# Are Cool Roofs Green? The Answer's Not Black and White

(http://www2.buildinggreen.com/print/article/are-cool-roofs-green-answer-s-not-black-and-white) (http://www2.buildinggreen.com/printmail/article/are-cool-roofs-green-answer-s-not-black-and-white)

***Roofing choices are complicated by heating tradeoffs, climate effects, and condensation, but proponents say reflective roofs still make sense in most climates.***

*By Candace Pearson*

Cool roofs—those with reflectance and emissivity that make them good at keeping out the sun's heat—are recommended widely without much regard for climate or project specifics. They've been adopted into multiple energy codes, including ASHRAE 90.1, the International Energy Conservation Code, and California's Title 24, not to mention LEED. The concept even has its own bill in the U.S. Senate, the Energy-Efficient Cool Roofs Jobs Act (http://www.cardin.senate.gov/newsroom/press/release/cardin-cool-roofs-bill-would-create-jobs-by-eliminating-barriers-to-energy-efficient-retrofits) (S. 2388).

(/sites/buildinggreen.com/files/articles/Seattle%20white%20roof_0.jpg)

This white roof tops Crane Technical High School on Jackson Boulevard in Chicago.

*Photo: Allie Goldstein, Great American Adaptation Road Trip*

But it turns out that, beneath one of the least controversial green building recommendations, a debate is raging, with some roofing companies and architects having doubts about the extent to which cool roofs are truly beneficial.

## Where to Draw the Climate Line

Cool roofs reduce cooling loads and thus energy costs by reflecting sunlight and emitting heat faster than conventional roofs can (the combination of these traits, *reflectivity* and *emissivity*, is a material's *solar reflectance index*, or SRI—see glossary). Cool roofs can come in all colors, but white is typical. Since this strategy is about cooling loads, it's a point of disagreement whether cooling savings in the summer outweigh heating penalties in the winter for northern climates. At one end of the spectrum, some manufacturers recommend that white membranes only be used in the southernmost U.S.—as Carlisle SynTec does (http://www.carlislesyntec.com/download.aspx?fileID=2438) —where cooling degree days outnumber heating degree days.

**Comparing Cool-Roof Calculations**

That's a simplistic view, according to Kurt Shickman of Global Cool Cities Alliance, because heating degree days

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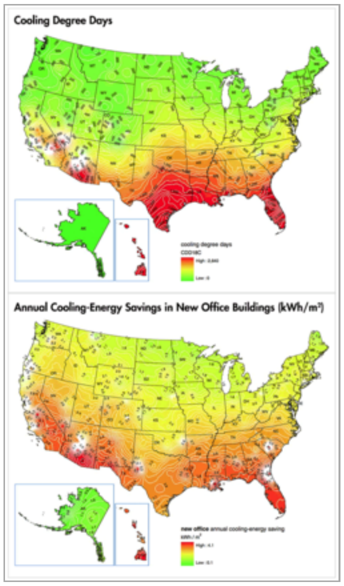
**with Cooling Degree Days**




(/sites/buildinggreen.com/files/articles/map-duo_800.png)

These maps show that annual cooling-energy savings for a new office building (bottom) extend beyond where cooling degree days dominate (top).

*Source: Lawrence Berkeley National Laboratory*

are a summary of how often average temperatures fall above or below a target temperature—not a direct translation of heating or cooling energy use. Many commercial buildings are internal-load-dominated; the lighting and equipment running inside as well as the warm bodies of occupants require cooling all twelve months of the year. There is no heating benefit for those buildings with dark roofs, while in the summer, cool roofs create savings: they "work with the building," in Shickman's words. It's generally also argued that cool roofs lower surface and ambient air temperatures, reducing the strain on air conditioning systems by providing cooler air around rooftop cooling equipment and air intakes—though the extent to which outside air temperatures are actually lowered is uncertain.

