiency, and could be copied by government agencies. Multiple utilities and government agencies may wish to support a single funding agent to avoid the need to create duplicative programs.

Who will benefit	Consumers of cool roofing products that would otherwise carry a cost premium. This would be especially helpful for the owners and occupants of homes with asphalt shingle roofs, since that is the roofing product category that most often carries a "cool" cost premium.
Where	Programs could be local, state, or national.
Implementation timeline	Short
Cost	Low to create; medium to implement but would draw from ratepayer or tax funds already designated for energy efficiency or building resilience.
Justice40 link	Eliminating cost premiums (where present today) will make cool surface materials more affordable, especially in DACs.
Undesirable side effects	Potential for fraud by recipients if the program is administered carelessly.
Model to follow	One or more successful *downstream* rebate programs [28].

5.2.17 City and regional government partnerships and training

Summary	Create partnerships and training for city and regional governments to facilitate incorporation of cool surfaces into climate action plans and initiatives, and into urban planning.
What	Establishment of networks and training materials/programs.
Why	City and regional governments often lack the bandwidth to incorporate new ideas into their planning processes.
How	Urban planning academics could co-develop materials including best-practices documents. Academic and non-profit partners could work together to develop partnerships and deliver training.
Who will implement	Non-profit organizations focused on cool surfaces, perhaps in partnership with university community planning programs that specialize in climate action plans and policy development.
Who will benefit	Local and regional government entities and the communities they serve.
Where	Nationally through online training and regionally/locally through dedicated in-person workshops with local government representatives.
Implementation timeline	Short to develop training materials, medium term to develop networks/partnerships and initiate training opportunities.
Cost	Low
Justice40 link	Partnerships and training can target cities and regions with DACs.
Undesirable side effects	None

Model to follow	There is existing literature on the use of climate action plans to implement urban cooling strategies. There are also networking, training, and workshop models that can be incorporated (e.g., Sustainability Directors Network, Geodesign workshop held at ASU, Portland State University's Urban Design Collaborative).

5.2.18 Cool-surface specifications and city-wide reflectance targets in climate action plans

Summary	Cool-surface specifications and city-wide reflectance targets for climate action and heat mitigation plans
What	Establish cool-surface specifications and city-wide reflectance targets
Why	Provide policymakers with well-researched cool surface and reflectance targets to incorporate into existing, legal climate action and/or heat mitigation plans.
How	Gather heat maps and surface reflectance estimates across city, establish baseline albedo of urban area, and set targets for increasing city-wide albedo. Work with city government to incorporate targets into existing climate action and/or heat mitigation plans.
Who will implement	City, with support of subject matter experts, will use the Smart Surfaces Coalition's cost-benefit engine (where applicable). City officials would propose legislation to incorporate new targets into existing plans.
Who will benefit	City residents (as cool surfaces are implemented), relevant local contractors/laborers (employment opportunities), and cities of similar size and demographic composition (through imitation of model rule)
Where	New targets should reflect benchmarks unique to each city.
Implementation timeline	Medium term to establish benchmarks and pass legislation.
Cost	Primarily for data gathering. Low- to medium-cost depending on existing data sets.
Justice40 link	Activity can target DACs.
Undesirable side effects	None so long as cool surfaces are promoted only in suitable climate zones.
Model to follow	Los Angeles Green Building Code (2014), CA Title 24, Baltimore Cool Roof Ordinance (expected 2023), ASHRAE Standard 90.1.

5.2.19 Seek input from stakeholder communities

Summary	Motivate local, state, and federal government programs to seek input from stakeholders to better understand the highly variable needs across the communities they serve, and to incorporate this information in the development of cool-surface deployment mechanisms—e.g., grant programs, incentives, and financing.

What	Promote co-design exercises, surveys, and workshops to facilitate stakeholder engagement and input into the development of cool-surface incentive programs
Why	Community interventions that incorporate stakeholder engagement and co-design are more successful, better accepted by the communities they serve, and more sustainable.
How	Neighborhood advisory groups and workshops. Workshops with target entities that serve specific communities (e.g., public housing authorities, manufactured housing associations). Emphasis would be put on identifying trusted community liaisons, which could be community-based organizations (non-governmental).
Who will implement	University or non-profit organizations can provide the framework.
Who will benefit	Community stakeholders, as they will have input into the development and implementation of interventions in their own communities.
Where	Distributed at neighborhood scale.
Implementation timeline	Short term. Ideally, this is a first step for many programs/efforts that would seek to have large-scale impact.
Cost	Low-cost engagement
Justice40 link	Stakeholder engagement can target DACs.
Undesirable side effects	It is possible that stakeholders will place a relatively low priority on cool surface deployment and may be further disenfranchised if programs are implemented in ways that ignore community input.
Model to follow	Co-design workshops are an increasingly common mechanism for incorporating local community feedback. These often function similar to an architectural design charette.

5.3 Timeline

Table 1 shows the timeline for implementation of each transformative idea, where short = less than 2 years, medium = 2 - 5 years, and long = more than 5 years. Note that some ideas labeled medium-term can also yield both short- and long-term achievements. For example, since building codes are typically updated once every three years, a campaign to modify a building code could take anywhere from one to four years depending on the current stage of the code's cycle. However, adoption and implementation of a model code or program by a state or local jurisdiction could take longer.

All timelines presume availability of funding and staff for execution.

Table 1. Implementation timelines for transformative ideas, where short = less than 2 years, medium = 2 - 5 years, and long = more than 5 years.

	Idea	**Short-term**	**Medium-term**	**Long-term**
1	Technical assistance to governments			
2	Leverage BIL and IRA			
3	"Keep Your Cool" educational campaign			
4	Contractor training			
5	Cool Surfaces Workshop			
6	Cool Roof Prize			
7	High-profile demonstration programs			
8	Cost-benefit analytic engine			
9	Incentive program guidelines			
10	Tools and calculators			
11	Enhance green-building standards			
12	Energy efficiency requirements for envelope retrofits			
13	Cool-surface boilerplate language			
14	Cool walls in codes, standards, & programs			
15	Deployment competitions			
16	Upstream rebates			
17	Government partnerships and training			
18	Climate action plan specifications & targets			
19	Stakeholder community input			

5.4 Synergistic interactions between stakeholders

Table 2 explores how stakeholder groups could help other groups (or help themselves) advance the deployment of cool surfaces. Read entries along a row—e.g., (1) City and state governments can [1C: Adopt building code requirements recognizing the benefits of cool roofs and walls, expanding their market.] to help the cool-surface industry (C).

Table 2. Matrix describing how stakeholder groups can support other groups (or themselves) in the deployment of cool surfaces. Read entries horizontally.

	...to help city and state governments (A)	**...to help the federal government (B)**	**... to help the cool-surface industry[a] (C)**	**...to help researchers and non-profits[b] (D)**	**...to help utilities (E)**
(1) City and state governments can...	Apply for technical assistance or deployment funding offered by state governments or the federal government. Join or create city/state networks to exchange experiences and best practices regarding cool-surface deployment in urban heat island mitigation or extreme heat adaptation programs.	Inform federal agencies of needed support. Apply for federal funding to support cool-surface deployment.	Adopt building code requirements and heat action plans recognizing the benefits of cool roofs and walls, expanding their market.	Directly fund cool-surface deployment research and demonstration or apply for state/federal technical assistance grants (e.g., such as those offered in Obama's Climate Action Champions program) that will fund researchers. Partner to conduct research on the demonstration and deployment of cool surfaces to monitor benefits	Direct municipal and regulated investor-owned utilities to support cool-surface deployment through customer education programs and product rebates, sometimes supported by utility-collected energy efficiency ratepayer fees.
(2) The federal government can...	Provide technical assistance that guides deployment programs funded and operated by cities and states. Create cool-surface deployment networks for city and state governments.	Direct federal agencies to collaborate on and fund cool-surface demonstration and deployment. Direct federal agencies already engaged in climate or extreme-heat adaptation initiatives to include cool-surface deployment in their plans. Mandate the use of cool-surface products for all federal facilities. (These actions can help the federal government make substantial progress toward its 2030/2050 energy and carbon	Support cool surface R&D through the Cool Roof Prize. Facilitate sale of cool-surface products by restoring federal tax credits for cool roofs and adding such credits for cool walls. Encourage selection of cool-surface products by advocating for the further inclusion of cool-roof and cool-wall requirements or credits in model codes for building energy efficiency (e.g., IECC) and green buildings (e.g., IgCC).	Fund a large scale deployment and monitoring program to support development of benefit calculation tools that guide local implementation. Include cool-surface R&D as a topic in BTO open solicitations, BTO Lab calls, and ARPA-E solicitations. Funding Cooperative Research & Development Agreements (CRADAs) between academics (universities, national labs) and industry.	Publicly recognize or otherwise reward utilities that support cool surface deployment.

