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Cool roofs and the pursuit of energy efficiency and infrastructure resilience - by Craig Hargrove

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In 2017 the USGCR released a report stating with medium-to-very-high confidence that the United States has been experiencing rapid warming since 1979, with recent decades being the warmest in the last 1,500 years. The report predicts that this trend will continue late into this century, with an increase of 2.5 degrees Fahrenheit expected by 2050 and much larger increases expected by 2100. As a result, in the coming decades heatwaves are expected to become more frequent and intense.[1]

One of the many consequences of this trend will be an increased demand for energy. And yet, as a result of our aging infrastructure, states are finding themselves with fewer traditional energy resources.

The combination of rising temperatures and decreasing sources of energy have prompted increased focus on the efficiency and resilience of the built environment. Buildings consume 40% of our energy and 70% of our electricity while emitting one-third of the United States' greenhouse gases.[2]

Efficiency continues to be captured and mandated by local building codes and legislation, like New York City's Climate Mobilization Act; a recently enacted suite of laws intended to make the city carbon-neutral by 2050. But resilience, arguably as important and a necessary partner of efficiency, is often harder to quantify.

What is Resilience? In general, resilience is the ability to resist or recover from difficulties. When we consider resilience in the built environment, we're really talking about two things. "Asset resilience" refers to a building's robustness, or, in this particular context, how well its design and construction can reduce operational costs, wear and tear due to thermal cycling, and impact on that asset's surroundings. "Community resilience" is the corresponding ability of the local infrastructure and environment, such as powerplants and the energy-supply grid, to resist stresses imposed by the collective assets.[3] Community resilience can significantly reduce disruptions in the energy supply chain, curtail greenhouse gas emissions, slow climate change, and limit demands on available resources.

Resilience and Roofing: Conventional low-sloped roofing assemblies can be a significant source of stress on the resilience of both the asset and the community. On warm days, such coverings absorb sunlight, holding that energy in the form of heat within the assembly, transferring it into the building and warming the surrounding air. Heat that is absorbed into the building results in increased energy consumption and deterioration of building components due to thermal fatigue. These roofs can be as much as 50 degrees Fahrenheit warmer than the outside air temperature, contributing to urban heat island effect and taxing community resources.

By contrast, a cool roof is one that resists the absorption of energy by reflecting much of the sun's radiation and efficiently emitting thermal radiation through the use of coatings or materials that combine reflectivity and infrared emittance. A cool roof can reflect 80% of solar radiation without warming the atmosphere, leaving a roof that might be only 5 – 10 degrees Fahrenheit warmer than the surrounding air. Such roofs can lower energy costs 10% - 15% by reducing the need to air condition a building using electricity during peak demand times, when such costs are 30% - 70% higher. [4,5]

The result is not just an increase in the resilience of the building, but of the surrounding community, by decreasing demand on available resources and infrastructure. The widespread use of cool roofs can also have a cumulative effect on the temperature of the planet.

Measuring Cool Roof Resilience: While helping to mitigate climate change and preserve our available resources are admirable goals, many building owners and operators are understandably interested in the extent to which resilience measures will also lower operating costs. There is substantial data to support the assertion that cool roofs lower utility costs by decreasing electricity usage during peak demand periods. The federal government has developed online tools, such as Oak Ridge National Laboratories' "Cool Roof Calculator," which "estimates cooling and heating savings for flat roofs with non-black surfaces" for specific locations within the United States.[6]

It should also be noted that the use of cool roof assemblies can extend the service life of building components by reducing thermal fatigue, further lowering life-cycle costs and preserving embodied energy.

Sensible Resilience: On both new and existing structures, simple measures like the installation of a cool roof can improve asset resilience by reducing energy usage and operating costs, extending the life-cycle of building components, and preserving the embodied energy of the built environment. The financial benefits of installing a cool roof on a facility are measurable, but the aggregate impact on community resilience – the reduction of greenhouse gas emissions, the mitigation of urban heat island effect, the lessening of the flow of materials into the waste stream, and the preservation of our existing infrastructure - is no less of a consideration.

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1. USGCRP, 2017: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp, doi:

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2. Alliance to Save Energy - https://www.ase.org/initiatives/buildings#:~:text=Energy%20Use%20in%20Buildings,other%20sector%20of%20the%20economy.

3. Whole Building Design Guide - https://www.wbdg.org/resources/building-resiliency

4. U.S. Department of Energy - https://www.energy.gov/energysaver/design/energy-efficient-home-design/cool-roofs

5. Lawrence Berkley Laboratories - https://heatisland.lbl.gov/coolscience/cool-roofs

6. Oak Ridge National Laboratories - https://web.ornl.gov/sci/buildings/tools/cool-roof/