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SMART SURFACES COALITION

Integrating Solar with Cool Roof Technologies

A Smart Surfaces Primer for State and Territory Energy Offices

Contents

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Introduction

As State and Territory Energy Offices work to support a more reliable, resilient, and affordable energy system, Smart Surfaces—which include technologies such as cool roofs and pavements, rooftop and canopy solar, green roofs, and trees—provide a cost-effective opportunity to reduce peak electricity demand and cut energy bills for households and businesses. In addition to their energy benefits, Smart Surfaces can also mitigate extreme heat and manage stormwater, helping protect critical infrastructure and improve public health and quality of life. Integrating multiple Smart Surfaces, for example by installing bifacial solar on low-slope cool roofs, can create additional benefits, extending the impact and cost-effectiveness of the individual technologies. State Energy Offices can help enable the strategic implementation of these proven technologies by incorporating Smart Surfaces into energy program design, coordinating with local governments, and educating key stakeholders. This primer, part of a series of Smart Surfaces resources developed for State Energy Offices, explores specific strategies State Energy Offices can adopt to support the integration of solar and cool roof technologies.

Benefits of Installing Solar on Cool Roofs

Benefits of Cool Roofs

On their own, cool roofs can achieve significant energy, economic, and health benefits. Higher performing cool roof technologies reflect more sunlight compared to traditional black roofs. As a result, on hot summer days, a cool roof surface can be over 50 degrees Fahrenheit cooler than a dark-colored roof,[5] helping lower indoor building temperatures and reduce peak cooling demand by 11 to 27 percent.[6] In addition to reducing energy costs for buildings, the reduction in the roof's surface temperature can also help mitigate extreme heat in the surrounding area, particularly in dense urban environments, thus adding overall cooling and energy saving benefits, as well as reducing summer peak demand. Some single-ply cool roof technologies for low-slope roofs are less expensive on a first cost basis than dark roof products, typically ranging from $2.51-$4.39 per square foot, while the national average for dark single-ply or asphaltic membranes is $3.04-$5.32 per square foot.[7] While the majority of cool roof products for steep-slope roofs have comparable costs to their less reflective counterparts, some of the steep-slope asphalt shingle products have advanced technologies (in particular those that look "dark" but still maintain higher solar reflectance) and may cost a bit more that alternatives. However, in the cases where there are additional first costs, the difference can be made up for in long-term energy savings, peak demand reductions, and other lifecycle cost benefits. When coupled with solar PV, those added benefits increase substantially.

WHAT ARE SMART SURFACES?

"Smart Surfaces" is a term coined by the Smart Surfaces Coalition[i] and includes a variety of surface infrastructure interventions and technologies that help enhance local resilience, reduce energy costs, and lower peak demand.

Cool Pavements
Cool pavement, also referred to as reflective pavement, reflects a higher percentage of sunlight than typical asphalt pavement. Due to the higher reflective value, cool pavement stays cooler throughout the day and reduces the urban heat island effect and thus peak demand. There is no specific reflectivity value that a pavement must have to be labeled as "cool." Rather, it is a relative category that may differ among jurisdictions with different definitions, requirements, or incentive thresholds.[ii] Cool pavement can be applied on roads or parking lots, although the materials for different applications may vary.

Permeable Pavements
Permeable pavement allows for the infiltration and temporary capture of water unlike typical impervious concrete or asphalt pavement. Permeable pavements reduce stormwater runoff, leading to increased flood prevention and lower water treatment costs, thereby saving energy. When specced properly with lighter colored materials, permeable pavements also reflect more sunlight and thus help mitigate urban heat island effects.

Trees and Green Stormwater Infrastructure
Trees and green stormwater infrastructure (such as bioswales, urban meadows, and rain gardens) can help manage stormwater, improve air quality, and mitigate extreme heat events by reducing the temperature of surrounding air, pavement, and building surfaces. For example, shade from trees can lower street-level temperatures by more than five degrees Fahrenheit.[1]

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i The Smart Surfaces Coalition is a 501(c)(3) organization committed to the rapid, cost-effective global adoption of Smart Surfaces to enable cities to thrive despite climate threats, save cities billions of dollars, create jobs, decrease heat, reduce flood risk, mitigate climate change, and improve city livability, health, and equity.

ii Although there is no common definition of cool pavement, a target solar reflectance of 0.30 or higher is a good starting point for policymakers and developers to consider.