	...to help city and state governments (A)	...to help the federal government (B)	... to help the cool-surface industry[a] (C)	...to help researchers and non-profits[b] (D)	...to help utilities (E)
		saving goals, and towards its Justice40 goals.)	Fund Cooperative Research & Development Agreements (CRADAs) between academics (universities, national labs) and industry.		
(3) The cool-surface industry[a] can...	Provide products (and maybe installation) at low or no cost in support of city/state government cool-surface demonstration projects. Manufacture cool surface products locally and at scale, lowering product cost and facilitating adoption by cities and states.	Manufacture cool surface products economically and at scale. Provide market research data that informs federally supported cool-surface deployment. (These actions can help the federal government make substantial progress toward its 2030/2050 energy and carbon saving goals, and towards its Justice40 goals.)	Create a cool-product industry association that spans all relevant roof and wall product categories. Help police industry against companies advocating fraudulent performance claims.	Provide products (and maybe installation) at low or no cost in support of researcher-operated cool-surface demonstration projects. Collaborate with researchers to develop the next generation of highly reflective, economical cool surface products. Support non-profit outreach campaigns to educate public, building industry, local officials, & other key stakeholders	
(4) Researchers and non-profits[b] can...	Provide technical guidance for cool-surface code requirements, heat island mitigation plans, and extreme-heat adaptation plans adopted by city/state governments. Lead or participate in city, state, or federally funded RD&D programs to deploy cool surface materials, especially those serving disadvantaged communities.	Respond to federal requests for information (RFIs), such as those guiding design and implementation of the Greenhouse Gas Reduction fund of the Inflation Reduction Act, to advise how cool surfaces can contribute to solutions. Provide technical guidance about cool-surface deployment to federal programs engaged in development of building	Collaborate with industry through participating in Cooperative Research & Development Agreements (CRADAs). Contribute to educational materials that can be used to market cool-surface products. Advocate the deployment of cool surface products in climate-appropriate locations.	Form or join research, educational, or advocacy networks that can promote cool-surface deployment. Participate in industry-wide projects aimed to better understand the performance of cool surface materials.	Perform the techno-economic analysis needed to support utility-funded code change proposals—e.g., Codes and Standards Enhancement (CASE) studies in California. Perform the techno-economic analysis needed to support utility-funded and operated cool-surface rebate programs.

	...to help city and state governments (A)	...to help the federal government (B)	... to help the cool-surface industry[a] (C)	...to help researchers and non-profits[b] (D)	...to help utilities (E)
		energy efficiency and green building codes and standards. Provide technical guidance about cool-surface deployment to federal agencies and programs engaged in urban heat island mitigation, extreme-heat adaptation, or climate adaptation programs. Participate in international collaborations that can advance cool-surface deployment in the U.S., such as IEA Annex 80: Resilient Cooling of Buildings. (These actions can help the federal government make substantial progress toward its 2030/2050 energy and carbon saving goals, and towards its Justice40 goals.)			Advocate for code changes that include cool surface products.
(5) Utilities can...	Add cool-surface deployment to utility-funded weatherization programs. Offer cool-surface rebates to ratepayers (downstream rebates).	Support adoption of low-cost, high-performance cool asphalt roofing shingles to be developed through a Cool Roof (CR) Prize. (This action can help the federal government make substantial progress toward its 2030/2050 energy and carbon saving goals, and towards its Justice40 goals.)	Offer cool-surface rebates to manufacturers (upstream rebates).	Fund universities and national labs to perform techno-economic analysis in support of utility-driven cool-surface code change proposals and rebate programs.	Join or create utility networks to exchange experiences and best practices regarding cool-surface code changes and rebate programs.

[a] Manufacturers and industry associations
[b] Such as energy efficiency, green building, climate adaptation, or equity advocates

6 Stakeholder feedback to draft Deployment Plan

In December 2022, a near-complete draft of this plan was circulated directly to over 120 stakeholders, both those contacted in spring 2022 and others who expressed interest following team presentations to the Cool Roof Rating Council (June 2022), the DOE Building Technologies Office (August 2022), the Chemical Film and Fabric Association (September 2022), and the White House Office of Science and Technology Policy (October 2022). The draft plan was also shared in articles about the project that appeared in the newsletters of the Cool Roof Rating Council (January 2023) and the University of Arizona Extreme Heat Network (January 2023).

Readers were encouraged to provide input via a Google form that posed nine questions about the plan. Here we summarize the answers received from the 15 reviewers who provided detailed comments. We note that the comments were overwhelmingly positive, constructive, and helpful.

Q1: Do you have feedback on the literature review (Section 3.1 and Appendix A), such as any studies, reports, or conference papers that should have been included? Please provide your specific comments here.

Reviewers encouraged us to look at cool-surface research by specific workers, including Mat Santamouris (University of New South Wales, Australia), Maria Kolokotroni (Brunel University London, England), and Agnese Salvati (Barcelona School of Architecture, Spain); smart surfaces others than reflective surfaces; best practices for passive cooling packages design; life cycle benefits of cool surfaces in future climates; surface soiling from wildfire smoke; cool-surface benefits to neighboring buildings; cool roof market share; and simplified models for making decisions about cool surfaces.

Q2: Do you have feedback on the stakeholder interviews (Section 3.2 and Appendix A), including any individuals or stakeholder groups that should be consulted in a future phase of the project? Please provide your specific comments here.

Reviewers recommended interviewing stakeholders interested in public health or air quality; additional public-sector landlords, such as universities, state & local governments, and school districts; additional state and federal officials to increase awareness; and more local and state government associations. One concurred with stakeholder comments about the need for forward-looking (future climate) building codes, adding that FEMA requires state & local plans to address climate change, but has yet to address extreme heat. They were generally pleased with the comprehensiveness of the stakeholder groups identified in Figure 1 and Figure 2 and the diversity of stakeholders interviewed.

Q3: Would you like to support one or more of the 19 transformative ideas (Sections 4.2 and 5.2)? If so, please select the idea(s) below. [19 transformative ideas listed]

Each of the 15 reviewers indicated support for one or more transformative ideas, and each idea received at least two votes (Figure 3).

- First place: ideas #5 (Cool Surfaces Workshop) and #10 (Tool and calculators) tied for first place with 10 votes each (67%).

- Second place: idea #14 (Cool walls in codes, standards, & programs) took second place with 9 votes each (60%).

- Third place: ideas #3 ("Keep Your Cool" educational campaign), #8 (Cost-benefit analytic engine), and #17 (Government partnerships and training) tied for third with 8 votes each (53%).

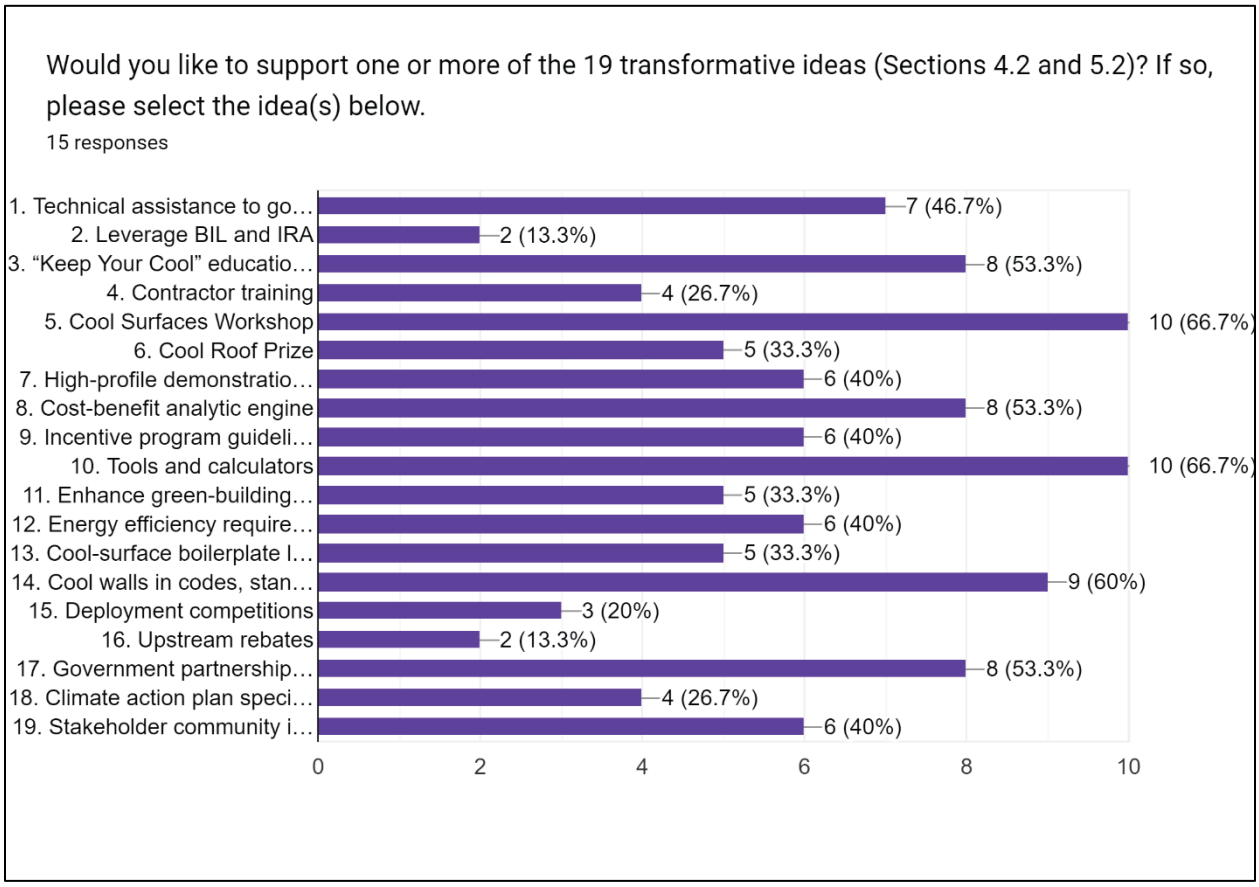

Figure 3. Total number of votes from the 15 reviewers indicating support for each of the 19 transformative ideas.

Q4: Is there a specific way in which you would like to support the transformative idea(s) selected above? If so, please elaborate here.