The angle of the sun's rays also plays a part, according to Ronnen Levinson, Ph.D., of Lawrence Berkeley National Laboratory (LBNL). "The solar irradiance available to a roof is three to five times less in winter than in summer because of the reduced angle of the sun and the increased cloud cover," he told *EBN*. In an oft-referenced LBNL study (http://heatisland.lbl.gov/publications/potential-benefits-cool-roofs-commercial-buildings-conserving-energy-saving-money-and-r) of commercial buildings that combined city-specific building energy simulations with state energy prices, Levinson found heating penalties barely ever outweighed the cooling benefits, including (although to a lesser extent) in states like Alaska and Maine. Retrofitting 80% of the 2.58 billion square meters of commercial building conditioned roof area in the U.S. would yield an annual energy cost saving of $735 million, according to the study.

## *When calculators disagree*

Multiple calculators have emerged to weigh such factors, but the models are still limited, and results can drastically change based on inputs, resulting in conflicting generalizations. "The data shows that with cool roofs in ASHRAE zones four and above [see map] you generally see a stronger heating penalty with white roofs," claims Ellen Thorp, associate executive director of the EPDM Roofing Association (ERA), which represents makers of *EPDM* single-ply roofing. Thorp said those claims can be substantiated with outcomes from the Cool Roof Calculator (http://web.ornl.gov/sci/roofs+walls/facts/CoolCalcEnergy.htm) and the Roof Savings Calculator (http://rsc.ornl.gov/), both published by Oak Ridge National Laboratory (ORNL).

However, Andre Desjarlais of ORNL, who helped create the Cool Roof Calculator for the U.S. Department of Energy, sees the output differently. He says the tool shows that only over Zone 6 does the heating penalty outweigh the benefit, and Zones 4 and 5 "are pretty much energy neutral." Furthermore, he says, the calculator is "agnostic to the building type and basically a metric of minimum benefits." An add-on to the calculator called the CoolCalcPeak factors in savings that could be achieved from reducing utility demand charges—based on peak loads, and often offering greater savings than simple energy reductions—but this too does not factor in building type.

This limitation was supposed to be resolved with the Roof Savings Calculator (http://rsc.ornl.gov/) (RSC) developed as an

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"industry consensus" by ORNL and LBNL. This calculator factors in building type and assembly details like radiant barriers and duct location. Yet, even with the added data, Carlisle's calculations using this tool show an owner of a 10,000 ft² building with R-20 insulation and a cool roof would experience an annual net loss to the tune of $643 in San Francisco, $490 in Boston, and $309 in Chicago.

**Glossary of Terms** (/article/are-cool-roofs-green-answer-s-not-black-and-white/sidebar/1)

Albedo: The fraction of solar energy (shortwave radiation) reflected from Earth back into space. Albedo is measured on a scale from zero to 1, from no reflection (a perfectly black surface) to perfect reflection of a white surface. It is roughly synonymous ...

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### *All about the ducts?*

Results like those may be behind a notice currently posted on the Roof Savings Calculator that reads, "RSC is currently undergoing validation due to discrepancies with previous studies, specifically with regard to ASHRAE climate zones three and four." Kurt Shickman indicated to *EBN* that the component of the model that deals with the attic ductwork was exaggerating heating penalties (see a Global Cool Cities Alliance press release (http://www.coolrooftoolkit.org/knowledgebase/roof-savings-calculator-rsc-development-update/) on the subject). *EBN* was not able to confirm that claim, but Levinson, who is helping to fix the model, says it is "currently undergoing improvement and should not be used." He recommends instead referring to the results of his 2010 study for a more accurate picture of where to draw the line, suggesting that once validated, this calculator may be more liberal about recommending cool roofs in northern climates.

To understand why the ductwork is so consequential, *EBN* spoke with Bob Andrews, P.E., of AHA Consulting Engineers, who says choice of a cool roof "all depends on whether the return air is ducted or not." In a building in which the ceiling cavity functions as a return-air plenum, heat that comes through the roof can be transferred into the building, while a ducted system is insulated from the heat of the attic. "You really don't see much of an advantage with a really high building or a lab building with a ducted roof," says Andrews, while cool roofs "are better for two- or three- story buildings with a return plenum."