Photo courtesy of Smart Surfaces Coalition

Benefits of Combining Solar and Cool Roofs

Integrating rooftop solar with cool roofs provides multiple benefits to the building or home owner as well as the surrounding communities, including lower building energy costs, improved air quality and other health outcomes, reduced urban heat island effect, and increased property values. Combining these surfaces can also enhance the performance of the solar panels. For example, installing monofacial solar on a cool roof can increase efficiency of the solar panels by 10 percent.[8] Installing bifacial solar panels in combination with a cool roof can further increase energy production. Because cool roofs have a higher albedo compared to dark colored roofs, the surface reflects more sunlight, which can be captured by the backside of a bifacial solar panel to produce more energy. One study found that for every 0.1 increase in roof albedo, bifacial solar panels produce 4.55 percent more electricity.[9] Installing bifacial solar on a cool roof can reduce the simple payback period by up to three years when compared to monofacial solar on a conventional dark roof.[10]

Cool Roofs
Similar to cool pavements, cool roofs reflect a higher percentage of sunlight away from the roof, leading to cooler temperatures on the roof surface and in the building. On a hot sunny day, cool roofs can stay more than 50 degrees Fahrenheit cooler than conventional dark roofs.[2] Because of their cooling effect, cool roofs can reduce air conditioning needs and lower energy costs in the summer. Studies show that retrofitting 80 percent of commercial building roof area in the U.S. with cool roofs would yield net annual cooling energy cost savings of $735 million.[3] In addition, cool roofs may experience less wear and tear due to reduced temperature fluctuation, which can lower maintenance costs and extend roof lifespan.

Green Roofs
Green roofs, also known as vegetative roofs, contain weather-tolerant plants and are typically installed on low-slope roofs. The vegetation on roofs reduces how much sunlight is absorbed by the building, saving energy used for heating and cooling, and reduces stormwater runoff.

Cool Walls
Like cool roofs, cool walls reflect more sunlight than non-cool walls. As with cool pavements, there is no set definition of a reflectivity threshold for cool walls; however, an initial solar reflectance of 0.40-0.50 or higher is a good starting point for policymakers and developers to consider. Cool walls can reduce the cooling needs of a building by keeping it cooler during hot summer days and thus reducing electricity consumption and stress on the grid. Researchers estimate that cool walls can shave up to 8.3 percent off monthly energy bills for single-family homes in warm U.S. climate zones.[4]

Solar Panels
Incorporating solar panels on building roofs, walls, and above parking lots and bus stops can provide shade for buildings and pedestrians while also generating clean electricity for the grid.

Opportunities for State Energy Offices to Support Combined Solar and Cool Roof Technologies

Photo courtsey of Smart Surfaces Coalition

Many State Energy Offices oversee or administer statewide solar programs, provide technical assistance and education related to solar, and help enable solar deployment by accelerating permitting and interconnection processes and connecting projects to financing. As they design new solar initiatives or expand and update existing ones, State Energy Offices can support the integration of solar and cool roof technologies in the following ways:

1. Offering adders or incentives that encourage integrated solar and cool roofs

State Energy Offices could consider incentivizing the integration of solar and cool roofs by providing an adder for those projects. For example, the Massachusetts Department of Energy Resources' Solar Massachusetts Renewable Targets (SMART) program offers multiple adders, including incentives for projects sited on brownfields and landfills, solar canopy and agrivoltaics projects, and projects that incorporate storage.[17]

INTEGRATING SOLAR WITH GREEN ROOFS

As an add-on over the top of a roofing membrane, green roofs result in greater surface temperature reductions and create added roofing membrane life extension, property value increases, and health and stormwater management benefits. The installation of green roofs can reduce surface temperatures by 56 degrees Fahrenheit compared to a dark roof.[11] Green roofs can also sequester carbon and reduce stormwater runoff. When installed in combination with solar panels, a green roof can increase the efficiency of the solar panels by three percent.[12] At the same time, solar panels provide shade for roof vegetation and can shield plants from high winds and other stressors. Some installers also use the green roof soil media as a ballast to support the solar panel racking instead of the concrete blocks traditionally used, which can reduce installation costs and lower embodied carbon.

To encourage the adoption of integrated solar and green roofs, state and local governments can consider several strategies. At the local level, building codes and zoning ordinances can be used to incentivize rooftop solar, green roofs, or a combination of the two on new buildings or roof replacements. For example, San Francisco's Better Roofs Ordinance requires 30 percent of roof space to be either solar, a "living roof" (green or vegetated roof), or a combination of the two.[13] New York City instituted a similar "sustainable roofing zone" for new buildings and roof retrofits through its building code[14] and incentivizes green roofs in priority zones through the Green Roof Tax Abatement program.[15] The Washington, D.C. city government has a green infrastructure policy in the DC zoning regulations known as the "Green Area Ratio" that requires new and substantially-renovated buildings to install green infrastructure features like green roofs and solar on a certain percentage of the roof and building site. Additionally, the District Department of Energy and Environment (State Energy Office) incentivizes green roof adoption through its Stormwater Retention Credit Trading program, which allows building owners to earn credits for installing green infrastructure.[16]

2. Leveraging financing programs to support combined solar and cool roof projects
State Energy Offices can also support combined solar and cool roof installations through existing financing mechanisms for solar. Well-established financing tools, such as Energy Savings Performance Contracts (ESPCs), Property Assessed Clean Energy (PACE) programs, and state-managed energy efficiency revolving loan funds, could be leveraged to support the implementation of integrated solar and cool roofs in commercial buildings and buildings owned by municipal and state governments, universities, schools, and hospitals (otherwise known as MUSH market buildings). ESPCs have financed more than $30 billion in cost-effective energy-related upgrades to MUSH market facilities over the last three decades and offer flexibility in terms of the measures able to be financed, as long as energy savings are guaranteed.[18] By raising awareness of the benefits of combining cool roofs and solar and offering technical assistance, State Energy Offices can help building owners and energy service contracting organizations maximize energy savings, improve resilience, and enhance thermal comfort for building occupants.