Reviewers offered to help incorporate cool surface requirements into energy codes, explore whether cool-surfaces projects could be incorporated into the Cool Capital Stack [29] (a $750 million investment pipeline to protect the world from extreme heat), and use information developed from the project to advise cities. They also proposed to use tools and calculators to inform customers about the local benefits of cool surfaces, teach educational material generated in the project, serve on project committees, or act as independent reviewers. Two offered to promote the Cool Roof Prize idea, one (with utility experience) by further developing the concept and another (from industry) by engaging the Green Chemistry and Commerce Council [30].

Google recently announced that it is working on a tool that will show high-resolution surface reflectance, which in turn could help provide the underlying data for both a cost-benefit analytic engine as well as tools

and calculations to show impact of cool surfaces [31]. In our conversations with the relevant Google stakeholders, they expressed interest in offering this data to support our work.

The Chief Heat Officer of Miami-Dade County would like to update requirements in its sustainable buildings ordinance and host a high-profile demonstration project.

Contingent on available resources, a US EPA program manager offered to support ideas #9 (Incentive program guidelines), #10 (Tools and calculators), and #17 (Government partnerships and training) as follows.

Q5: Would you like to nominate a colleague who might be interested in supporting one or more of the 19 transformative ideas? If so, please identify the idea(s) and provide your colleague's contact information (name, affiliation, email) here.

Reviewers identified individuals who might be able to support roof albedo mapping, suggested contacts in the California state government and the University of California for government partnerships on codes and demonstration programs, and identified city contacts in Massachusetts. A US EPA program noted that if it becomes an active implementer of the deployment plan, EPA would establish a team of key experts from relevant departments.

Q6: Are there any transformative ideas to accelerate the deployment of cool surfaces that are not included in Section 5.2 (Transformative ideas, detailed)? If so, please describe them here.

Reviewers suggested innovative financing; heat action planning and coordination; celebrating success (awards, publicity); group purchases—e.g., the California Department of General Services allows schools and local governments to piggyback on state contracts for materials and equipment; a GHG/carbon meter to constantly display reductions from cool surfaces in U.S. and/or individual states; making the "technology" developed in response to the Cool Roof Prize an open patent after 1-2 years so it can be used by other manufacturers; emphasizing how cool-surfaces can slow global climate change, improve public health, and save urban water; and focusing on the carbon offset (global cooling) benefits of cool surfaces, noting how this feature could be a strong driver for cool roofs.

The Chief Heat Officer of Miami-Dade County proposed incorporating a high-profile demonstration of retrofitting low-income rental housing that includes (but is not limited to) cool roofs and surfaces.

A former environmental planner for Cambridge, MA remarked, "there needs to be a path to create market demand for cool roof shingles. Cambridge discussed this issue with the Global Cool Cities Alliance and their industry partners. Los Angeles created sufficient market demand when it established a cool roof regulation. In the Boston market, it would probably require multiple municipalities to coordinate to create sufficient demand to bring cool roof shingles to local distributors. So some combination of education, regional policy making, regional coordination on establishing new regulations, and incentives. Also, it would be useful to issue guidance to provide a palette of policy and regulatory methods for local governments to follow."

A US EPA program manager noted, "I think a key piece that's missing is engagement with big corporations that own lots of commercial building square footage and have corporate climate/energy/environmental goals. If companies like Target, Walmart, Amazon, Costco, etc. used cool roofs and cool walls on all their buildings, it would significantly drive the market. We could work with their national associations and

environmental conferences to assess barriers and opportunities specific to them and then figure out how to mesh solutions with the other transformative ideas."

Q7: Are there ways for stakeholder groups to support one another in accelerating the deployment of cool surfaces that are not identified in Section 5.4 (Synergistic interactions between stakeholders)? If so, please describe them here.

Reviewers proposed considering a declaration around the use of cool surfaces (built on the C40 model for electric buses) that would signal the market and create opportunities for bulk purchasing; having a set of pioneer cities adopt policies and programs that would enable other cities to emulate them and reduce political risk; and sharing the training load across all groups to get the educational material out faster. Another reviewer suggested including the National Academies of Sciences, Engineering, and Medicine (NASEM); National Science Foundation (NSF); and National Institute of Environmental Health Sciences (NIEHS) because they are working on climate change, especially the impacts on older persons in homes and care facilities.

Q8: Are there federal agencies that could help accelerate the deployment of cool surfaces that are not identified in Section 3.4 (Federal agency engagement)? If so, please describe them here, and advise whether you could help connect the team to the agency.

Reviewers suggested engaging the U.S. Department of Health and Human Services, with attention to its Low Income Home Energy Assistance Program (LIHEAP); the U.S. Department of Defense (DOD); and the U.S. Department of Education, noting that K-12 schools are vulnerable to heat and often cash strapped. Another noted that there are other parts of DOE that are critical to get involved, like the State Energy Program, Better Buildings Program, and the Energy Efficiency and Conservation Block Grant Program. One reviewer remarked that lessons about cool roofs and walls from this project could be shared with the Federal Highway Administration (FHWA), which in turn could promote cool pavements.

Q9: Do you have any other comments? If so, please provide them here.

One reviewer raised the need for information about changes to solar reflectance after 10 or more years, asked whether increasing the albedo of steep residential roofs provides the greatest opportunity for the quickest, more significant impacts, recommended distinguishing time to execute a transformative idea from the time to see its results, noted that it is impractical to address all 19 ideas simultaneously with equal priority, and remarked that several ideas in addition to #1 (Technical assistance to governments) and #2 (Leverage BIL and IRA) would benefit from coordination through one organization..

Another reviewer recommended consistent, broad messaging about where winter heating penalties for cool roofs matter (e.g., in certain parts of the northern U.S.), and noted that in Massachusetts, cities sometimes use local zoning rules as a workaround to promote energy efficiency because local building energy codes are pre-empted by the state code.

Another reviewer suggested adding a flowchart based on Table 2; emphasizing the health, learning, job creation, and other non-energy environmental justice benefits of cool surfaces; and working with energy and health groups for consistent, evidence-based messaging about (1) preparing building for the cooling season and for heat waves and (2) quick fixes to keep occupants cooler during heat waves. This reviewer also posed an interesting question: "The original Manhattan Project probably had a hefty budget for its

time, and we are fighting a war for the planet now. So what is the overall level of investment needed in the US or key states to accelerate and capture the cool surface benefits?"

Other recommendations included simplifying the messaging, possibly engaging a communications specialist to distill some of the themes and create infographics; and mentioning additional non-energy benefits, such as global cooling, urban heat island mitigation, and water conservation, in the introduction to the plan, to help policymakers quickly see how cool surfaces can help solve these challenges.

Multiple reviewers used this space to praise the plan:

- "Great work!"
- "Great job on addressing the who, what, where, why, how, when!"
- "Very informative paper! Very well done. This paper is educational all by itself."
- "Overall, a comprehensive and actionable overview of the current cool surfaces deployment issues and opportunities."
- "Great summary."
- "Congratulations to the entire team! This is a well thought out project, and you included all the essential components - research, stakeholder feedback, workshop, etc. EPA looks forward to helping to make the Project a success!"

7 Summary

The project team has developed this multi-year plan to dramatically increase the climate-appropriate deployment of cool surfaces across the U.S., with an emphasis on their application to disadvantaged communities.

Deployment opportunities, barriers, and models were identified by reviewing the history of cool-surface deployment activities, including code improvements, utility incentives, recognition by green-building programs and energy-efficiency labels, and demonstrations, as well as that of energy-efficiency/green building deployment programs that could serve as role models for cool surface deployment. Opportunities include adoption in city/regional government climate action plans, ongoing R&D to address technology challenges, availability of models for implementing cool surfaces in codes and standards, and market expansion supported by public incentive and rebate programs. Barriers include aesthetic concerns, lack of awareness, and financial pressures that prolong the use of existing hot roofs and walls.

We also sought professional guidance from cool-surface stakeholders, such as policymakers, code officials, state energy and housing agencies, utilities, insurers, cities, non-governmental organizations, local civil society organizations, cool-product manufacturers, and researchers. Key takeaways from interviewing over 50 stakeholders included the need for better tools to assess energy savings and UHI reduction, growing demand for cool surface products in increasingly hot cities, readiness of some city/federal government stakeholders to proceed to wide-scale deployment, encouragement from non-profits to mandate cool roofs (or vegetated roofs, also known as green roofs), need for cost-effective, high-performance cool asphalt shingle roofing, need for greater public education about cool surfaces, and concern about discoloration of white roofs.

We conducted a daylong online stakeholder workshop with 62 participants to present our research findings, hear from federal agencies and non-federal stakeholders about their interests in cool-surface deployment,

and collaborate in the development of a deployment plan. From the workshop we developed a list of top 10 objectives for deployment, including local demonstration projects, better solutions and more incentives for cool steep-roofing products on homes, widespread education, incentivization of the non-energy benefits of cool surfaces, tools to report these non-energy benefits, a cool surface standard to incorporate in policies, increased community input, building-code consideration of cool-surface performance in future (hotter) climates, CO_2 offsets, and incorporation in climate action plans.

We engaged six federal agencies—Department of Energy, Environmental Protection Agency, Department of Housing and Urban Development, Federal Emergency Management Agency, National Oceanic and Atmospheric Administration, General Services Administration—and the White House Office of Science and Technology Policy to ask each agency or office how cool surfaces and cool surface stakeholders could support its mission, and how its activities could support cool-surface deployment. We identified many areas of overlap between cool surface deployment and agency/office missions.