## Heat Island and Climate Effects

At least one thing is certain. Well—mostly.

Many scientists agree that reflective roofs are likely to cool air temperatures locally, and cool roofs are widely used to reduce the urban heat island effect (see Rural Areas Feel Heat from Cities (http://www2.buildinggreen.com/article/rural-areas-feel-heat-cities) ). The U.S. Environmental Protection Agency (http://www.epa.gov/heatisland/mitigation/coolroofs.htm) and the latest report from the Intergovernmental Panel on Climate Change (http://report.mitigation2014.org/drafts/final-draft-postplenary/ipcc_wg3_ar5_final-draft_postplenary_chapter12.pdf) both recognize reflective roofs as an effective strategy to cool local air temperatures.

However, because municipalities are just starting to pass building codes requiring white roofs (more on that later), and because they tend to be phased in rather than installed all at once, there is little field data actually linking cool-roof installations to reduced temperatures.

The notable exception is "Mesoscale Climatic Simulation of Surface Air Temperature Cooling by Highly Reflective Greenhouses in SE Spain (http://pubs.acs.org/doi/abs/10.1021/es402093q) ," conducted by Dev Millstein, Ph.D., and Pablo Campra, Ph.D., of LBNL. The authors looked at an area in the city of Almería in Spain, where a rise in greenhouse farming sparked a sudden jump in reflective

(/sites/buildinggreen.com/files/articles/Almeria.jpg)
The province of Almería Spain is said to be the only human settlement that can be seen from space because of its gleaming white reflective greenhouses. Scientists have also attributed an observed decrease in air temperatures to the rise in albedo (http://www2.buildinggreen.com/glossary/6#term2220) .

*Photo: Pere Papasseit*

surfaces. The farmers whitewash their greenhouse roofs with slaked lime every June to keep out heat during the summer months, and the lime is later washed away to provide winter heat. These reflective greenhouses create roughly 100 square miles of high-albedo surface area.

By comparing the local temperatures with historical weather data, the scientists observed that the town has experienced a local long-term cooling trend in surface air temperatures of 0.54°F per decade despite the generalized warming in the surrounding region of 0.72°F per decade, with the reflective greenhouses apparently providing the difference. The scientists also noted that their models predicting temperature changes based on albedo were well correlated with the actual observed temperatures.

That study bolstered the findings of some earlier work in which Millstein and Surabi Menon, Ph.D., used the same tool, the Weather Research and Forecasting model, to predict the climate consequences of converting all roof and pavement surfaces to cool technologies in major U.S. cities. The results of the study show that, in most cases, increasing urban albedo would provide significant cooling benefits. The findings (http://iopscience.iop.org/1748-9326/6/3/034001/pdf/1748-9326_6_3_034001.pdf) , published in *Environmental Research Letters* in July 2011, show cool roofs could help provide an average of 0.95°F of cooling during the summer in Los Angeles, 0.70°F in Detroit and 0.54°F in New York, for example, with albedo changes accounting for 60% of the temperature change in the model.

## *Resilience benefits*

Reduced temperatures both on a city level and at a building level could also provide resilience benefits (see Resilient Design—Smarter Building for a Turbulent Future (http://www2.buildinggreen.com/article/resilient-design-smarter-building-turbulent-future) ). One evaluation (http://www.sciencedirect.com/science/article/pii/S0378778813007652) by researchers at LBNL and Nanyang Technological University recommends that every U.S. city and state as far north as Chicago or Boston require white roofs for new construction and end-of-life roof replacements of flat-roof commercial buildings.