3. Educating installers and contractors on the benefits of combining solar with cool roofs
Workforce development programs and state-managed solar contractor networks present an opportunity to raise contractor and installer awareness of cool roofs and the benefits of combining them with solar installations. State Energy Offices can provide contractors with educational resources and guidance on how to communicate with households and building owners about the benefits of cool roofs. For example, the Cool Roof Rating Council has a resource page for contractors with key talking points and links to Frequently Asked Questions, product directories, and educational materials for home and building owners. New York City also offers an on-the-job training program, NYC CoolRoofs, through a collaboration between the city's Department of Small Business Services, the Mayor's Office of Climate and Environmental Justice, and other partners.

4. Coordinating with local governments
State Energy Offices can coordinate with local governments to support the integration of solar and cool roofs. For example, State Energy Offices can support the integration of cool roof requirements or voluntary credits in their building code or stretch code and/or share information with local governments on the benefits of cool roofs (See *Incorporating Smart Surfaces into Building Energy Codes* primer for more details and examples). The Smart Surfaces Coalition and its partners also maintain a searchable Policy Tracker with example state and local policies that encourage the adoption of Smart Surfaces, including cool roof code provisions, and have published a model city ordinance for adopting cool roof requirements that could provide a helpful starting point for jurisdictions interested in expanding cool roof adoption.

In addition to supporting state or local cool roof code requirements, State Energy Offices can also collaborate with local governments on lead by example projects on government buildings to demonstrate the benefits of integrated solar and cool roof solutions and inspire private sector investment. For example, state and local governments could install combined solar and cool roof demonstration projects on government-owned buildings and use the site for stakeholder education and training while reducing energy costs for the building. These types of projects could also leverage Elective Pay, also known as Direct Pay, which allows tax-exempt entities such as state and local government agencies to take advantage of the tax benefits of clean energy, potentially covering 30 to 70 percent of the solar project costs.[19]

Implementation Considerations

What types of cool roof products are available?

Cool roofing materials can include light-colored single-ply membranes, reflective coatings applied on top of existing roofs, and higher reflectivity products for residential/steep-slope buildings, including asphalt, tile, and metal options.

How is cool roof performance measured?

While definitions vary by jurisdiction in terms of what qualifies a roofing product as "cool," two key metrics can help compare different products' cooling performance: solar reflectance, or the portion of solar energy that a roof surface reflects, and thermal emittance, or a roof's ability to radiate heat. Both are measured on a scale from zero to one, with one being the most reflective or emissive.[20] The Solar Reflectance Index (SRI) combines these two values into one calculated indicator (between zero and 100), which is often used to set thresholds for government policies and incentive programs.

The Cool Roof Rating Council maintains a Rated Roof Product Directory that policymakers, contractors, and building owners can use to compare different products based on their solar reflectance, thermal emittance, and SRI. The Smart Surfaces Coalition also developed a model ordinance,[21] which outlines recommended solar reflectance, thermal emittance, and SRI thresholds for different types of roofing products based on availability and cost.

Photo by OakCityDrone/istock

Where does installing solar with cool roofs make the most sense?

While cool roof technologies and solar could be installed on most roofs, State Energy Offices and local partners can prioritize the integration of rooftop solar and cool roofs in areas and use cases that maximize cost savings, energy production, and urban heat reductions. Buildings with low-slope roofs, such as multifamily buildings; commercial buildings; and buildings owned by municipal and state governments, universities, schools, and hospitals (also known as the MUSH market) may be particularly good candidates for combining cool roof technologies with solar because the cool roof products available for low-slope roofs tend to be either less expensive or first cost neutral when compared to low-slope dark roof products. State Energy Offices and local governments can also consider targeting policies and incentives for combining solar and cool roofs in dense, unshaded areas with mostly dark and impervious surfaces, where urban heat island impacts pose the most risk to residents' health and safety. For example, the Metropolitan Area Planning Council (MAPC), a regional planning agency serving the Greater Boston area, developed a Cool Roof Suitability Tool and Self-Assessment for municipalities in the region to determine where a cool roof would be most feasible and beneficial. Users can filter data layers by building and roof type, land use and ownership, as well as social and environmental characteristics to understand where investments could be targeted.[22]

Photo courtesy of Smart Surfaces Coalition

Additional Resources

- Beating the Heat: Recommendations and Considerations for States to Support Cost-Effective Residential Cooling, NASEO, 2024.
- Smart Surfaces Policy Tracker, Smart Surfaces Coalition.
- A Modeling Study of Cool Surfaces and Outdoor Workers Productivity at San Francisco International Airport, National Academy of Sciences, 2025.
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- Heat Island Community Action Database, U.S. Environmental Protection Agency.
- Resources, Cool Roof Rating Council.
- Model Cool Roof Ordinance, Smart Surfaces Coalition.
- The Integrated Benefits of Smart Surfaces, Smart Surfaces Coalition.

Endnotes

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