We synthesized from the literature review, stakeholder interviews, stakeholder workshop, and federal agency/office engagement a list of 19 top transformative ideas for cool-surface deployment. These include technical assistance to governments; leveraging funds, initiatives, and programs enabled by recent federal legislation; "Keep Your Cool" educational campaign; contractor training; cool surfaces workshops; cool roof prize; high-profile demonstration programs; cost-benefit analytic engine; incentive program guidelines; tools and calculators; enhancement of green-building standards; energy efficiency requirements for envelope retrofits; cool-surface policy boilerplate language; cool wall provisions in codes, standards, and programs; deployment competitions; upstream rebates; government partnerships and training; climate action plan specifications and targets; and stakeholder community input. Each idea is elaborated with statements addressing what, why, who will implement, who will benefit, where, implementation timeline, cost, Justice40 link, undesirable side effects, and model to follow. We also charted the implementation timelines for all 19 transformative ideas and generated a matrix showing how stakeholder groups can help other groups (or themselves) advance the deployment of cool surfaces.

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Appendix A: Stakeholder Interview Report

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Summary

Overview of Project

The team interviewed a diverse set of over 50 stakeholders in April and May 2022 to inform the development of a cool surfaces deployment model for the U.S. Interviews were held either via online video conferencing or phone and lasted between 30–60 minutes. This document contains summaries of each of these conversations as well as general takeaways from each stakeholder group. Among these stakeholders were cool product manufacturers, city officials, federal employees, private consultants, and more. The full list of stakeholder categories is provided below.

Stakeholder Group	Description
City Employee	Employee who works for a city government
Industry Association	Member-based national organizations for specific industries/ trades
State Energy Office	State and territory energy offices involved in energy efficiency and renewable energy programs
Cool Product Manufacturer	Organizations that design and/ or manufacture new "cool" products such as coatings, shingles, walls, etc.
Non-Profit + Think Tank	501(c)(3)s and other NGOs that focus on policy, research, and advocacy concerning topics related to cool surfaces
Researcher	Employee or organization who conducts research and organizes studies
Utility	State and local utility
Federal Employee	Employee who works for the federal government
Private Consultant	Private consultant

Sample Interview Questions

The team developed questions for each stakeholder group prior to the interviews. A sample high level question list from the city/federal government employee stakeholder interviews is provided below. Please see Annex 1 for the questions from the other stakeholder groups.

Questions for City/Federal Government Employee Stakeholder Interviews
What is your role at {*agency/company/organization*}?
How long have you been in that role and with {*agency/company/organization*}?
Have you considered or implemented energy efficiency or cool surface (wall, roof, or pavement) codes, ordinances, or voluntary programs?
Have you implemented any projects or demonstrations that could serve as a model, or offer lessons learned related to cool surfaces?
Are there any challenges or impediments to requiring or promoting cool surfaces in {*city/county/state*}?
Are you aware of any other reasons to not require the installation of cool surfaces? If yes, what are they?

Stakeholder Interview Takeaways

City/Federal Government Employee Stakeholder Interviews

Jane Gilbert
Chief Heat Officer, Miami-Dade County, FL

- Partnering with recognizable brands (in this case, it was Coors Light) on campaigns that focus on outreach and education can quickly build awareness.
- Perceived financial constraints are the main barrier to cool surface implementation. Work thus far has focused on outreach and education.
- Heat maps and vulnerability assessments can inform focused cool roof campaigns and stricter codes beyond ASHRAE and IECC codes.

Victoria Ludwig
Program Manager of Urban Heat Island Reduction Program, US Environmental Protection Agency

- Producing technical guides for local governments on cool roofs allows city officials to better understand health, environmental, and climate impacts.
- New regulations on cool roofing help incentivize projects; requirements for the commercial sector would further this.
- Programs from San Antonio and New York demonstrate successful models that utilize city funds, workforce development programs, tax incentives, etc.
- There are sensitivities on cool pavements due to the federal government not wanting to promote one surface over another (cement and asphalt), but the Federal Highway Administration is moving.

Katharine Kaplan/Doug Anderson
Product Development Manager/Project Manager ENERGY STAR, US Environmental Protection Agency

- The only real way to understand energy savings in different climates is through robust modeling, areas with more new developments tend to have more progressive roofing codes.
- Impact of roofing color is overemphasized. Energy efficiency is a function of building use, climate zone, and energy cost, not just building materials.
- The best tool for demonstrating the impact of cool roofs will have clear labels, be intuitive to use, work on many scales, and point towards individual products.

Braden Kay
Sustainability Director, Tempe, AZ

- Implementing cool roofs not only becomes more important as days of extreme heat increase, but also as nighttime temperatures become worse.
- The main barrier to cool roofs is cost. Assessing the ROI of different cooling strategies should be encouraged before deciding on any one solution.
- You have to account for degradation of roofing material and dirtying when applying reflective surfaces. 3-year SRI values should be used.

Craig Tranby
Environmental Affairs Officer, Department of Public Works, Los Angeles, CA

- People often bypass permits to put in cool roofs because acquiring the permit and hiring a certified contractor is much more expensive than just buying a tub of paint and doing it yourself (can be dealt with using rebates).
- No tools for utilities exist to adequately measure the cost-effectiveness/ usefulness of cool roofs.
- If cities understood the marketplace better, they could help reduce the non-compliant materials that are being sold out of roofing supply shops.

Lucinda Wilcox
Funding and Policy Manager, Department of Public Works, Sacramento, CA

- Believes that the LEED standard is outdated and thinks it should be replaced or revamped because it does not provide the necessary results in energy efficiency and heat reduction.
- Cost and aesthetics (people generally disapprove of white roofs) of cool surfaces are the largest barriers. For example, pavements need to be in good condition and smooth before applying a reflective coating.
- Trees are the city's main cooling tool and they have been happy with those results and therefore don't feel a pressing need to pivot to cool roofs.

Daphne Lundi
Deputy Director for Social Resiliency, NYC Mayor's Office of Climate Resiliency, NYC, NY

- NYC has a successful tax abatement program that provides benefits to those disproportionately affected by the UHI.
- Because heat is an "invisible killer" and does not have a visible presence like fires or

hurricanes, it can be difficult to convince policymakers that it is a real issue. This makes heat vulnerability indexes and other metrics so valuable.

- Roofs in NYC are small and there are a large number of regulations that compete for roof space, making it difficult to fight for mandates and stricter codes. The city's "sustainable roofing zones" therefore allow for solar PV, green roofs, and cool roofs.

Kevin Buettell
Landscape Architect, Department of Public Works, Cambridge, MA
John Bolduc
Environmental Planner, Cambridge Community Development Department, Cambridge, MA

- Vulnerability mapping is a key step in developing a functional climate action plan.
- An energy efficiency performance standard was seen as more attractive than a requirement because it allowed people to comply in different ways. Cool roofs were a prerequisite.
- The minimal reduction on a person's energy bill from cool roofs is often not enough to convince them to switch roof types. It would be helpful to have a more comprehensive, yet intuitive, way to calculate energy savings for any given home.

Saleem Chapman
Chief Resilience Officer, Philadelphia, PA

- "Visioning sessions" don't adequately address community needs, but a transparent planning process with consistent community engagement allows local stakeholders to have more faith in the project and be more responsive.
- Cities in hot climates have universities that focus on these issues given their surroundings (e.g., ASU). In a city like Philadelphia, schools don't specialize in urban heat mitigation as much and so there could be an opportunity to connect them with programs that do.
- High cost premiums made it difficult to get low-income homeowners to support major renovations to their homes.

Carrie Whitlock
Planning and Innovation Program Manager, Elk Grove, CA

- State regulations made the city feel it was unnecessary to develop a cool roofing ordinance, allowing it to focus on GHG emissions.
- One of the main issues is the lack of political will to implement mandates. There are worries with expanding cool pavements into residential areas as there is a belief people are more accepting of them in commercial zones than they will be with them near their homes. If there was a greater supply of smart solutions and more readily available

information, there might be more incentives to generate the political will required to make changes happen.

- It is difficult to prove the efficacy of pilot programs when cost reductions will occur as that solution scales.

Greg Spotts
Chief Sustainability Officer, Los Angeles, CA

- The city partnered with an incubator to get cool pavement products developed and showcased, which helped identify the cheapest, most effective street coatings.
- Leveraging the city's buying power to force efficiency up the supply chain significantly lowered costs for early-stage development. Piggybacking off other cities' orders is another good, cheap way to get pilots done.
- There were significant cost reductions in the application as the city switched from hand rolling cool coatings to a machine that can evenly spray it as it moves.

Michael Blandford
Research Engineer, Affordable Housing Research and Technology Division, Office of Policy and Research, US Department of Housing and Urban Development

- HUD does not have the authority to mandate programs. Its funds are disbursed annually to housing authorities who typically have a long laundry list of life/safety issues to address.
- Occasionally, there are competitive grants issued where HUD can focus funding on a specific activity such as energy efficiency; these are typically not associated with envelope retrofits.
- Manufactured housing is not considered worth reinvestment with retrofits since their value decreases over time.
- Most of the housing under HUD has steep roofs. This leads to issues of cost-effectiveness and aesthetic when thinking about cool roofs.

Syed Ali
Head of Green Building Division, Department of Building and Safety, Los Angeles, CA

- Not much can be done about illegal construction since neighbors can call in code infringements but don't often actually do it. Code enforcement calls sometimes happen even 40 years after the fact but it is believed most roofing will be done legally.
- Making stricter codes is likely a bad thing given the unclear benefits and high-cost premiums (though, these are coming down over time).