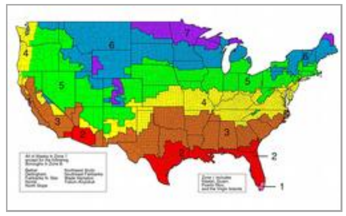
"The suggestion is not based on anything analytical about cooling benefits or heating penalties," Ben Mandel, one of the authors of the study, told *EBN*. Rather, it was based on a concern about cities that are most vulnerable to heat waves. "The most vulnerable locations are not those that are hot year round; they are the ones that experience large temperature changes, because both the infrastructure and the people are not as adapted to extreme heat." Mandel suggests that even if cool roofs are "energy neutral" in northern climates, they could be in the interest of public health, especially as heat waves are predicted to increase with global warming (see Designing for the Next Century's Weather (http://www2.buildinggreen.com/article/designing-next-centurys-weather) ).

Recently, there have been strong indications that many cities agree. In a survey (http://aceee.org/research-report/u1405) by the American Council for an Energy Efficient Economy (ACEEE) and the Global Cool Cities Alliance (GCCA), nearly two-thirds of 26 North American cities surveyed cited local extreme weather events as a key reason for initiating urban heat-island mitigation strategies, including reflective roofs. Furthermore, those cities that have instituted cool-roof ordinances are not restricted to southern climates; New York City and Washington D.C. are two examples.

### *Beyond urban boundaries: Global effects*

However, questions are just now being raised about what impact changes to albedo may have on a global scale. The same model Millstein used to demonstrate such significant urban cooling benefits also shows other cities, such as Jacksonville, Florida, would see close to zero cooling, and in some cases, regions downwind of urban areas registered small but significant temperature increases. Millstein told *EBN* the reason might have to do with how changes to convective heat transfer affect the formation of clouds. Less cooling usually occurred in areas that traditionally see a lot of thunderstorms, and reduced air temperatures could disrupt cloud formation and consequently could reduce the number of rain events that normally bring down surface temperatures.

**U.S. Climate Zones**



(/sites/buildinggreen.com/files/articles/ClimateZoneMap.jpg)

This map shows the climate zones specified in ASHRAE and IECC (http://www2.buildinggreen.com/glossary/6#term2417) .

A separate study, "Effects of Urban Surfaces and White Roofs on Global and Regional Climate (http://www.stanford.edu/group/efmh/jacobson/Articles/IV/HeatIsWhitRoofJClim12.pdf) ," conducted by researchers at Stanford University found that if all roofs worldwide were converted to white, the change would cause 0.07°C of warming. Jacobson told *EBN* that a combination of reduced cloud formation and the absorption of more sunlight by pollutants in the atmosphere make it possible for cooling at the city scale to occur at the same time as warming on a global scale. However, as the study notes, the results of the modeling are "highly uncertain."

"Once you change weather events locally, you start seeing larger changes to circulation," says Millstein. "That's why some global models are not registering a net cooling." However, according to Millstein's model, warming trends that do show up are subtle; the largest increase he found was 0.49°F, and that was not in an urban area. In reaction to Jacobson's study, the scientists of the LBNL Heat Island Group, of which Millstein is a part, issued a response (http://heatisland.lbl.gov/sites/all/files/LBNL_Heat_Island_Group_response_to_Jacobson_and_Ten_Hoeve_%282011%29,_November_4_2011.pdf) . They point to other research indicating that increasing albedo would cause a change in total outgoing radiation at the top of the atmosphere, suggesting cool roofs would reduce net solar radiation absorbed by the earth. A 2012 study from the Heat Island Group, "The long-term effect of increasing the albedo of urban areas (http://www.globalcoolcities.org/wp-content/uploads/2012/08/Akbari-Long-Term-Albedo-Changes-in-Cities.pdfhttp://www.globalcoolcities.org/wp-content/uploads/2012/08/Akbari-Long-Term-Albedo-Changes-in-Cities.pdf) ," also came to this conclusion, estimating that increasing the albedo of surfaces in a hot or temperate climate results in a small but measurable long-term global temperature decrease.