- Most pushback/challenges received by the LA Department of Building and Safety come from a new requirement as seen with the Green Code in 2011, which provides environmental benefits, but was not related to energy savings.

Bud Lewis
Resource Efficiency Manager, US Army National Roofing Program

- Roofing needs to be able to survive with only periodic maintenance.
- Roofing systems are selected based on having a 20-year history of performance and a manufacturer willing to supply a no-limit 20-year warranty. The specifics of the roofing systems are not considered.
- There is no question that white roofs do help lower ambient temperature but have little effect on reducing energy needed for cooling the building interior; that is best accomplished thru meeting the ASHRAE standards for above deck insulation (target is R-30 minimum).

Key Points
City/Government Employee Stakeholders

- Given the size of the issue (not just UHI but climate in general), securing enough funding to cover all fronts is a challenge. Need to find ways to ensure that cool roofs are recognized as a solution for multiple problems (e.g., climate impacts, public health) outside of just energy and that they are embedded into broader grant opportunities.
- Giving building owners multiple pathways to meet cool-roof requirements is favored.
- Educating agencies and homeowners through outreach and the development of data-driven tools to measure costs and benefits of cool surfaces will help reduce perceived risks.

Industry Association/Product Manufacturer Stakeholder Interviews

Randy Ober
Technical Director, Single Ply Roofing Industry

- Regulations are the largest drivers in development of new cool roof products and expansion in cool roof product manufacturing.
- Market trends are shifting towards cool roofing solutions leading to manufacturers investing in production.
- Some issues are perceived quality of cool roofing materials and issues with condensation

build up and mold development.

Rick Olson
President and Technical Director, Tile Roofing Industry Alliance

- Tile's thermal mass and air space provide greater benefit than higher solar reflectance. Tiles can be any color and still more energy efficient than other products.
- There is an overall lack of education on cool roofs. If information sharing amongst states and cities occurs, then deployment will rapidly scale, but that starts with California and other states taking the lead.
- Customers want the cheapest way to get a new roofing product more than anything else. They may choose tiles for their longevity but will still go for the cheapest possible tiles.

Frank Klink
Division Lab Head, 3M

- Cool roofing advocacy and outreach won't come from manufacturers who don't want to change their products and methods of production.
- Construction industry is slow to change because production happens on site instead of in factories meaning contractors have to be trained and educated.
- Regulations were fundamental to 3M decisions to offer cool products. 2005 code amendment in California T24 drove low-slope demand but the big increase occurred when the City of Los Angeles put its cool-roof regulation in place.

Melissa Wackerle
Director of Resilience, American Institute of Architects

- ENERGY STAR roof rating system helped drive development as well as the CRRC. There is a large drive for modularity of components in built environments to maximize deployment efficiency.
- Energy efficiency has a larger allure than carbon emissions reduction to architects; this guides AIA's outreach strategy.
- There is a lack of understanding of cool roofs among residential building architects. Since smaller firms often work on commercial or high-end residential units, there is a need to educate residential roofing contractors to avoid developing using the status quo.

Bob Zakbcik
Technical Director, Metal Construction Association

- Since climates and building type vary, cool roof performance should only be one part of the energy efficiency solution or palette of solutions.
- Regulations are the most important thing in development. Innovations in performance only happen to get products up to par with code or even slightly better than it.
- Having a city code on cool roofs that exceeds what is required in ASHRAE or the IECC such as in Houston, TX can bring products to the market without much additional effort.

Lee Martucci
Senior Account Executive, GAF

- The most successful method for communicating the values of cool surfaces is making sure you are talking to the right people.
- Issues with the cool-product supply chain and finding the right people with the right training (look towards automation) hinder deployment and R&D.
- People really care about the durability and longevity of the product. If there can be less frequent installations of roofs or pavements, it reduces a large cost.

Richard Ridenour/Jason Rauter
Manager of Heat Management Project/Business Development Manager, Sun Chemical

- Comfort, durability, and savings are the three main benefits Sun Chemical emphasizes when selling their product.
- Most objections to cool surfaces are cost-related but they aren't always a problem as larger customers can effectively reduce cost through implementation and purchasing deals.
- Sun Chemical's R&D is being driven by future demands/regulations and whatever is popular on the market now.

Terry Wallace
VP of Sales, Texcote

- Issues with innovation include raw material availability and regulations. Transport regulations increase costs for consumers.
- The global materials shortage is a larger issue than the labor shortage.
- More accessible data on the product cost, UHI reduction, and energy savings from cool roofs would help to communicate value more effectively.

Elizabeth Beardsley

Senior Policy Council, US Green Building Council

- Cool roofs are seen as part of the package for upgrading a building's energy efficiency, but not the whole solution.
- Homeowners and business owners don't know enough about financial support programs around the installation of cool roofs.
- Having tangible examples and demonstrations that are highly visible will make cool surfaces more palpable to consumers, but it needs to be accompanied with R&D and incentives to drive down costs.

Maureen Kavanagh
Director of R&D-Industrial Mineral Products Division*, 3M*

- Cool roofing industry communication centers around meeting reflectivity requirements; product development is driven by consumers and codes.
- Product development is driven by customer demand and codes.
- Most manufacturing for their products is done in CA (where the market is largest), meaning their products are more expensive in smaller markets because of shipping costs.

Chadwick Collins
Director of Technology Services, Roof Coatings Manufacturers Association

- Most of the buildings that will be built have already been built; products manufactured for retrofits (coatings) should be prioritized over products manufactured for roof installations (paints).
- The roofing industry is a market-driven industry, which means there are gradual innovations that are more like iterations (slight improvements).
- Cool surfaces, unlike their predecessors, as a coating require frequent maintenance and are "not set and forget" like many older roofs. The fact is that soiling and staining will cause reduced reflectivity. This means things have to be reapplied or monitored and cleaned.

Vladimir Kochkin
Codes and Standards, National Association of Home Builders

- The insulation levels mandated in the codes are such that energy savings are not significant in their applications.
- With their membership being primarily builders, cost is really the only consideration, and they support anything that reduces the cost of construction. They believe that this limits

the benefits of cool roofing to Climate Zones 0 and 1.

- They are aware of the availability of darker "cool colors" but those cost more and, with no perceived benefits, do not pass their cost effectiveness criteria.

Jonathan Humble
Regional Director of Codes and Standards, American Iron and Steel Institute

- Trust is the characteristic that drives the adoption of cool roofing in the marketplace. This trust is in place for low-slope roofing but not steep-slope.
- There are criticisms regarding deploying reflective surfaces on steep-slope roofs, requiring an assessment of their performance and cost.
- Resources and time are lacking to educate people on cool surfaces.

Emily Lorenz
Director Technical Services, International Institute of Building Enclosure Consultants (IIBEC)

- Cool roofs are being widely used where they need to be and that using them in suboptimal conditions leads to negative impacts on energy efficiency as well as development of mold.
- Developing best practice guidelines for climate zones 4 and 5 would be useful.
- Have not seen increased demand. Through participation in IECC and ASHRAE 90.1, IIBEC knows that requirements will be increasing so there will be increased demand as newer versions of codes are updated and adopted.

Stephen Shanks
Senior Consultant, Intertek

- Cool roofing has an adequate history of deployment. Therefore, there is not much PR today because of this status.
- Cool surfaces are primarily driven by codes that limit their inclusion to specific climates. Data to support extending cool roofs to northern climates or to steep-slope roofing is not convincing.
- Low-income properties typically have absentee owners who do not benefit from energy savings. Other perks such as tax breaks are required to interest them.

David Roodvoets
Technical Director, Single Ply Roofing Industry

- Using too much technical jargon means many cool roof benefits may be lost in translation in educational offerings.
- There is less exposure and media attention on cool roof developments because it is already seen as an established solution.
- High levels of insulation may present energy savings issues.

Key Points
Industry Association/Product Manufacturer Stakeholders

- Regulations and consumer demand drive innovation and control the scale of the market.
- There is little desire to expand the market to places where isn't a direct call or promise of business for more cool-surface materials.
- Cool roofing has been around for long enough to be seen as an established solution that doesn't get much media attention and is not viewed as innovative tech or an exciting solution.

State Energy Office Stakeholder Interviews

Howard Wiig
Energy Analyst, Hawaii State Energy Office

- Adding multiple compliance options to codes makes them more likely to succeed.
- Putting white roofs in already built-up neighborhoods can mitigate issues of roofs getting dirty quickly due to new development.
- Reducing thermal resistance requirements in exchange for increased home reflectivity could make builders happy.

Payam Bozorgchami
Senior Civil Engineer, California Energy Commission (CEC)

- There can be pushback from manufacturers who are worried about meeting compliance standards and therefore losing access to entire markets.
- Issues with enforcement — CEC is adamant about avoiding "weekend projects" or putting up roofs over the weekend without a permit.
- Outreach programs have been really successful in comforting building owners on achieving desired aesthetic and energy savings benefits.

Key Points
State Energy Office Stakeholders

- Giving building owners multiple options/pathways to meet key energy efficiency or heating metrics leads to better received and more successful building codes.
- Manufacturers and contractors may push back on regulations they feel ill prepared for as it can lead to them losing access to entire markets.

Non-profit Stakeholder Interviews

Kurt Shickman
Extreme Heat Initiative Director, Adrienne Arsht-Rockefeller Center, Atlantic Council

- Reasons for a project must extend past the core implementing department. Sustainability offices may lead the charge, but many other agencies and pilots are required to help forge cross-agency relationships.
- Climate funders more focused on mitigation approaches over adaptation approaches, which creates competition among broader grants.
- Roof rebate levels need to be set correctly for rebates to be a successful uptake strategy.

Jonathan Parfrey
Executive Director, Climate Resolve

- Cool roofing is a strategy that makes climate activists happy while providing tangible benefits to homeowners (could be a "gateway drug" to greater climate activism).
- Cool-surface programs could take years to develop because they usually spawn from experiments or pilots plus long conversations with city officials.
- Building and safety requirements drive demand for cool surfaces more than do incentives.

Kim Cheslak/ Bryce Seymour
Director of Codes, Project Manager on Codes/Policy Team, New Buildings Institute

- The primary audience for communicating value should be policy makers, then designers, then contractors, focusing on energy savings, equity, and the importance of using cool surfaces even in moderate climates.
- New concepts should be incentivized, but green and cool roofs should be mandated as

proven, cost-effective solutions.

- Stormwater ordinances take a site-based approach which could be smart to avoid.

Mischa Egolf
Project Analyst, New Buildings Institute

- Demonstration projects on shading devices and heat pumps were used to gauge consumer acceptance. Customer questions about maturation of the technology and a lack of application information helped inform installation practices.
- There is too little information available on the cost effectiveness of cool roofing based on today's insulation levels and on the benefits associated with grid reliability and peak demand.
- Cool roofs are already widely used where it is effective.

Kale Roberts
Senior Program Officer, ICLEI

- Since the majority of roofing conversations being had are about solar, cool roofs are often undervalued just as green roofs are.
- More financial case studies in different climate zones would help guide effective implementation.
- City networks and climate mayors can help build momentum and foster information sharing on best practices.

Key Points
Non-profit Stakeholders

- There is a general feeling that there either cool surface case studies aren't easily accessible or there simply haven't been enough done.
- Pilots also provide an opportunity to create cross-departmental relationships in cities that can lead to more administrative efficiency in the future, but those original pilots take time and effort to get off the ground.
- Cool roofing products are too old and established to be in conversations as an exciting emerging technology but too new to be the industry standard.

Researcher Stakeholder Interviews

Amy Turner

Senior Fellow, Sabin Center for Climate Change Law at Columbia University

- Lack of education and awareness are the biggest reasons cool roofing is not more adopted as a strategy.
- The perceived tradeoffs in funding climate change adaptation vs. mitigation in many cities, results in cities choosing to champion one and leave the other to the side; this leaves cool roofs (a strategy which does both) in an awkward middle zone where they are seen as ineffective.
- Costs of not using cool roofs should be emphasized to building professionals.

Danny Parker
Researcher, Florida Solar Energy Center

- Providing credits for reflective surfaces raised awareness of them among contractors and consumers. Florida may have had more white surfaces in the 50s before AC than it does now.
- An advantage of cool roofing over insulation is that thermography can be avoided in measuring effectiveness of the job done.
- Commercial facilities seem less bothered about aesthetic issues of reflective roofs.
- There are issues with tile roofing in hurricane conditions as well as with algae growth in tiles.

Hashem Akbari
Professor, Concordia University

- Education on cool roofing is important but the most important thing is developing better codes and standards to see greater saturation of cool roofs in the market.
- Contractors often know of the benefits of cool roofs but decide to keep selling whatever it is they have been selling historically.
- Important to recognize that cool roofs are not a silver bullet but rather a steppingstone to greater climate positive action.

Key Points
Research Stakeholders

- Contractors are often aware of the benefits of cool roofs but choose not to advertise them to customers so that they (the contractors) don't have to adapt; this means that implementing new codes is crucial so that there is an inherent cost for the contractor in not advertising cool roofing products.
- Cool roofs are not the silver bullet that will end human caused climate change or allow us

to perfectly adapt but it is a good steppingstone or "gateway drug" to further climate action.

Utility Stakeholder Interviews

Peter Turnbull
Codes and Standards, Pacific Gas & Electric

- Extreme weather events like fires take precedence over funding for cool roofing programs.
- Construction industry pushes back against change; supply chains are already established and changing to a majority cool roof market could mean a total industry overhaul.
- Mad Magazine cooked an egg on hot pavement, which created a lot of media attention. More demonstrations like this are needed.

Mike Denby
Sustainability Policy Advisor, Arizona Public Service

- The utility is mainly focused on energy concerns and doesn't really see a need for a cool surface focus.
- Finding ways to make the product economical is important.
- Has no experience with cool surfaces.

Key Points
Utility Stakeholders

- Cities need a better understanding of the roofing market so they can address issues like non-compliant products and can drive roofing supply chains to adapt to the production of cool roofing products.
- Finding ways to make products more economical and ways to demonstrate that cost effectiveness are crucial in proliferating cool surface products.

Broad Observations

After interviewing a diverse group of stakeholders with wide-ranging expertise, it is important to identify any broad observations or takeaways from multiple conversations. Each participating organization's broad observations are detailed below.

From the Smart Surfaces Coalition

- Most of the stakeholders with whom SSC spoke were either city officials or federal employees. Nearly every stakeholder generally agreed that cool roofs or walls could reduce UHI and save building owners money on energy bills, but nobody knew how much those savings would total. The greatest need among city and federal employees is an effective way to conduct detailed analyses of the energy savings and UHI reduction benefits that will result from investment in cool surfaces. According to many stakeholders, the current palate of tools is inadequate at accomplishing this.
- How we label the impacts of different solutions matters. If we are to encourage the use of cool roofs because they mitigate heat and reduce UHI city-wide, communities or funding sources may only look at cool roofs from an adaptation perspective, when in fact the energy reduction benefits from cool roofs also makes it a climate change mitigation solution.

From Arizona State University

- Manufacturing stakeholders were concerned with the current supply chain issue, as this affects getting raw materials for cool surfaces. They are also seeing a growing demand in the market from cities for cool surfaces product, as these cities become hotter, and because of the recent regulations. There were some concerns from cities related to awareness of cool surface products (including the benefits) and costs.
- City/federal government stakeholders said that some of these technologies no longer require pilot experiments— they are ready to scale up. Regulations and financial incentives help to implement the cool surfaces. Concerns remain related to longevity, durability, and maintenance of cool surface products.
- Non-profit stakeholders agreed that cool roofs and/or green roofs should be mandated because it is not encouraged simply through incentives anymore.
- Interviews from utility stakeholders revealed that while some stakeholders did not directly work with cool surfaces, they had concerns about product costs and financing.

From Lawrence Berkeley National Laboratory

- Broad questions that stakeholders were considering:
    - Are we satisfied with today's cool roof products or do we need to push for more innovation? Is the problem the cost premium or performance of current products when we think about increasing adoption of cool surfaces?
    - Can there be a grand challenge in which housing authorities or jurisdictions use their portfolio as a market incentive to drive innovation and/or cost? Can that product then be bought and bulk and offered at a discount to other consumers?
- Too few small towns and suburbs were interviewed. Given that adoption in smaller suburban areas is less than in big cities such as Los Angeles and New York, the following questions frequently came up:

    - How can big cities engage smaller jurisdictions to share their experience with cool surfaces, develop innovative large purchasing agreements, offer training to regional trades, etc.?
- A common sentiment is the need for more education and awareness among the public (consumers), trade associations (developers, roofing contractors), and policymakers. Cities are thinking about innovative communications partnerships or ideas (such as a partnership Miami-Dade County, FL has with Coors to promote cool roofs).
- A barrier that came up in multiple interviews is discoloration for soiling and aesthetics reasons.
- There seems to be a cycle of linked public-private interest, policy, investment, and innovation that drives adoption, markets, and product development for cool surfaces.

Annex 1

The following tables are the high-level question lists from each stakeholder interview. For an example of the specific questions, we provide the script for city/federal government employee stakeholders in Annex 2.

Questions for Industry Association/Product Manufacturer Stakeholder Interviews
What is your role at {agency/company/organization}?
How long have you been in that role and with {agency/company/organization}?
How do you think about and communicate the value of cool surfaces?
What drives your development of new cool surface products and innovations?
Have you seen an increased demand from your customers/public for cool surfaces?
Are you aware of any other reasons to not require the installation of cool surfaces? If yes, what are they?
Have you experienced or are aware of any challenges in communicating/educating customers/stakeholders about cool surfaces?

Questions for Non-profit Stakeholder Interviews
What is your role at {agency/company/organization}?
How long have you been in that role and with {agency/company/organization}?
Have you completed projects or demonstrations related to cool surfaces (walls, roofs, or pavement coatings) that could serve as a model for future deployment?
How do you think about and communicate the value of cool surfaces?
Have you seen an increased demand from your customers/public for cool surfaces?
Can you describe any unsuccessful projects or demonstrations related to cool surfaces?
Are you aware of any other reasons to not require the installation of cool surfaces?

Questions for Researcher Stakeholder Interviews
What is your role at {agency/company/organization}?
How long have you been in that role and with {agency/company/organization}?

Have you implemented any projects or demonstrations that could serve as a model, or offer lessons learned related to cool surfaces?
Are there any challenges or impediments to requiring or promoting cool surfaces in {city/county/state}?
Are you aware of any other reasons to not require the installation of cool surfaces? If yes, what are they?

Questions for State Energy Office Stakeholder Interviews
What is your role at {agency/company/organization}?
How long have you been in that role and with {agency/company/organization}?
Have you implemented any projects or demonstrations that could serve as a model, or offer lessons learned related to cool surfaces?
Are there any challenges or impediments to requiring or promoting cool surfaces in {city/county/state}?
Are you aware of any other reasons to not require the installation of cool surfaces? If yes, what are they?

Questions for Utility Stakeholder Interviews
What is your role at {agency/company/organization}?
How long have you been in that role and with {agency/company/organization}?
Have you considered or implemented energy efficiency or cool surface (wall, roof, or pavement) codes, ordinances, or voluntary programs?
Have you implemented any projects or demonstrations that could serve as a model, or offer lessons learned related to cool surfaces?
Are there any challenges or impediments to requiring or promoting cool surfaces in {city/county/state}?
Are you aware of any other reasons to not require the installation of cool surfaces? If yes, what are they?
Have you experienced or are aware of any challenges in communicating/educating customers/stakeholders about cool surfaces?

Annex 2

This is the script for city/federal government employee stakeholders, followed by high-level questions sent with the call reminder email.

Text in colored braces is adapted to the interviewee.

Stakeholder:
Interviewer:
Date:

- Thank you for taking the time to speak with me today.
- As I mentioned in my email, I am part of a team working on a project sponsored by DOE that seeks to dramatically increase the climate-appropriate deployment of cool surfaces (e.g., roofs and exterior walls) across the U.S.
- We've been interviewing various stakeholders to learn more about the opportunities and barriers for cool surfaces.
- I wanted to speak with you about your {organization's/agency's/utility's/association's/company's} {climate-related/heat-related/sustainability/environmental/cool surface/roof/wall {policies and programs} {products/practices}.
- I've got a few questions I'd like to ask you over the next 30 minutes.
    - Please let me know if you have a hard stop or can talk for longer if need be.
- We'd like you to discuss this topic from the standpoint of your organization or in your role as a subject matter expert.

1. What is your role at {agency/company/organization}?

2. How long have you been in that role and with {agency/company/organization}?

3. Have you considered or implemented energy efficiency or cool surface (wall, roof, or pavement) codes, ordinances, or voluntary programs? [1B: Policy]

a. What were the reasons for implementing such a program or code?
b. Did you have leadership support? From who?
c. Was there opposition from internal or external stakeholders? If so, why?
d. How have climate trends—specifically surges in extreme heat—impacted your work?
e. Do you have programs in place that include climate considerations? If so, how are they going? If not, why?

4. Have you implemented any projects or demonstrations that could serve as a model, or offer lessons learned related to cool surfaces? [1A: Programs]

a. What was the impact of the project?
b. What factors helped them become successful?
c. Who were your partners?
d. How long did the project take to develop?
e. Was environmental justice/equity factored into decision making? How?

—- OR —-- (Barriers)

f. What were lessons learned, if a project was unsuccessful?
g. What changes would you make/or were made to ensure future success? Please describe changes made, if any.

5. Are there any challenges, political sensitivities or impediments to requiring or promoting cool surfaces in {city/county/state}? [2D: Policy]

6. Are you aware of any other reasons to not require the installation of cool surfaces? If yes, what are they? [2B: Regulations and Enforcement]

- **a.** What are common objections to the use of cool surfaces?
- **b.** Why do you think these claims are made?
- **c.** What factors influence or affect your perception of cool roofs and walls?
- **d.** Has glare been a concern, and if so, what can be done to reduce it?
- **e.** Can you tell us your experience with moisture build-up in roof spaces when using cool roof products?
- **f.** Can you tell us your experience with roof surface discoloration from moisture?

ADDITIONAL QUESTIONS (IF THERE IS TIME)

7. How do you think about and communicate the value of cool surfaces? [1C: Benefits and Awareness]

- **a.** What have been the most successful methods for building awareness?
- **b.** What was the most helpful source of information that was used?
- **c.** Have you experienced or are aware of any challenges in communicating/educating customers/stakeholders about cool surfaces?

8. How does climate factor into your projects or influence what is adopted into your building code or land use ordinances? [1E:Climate]

- **a.** Do you have an existing or emerging extreme heat problem?

Closing remarks:

- Thanks again for your time and for helping us understand the best ways to promote the appropriate use of cool surfaces.
- As discussed, your input will help inform our report to the Building Technologies Office of the U.S. DOE regarding efforts to increase the climate-appropriate deployment of cool surfaces across the U.S.
- We will share the final document with you when it is released {by this fall}, if you are interested.
- Is there someone else to whom we should speak?

ACTION ITEMS (for interviewer):

—---------

High-level question list to send with the call reminder email

1. What is your role at {agency/company/organization}?

2. How long have you been in that role and with {agency/company/organization}?

3. Have you considered or implemented energy efficiency or cool surface (wall, roof, or pavement) codes, ordinances, or voluntary programs?

4. Have you implemented any projects or demonstrations that could serve as a model, or offer lessons learned related to cool surfaces?

5. Are there any challenges or impediments to requiring or promoting cool surfaces in {city/county/state}?

6. Are you aware of any other reasons to not require the installation of cool surfaces? If yes, what are they?

Appendix B: Stakeholder Workshop Report

Executive Summary

This project, sponsored by the U.S. Department of Energy, seeks to dramatically increase the climate-appropriate deployment of cool surfaces across the U.S., with an emphasis on their application to disadvantaged communities. The project team first conducted an in-depth literature review and interviewed a diverse group of stakeholders to better understand cool surfaces deployment barriers and opportunities. The team then organized a stakeholder workshop to solicit feedback on the deployment plan. This workshop was held on September 8, 2022, from 8:30 am to 2:30 pm PT and included 62 registered participants from a range of backgrounds, including city employees, industry associations, federal agencies, cool product manufacturers, non-profits, state energy offices, researchers, and consultants. Members of the project team first shared key findings from the literature review and stakeholder interviews. Then, workshop participants heard from federal and non-federal stakeholders about their experiences with cool surfaces deployment. Next, workshop participants were divided into small groups to answer a series of questions related to cool surfaces deployment models and best practices, which were then shared and discussed with the entire workshop in Deployment Plan Session 2. The project team will use the materials from the workshop, stakeholder input, and other key takeaways to inform the deployment plan.

Introduction

Solar-reflective building envelope surfaces, such as cool roofs and walls, can save energy, reduce carbon footprint, and lower peak power demand in air-conditioned buildings. They improve comfort and safety in buildings that are not air-conditioned due to a lack of equipment or power, mitigate the urban heat island effect, improve air quality, and slow global warming.

Cool roofs and walls can be especially helpful in disadvantaged communities that often have poorly insulated older homes, aging or absent air conditioning units, steep utility bills, polluted air, and high vulnerability and exposure to extreme heat. Cool surfaces are among the least-expensive ways to improve energy efficiency and lower energy costs in these communities. They also boost resilience to coincident power outages and heat waves by limiting temperature rise during these events.

Uptake of cool surfaces has been strong in California and Florida, but more limited nationally. Our project, sponsored by the Building Technologies Office of the U.S. Department of Energy, seeks to bridge this gap by dramatically increasing the climate-appropriate deployment of cool surfaces across the U.S., with an emphasis on their application to disadvantaged communities.

To do this, the team first sought to identify cool surface deployment barriers, opportunities, and models by (a) reviewing the history of cool-surface deployment activities, including code improvements, utility incentives, recognition by green-building programs and energy-efficiency labels, and demonstrations; (b) interviewing cool-surface stakeholders, such as policymakers, code officials, state energy and housing agencies, utilities, insurers, cities, non-governmental organizations, local civil society organizations, cool-product manufacturers, and researchers; (c) researching energy-efficiency/green building deployment models with successful track records; and (d) interviewing the actors who have implemented these models. This is further detailed in the Literature Review Report and Stakeholder Interview Report.

Then, the team engaged stakeholders in plan development after sharing the literature review and stakeholder interview reports with cool-surface stakeholders (e.g., DOE, HUD, HHS, NOAA, EPA, state energy and housing agencies, utilities, insurers, cities, local civil society organizations, and cool product manufacturers). The team conducted a

virtual workshop in which stakeholders provided feedback and recommended proven or novel strategies, thereby investing in the deployment plan. This report will cover the cool surfaces stakeholder workshop.

The Cool Surfaces Stakeholder Workshop

The stakeholder workshop, sponsored by the U.S Department of Energy, was held online on September 8, 2022, from 8:30 am to 2:30 pm PT to solicit feedback on an effective cool surface deployment model. In preparation for the workshop, the project team invited over 120 stakeholders from a range of backgrounds including city and federal employees, industry associations, manufacturers, non-profits, state energy offices, researchers, utilities, and consultants. The workshop's purpose was not only to share information related to the findings from the literature review and stakeholder interviews, but also to brainstorm other potential barriers and opportunities for cool surfaces deployment.

Takeaways and deliverables from the literature review, stakeholder interviews, and stakeholder workshop will inform the development of a cool surface deployment plan for Phase 2 of the project, producing a detailed multi-year action plan, targets, and metrics for large-scale cool surface deployment on residential, commercial, and institutional buildings. This plan is expected to be finalized by the end of October 2022.

Workshop Participation

We invited over 120 stakeholders; 62 attended the workshop. Figure 1 shows a breakdown of what stakeholder groups registered for the workshop (the numbers in the parenthesis represent the number of stakeholders registered for each group).

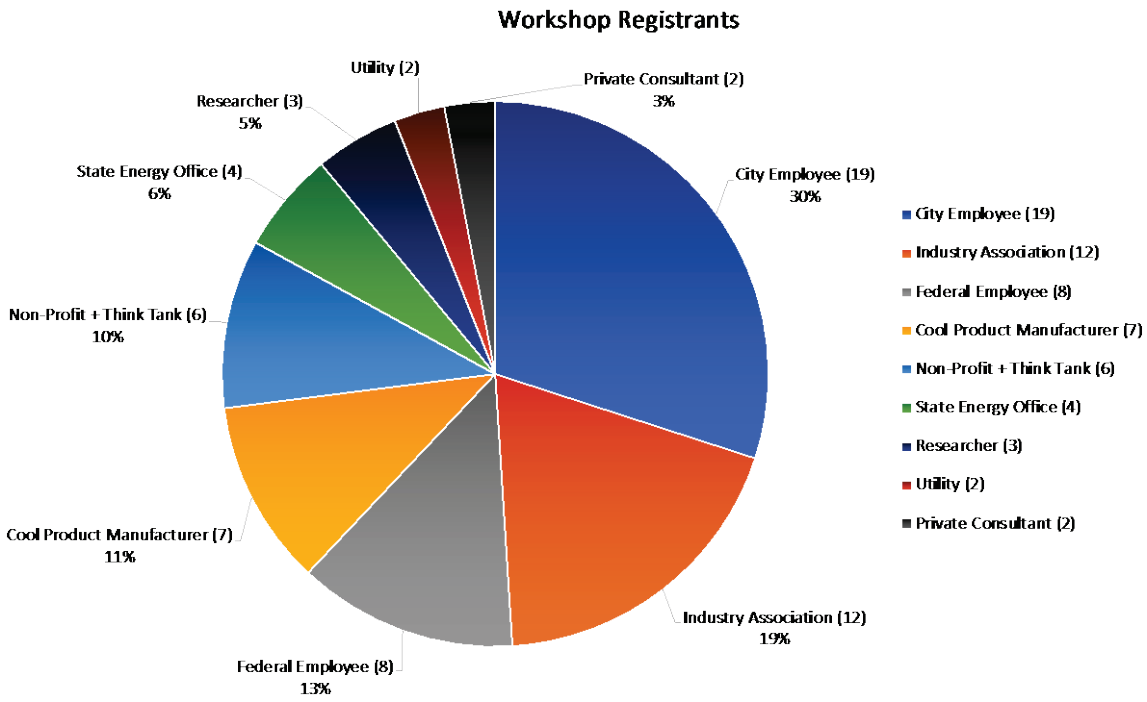

Figure 1. Workshop registrants by category.

Workshop Activities and Materials

Table 1 lists the workshop agenda. For a complete package of presentations, zoom recordings, and other materials, please refer to the Stakeholder Workshop Presentations and Notes.

Table 1. Workshop agenda.

Topic	Time (Pacific)
Introduction & Overview of Project	8:00–8:15 am
Literature Review Findings	8:15–8:40 am
Stakeholder Interview Findings	8:40–9:05 am
Open Discussion on Literature Review and Stakeholder Interviews	9:05–9:35 am
10-minute Break	9:35–9:45 am
Federal Agency Presentations and 15-minute Q&A	9:45–10:40 am
30-minute Break	10:40–11:10 am
Non-federal Stakeholder Presentations and 15-minute Q&A	11:10 am–12:05 pm
Deployment Plan Session 1	12:05–1:05 pm
10-minute Break	1:05–1:15 pm
Deployment Plan Session 2	1:15–2:15 pm
Conclusions and Next Steps	2:15–2:30 pm

In the Introduction & Overview of Project section, Ronnen Levinson (Lawrence Berkeley National Laboratory) spoke broadly about the project team, timeline, and purpose of a deployment plan as well as outlined the agenda for the workshop.

In the Literature Review Findings section, David Sailor (Arizona State University) shared key takeaways and methods of organizing studies to better understand successful and unsuccessful cool surfaces deployment models.

In the Stakeholder Interview Findings section, Jackson Becce (The Smart Surfaces Coalition) walked through the stakeholder interview process, including what types of stakeholder groups we engaged and what questions we asked, as well as summarized broad takeaways from discussions across stakeholder groups.

In the Open Discussion on Literature Review and Stakeholder Interviews section, workshop participants asked questions and suggested other topic areas to explore regarding cool surface deployment barriers and opportunities. The discussion prompts used are listed in Table 2. These recommendations will be reflected in the deployment plan.

Table 2. Questions posed to participants after presenting findings of the literature review and stakeholder interviews.

Guiding Questions for Open Discussion on the Literature Review + Stakeholder Interviews
What do you still need to know about the adoption of cool surfaces?

How do these insights resonate with you?
Are there other insights that would be helpful to share to help us identify barriers and opportunities?
Is there other key information we are missing (policies, similar successful/unsuccessful models, market studies, utility reports?
Are there key entities/stakeholders who can contribute to the successful implementation of this deployment program that we have missed?

After a short break, Andre Desjarlais (Oak Ridge National Laboratory) introduced our Federal Agency and Non-federal Stakeholder Presenters to share more about successful and unsuccessful cool surfaces deployment case studies from around the U.S. From the Federal Agency Presentations section, we heard presentations from Marc LaFrance of the Department of Energy's Building Technologies Office, Derek Schroader of the Department of Energy's Weatherization Assistance Program, Joseph Baietti of the Department of Housing and Urban Development, Victoria Ludwig of the Environmental Protection Agency's Heat Island Reduction Program, and Hunter Jones and Morgan Zabow of the Department of Commerce's National Oceanic and Atmospheric Demonstration. From the Non-federal Stakeholder Presentations section, we heard presentations from Maureen Kavanagh of the 3M Corporation, Craig Tranby of Los Angeles Department of Water and Power, Kurt Shickman of the Adrienne Arsht Rockefeller Center, Sumedha Rao of Louisville's Metro Government Office of Advanced Planning and Sustainability, and Howard Wiig of Hawaii's State Energy Office.

In Deployment Plan Session 1, members of the workshop were split into four groups to answer a series of questions related to best practices with a breakout room leader and notetaker. These questions involved soliciting feedback on effective deployment models that involve policy; information and education; research, development, and deployment; programs and standards; and incentives and financing. The primary and secondary questions asked are listed in Tables 3 and 4. Groups populated a PowerPoint slide laying out their actionable ideas and a timeline for implementation of those ideas for each of the discussion areas (policy; information, research, development, and deploymnet; programs and standards; and incentives and financing.) Then, after a short break, the breakout room leader and notetaker shared these takeaways with the entire workshop in Deployment Plan Session 2.

Table 3. Primary questions considered by the participants during the Deployment Plan sessions.

Primary Questions: To advance the deployment of cool surfaces across the United States…
What are the top three policy levers? (e.g., mandatory of prescriptive code requirements, legislation, climate/energy action plans)
What are the top three information channels? (e.g., outreach, education, communication, training)
What are the top three research, development, and deployment (R&D) needs? (e.g., emerging technologies demonstration projects)
What are the top three programs and standards opportunities? (e.g., definitions, ratings, methods, certification)

What are the top three incentives and financing mechanisms? (e.g., tax credits, rebates, development benefits, loans)
*Note: we are not asking participants to choose from the examples lisulted– these are just prompts to stimulate thinking. An answer of the form "outreach, education, and communication" will not be useful

Table 4. Secondary questions considered by the participants during the Deployment Plan sessions.

Secondary Questions
What is the top benefit cool surfaces provide for my organization or industry?
What is the greatest opportunity to advance the use of cool surfaces by my organization or industry?
What is the greatest barrier to the use of cool surfaces faced by my organization or industry?

In the Conclusions and Next Steps section, Ronnen Levinson summarized key takeaways of the workshop and informed participants about the timeline for finalizing the deployment plan and sharing workshop materials.

Key Takeaways

The cool surfaces stakeholder workshop was essential in soliciting feedback from a diverse range of stakeholders to better inform the cool surface deployment plan. Below we list 10 broad observations from the workshop.

A cool surface deployment plan must ensure that….

1. There are effective tools and calculators to provide actionable information on the impact of cool surfaces at the building, neighborhood, and city scales with respect to multiple outcomes (not just energy).

2. Small- and large-scale demonstration projects in multiple climate zones are abundant and easily accessible to end users and policymakers. Pursuing scalable pilot deployments across varying regions (different physical and political climates) will provide "local" examples and data regarding the performance of cool surfaces while explicitly addressing concerns.

3. Building codes change to be forward-looking with respect to the impact of climate change and temperature changes that will help realize the future benefits of cool roof technologies deployed today.

4. Partnerships and training facilitate the incorporation of cool surfaces into climate action plans across the U.S.

5. There are better solutions for steep-slope roofs and more incentives for cool surfaces in the residential roofing sector. A possible avenue for this goal could be a manufacturers' innovation challenge for steep-slope roof products. The competition would demonstrate the value of cool surfaces in the residential sector, while also spurring innovation from manufacturers to develop more cost-effective and impactful products.

6. Carbon reduction and other non-energy benefits of cool surfaces are being incentivized and helping to underwrite the cost of retrofit applications.

7. We are evaluating the efficacy of existing incentive programs toward a benefit-cost analysis that can be used by decision makers in other jurisdictions.

8. Government relations offices facilitate providing input to the federal legislation process, perhaps focusing on promoting federal grant programs (or incentive/financing) for city and regional governments that focus on environmental (heat) justice.

9. A CO_2 equivalence of cool surfaces benefits is developed to be included in carbon offset market programs.

10. Steps are taken to develop a Cool Surface Standard that will be inserted into policy regarding roof retrofits.