Millstein cautions that these studies "are pretty hypothetical." Converting all roofs in the world may have a significantly different effect than converting them just in some cities or in most. Even if temperatures do slightly increase in some areas, Millstein says, "The energy savings on an individual building level still hold," so planet-warming carbon emissions would still be reduced. "It's still an area of research," according to Millstein, and since we are not even close to having white roofs cover every city, "the building-level issues matter more from an architectural perspective than the global patterns."

## Concern About Condensation

Concerns about cool roofs extend beyond temperature to moisture. Referencing an article that appeared in the January/February 2012 issue of *Western Roofing* (http://www.epdmroofs.org/attachments

/2012-jan_coolroofscausecondensation_dregger_wr01123.pdf) , Ellen Thorp told *EBN*, "There are very well documented cases of condensation under white roofs as far south as San Francisco." Condensation may be more likely under mechanically attached, cool roofs because billowing of the membrane pulls moist air up from the interior, where it can find its way through insulation joints to the underside of the roofing membrane. Since cool membranes dip below the dew point more often, the moisture condenses more readily than it would under a black membrane. This water can then saturate the insulation or form a layer of ice.

(/sites/buildinggreen.com/files/articles /condensationfieldtest.jpg)

According to one field study, three reflective roofs out of ten were wet below the membrane, but none showed signs of significant damage.

*Photo: International Roofing Symposium*

## Worse in colder climates

In a study (http://staticcontent.nrca.net/masterpages/technical /symposium/pdf/25_ennis_paper.pdf) conducted by Mike Ennis of SPRI, an association for single-ply roofing manufacturers, and Manfred Kehrer, Ph.D., of ORNL, three of ten roofs located in ASHRAE Climate Zone 5 showed signs of moisture condensation. However, the researchers determined this moisture had minimal effects on the roofing system and did not affect its integrity, insulating value, or performance.

In a second part of the study, the researchers used WUFI hygrothermal modeling (http://www2.buildinggreen.com/article /using-wufi-prevent-moisture-problems) to evaluate locations in Climate Zone 5. The modeling showed that the amount of condensation accumulating under white roofs was more than twice the amount under black roofs due to less heat available to dry them out. Although both types of roofs returned to a dry condition during the course of the year, condensation evaporated less quickly under the cooler, white roofs. These results should be taken with a grain of salt, however, because, as the authors note, there was no significant correlation between the simulation results and their field observations (see WUFI Without Worries: Doing More Good than Harm with Hygrothermal Modeling (http://www2.buildinggreen.com/blogs/wufi-without-worries-doing-more-good-harm-hygrothermal-modeling) ).

A more recent study by Kehrer and Simon Pallin of Chalmers University of Technology utilizes a more sophisticated WUFI model to analyze condensation risks in ASHRAE zones 4–7 by taking into account air leakage and various indoor moisture conditions. The report, "Condensation Risk of Mechanically Attached Roof Systems in Cold-Climate Zones (http://www.rci-online.org/interface/2013-CTS-kehrer-pallin.pdf) ," finds that cool roofs do make the assembly more sensitive to condensation, especially when there is high air intrusion, regardless of indoor moisture levels. The conclusions suggest managing airtightness should be a priority, but managing interior moisture with a vapor retarder is also important. Although this study was not verified with field studies representing the same moisture loads and airtightness conditions (which would be necessary to view these findings conclusively), it is hard to argue against the importance of a continuous air barrier.

Thorp acknowledged that installing a vapor retarder or air barrier could greatly mitigate condensation risks in northern climates, "but why would you do that when you could just put on a black roof with the proper insulation in the first place and be fine?" she asks. The authors of the SPRI study note that double-layer insulation and properly sealed penetrations would also alleviate the moisture risk and that systems using direct adhesion of membranes to the roofing substrate are not in danger of condensation issues at all.

## In practice

The problem is that most codes do not require air barriers or vapor retarders, according to Samir Ibrahim of Carlisle SynTec, so there is more of a burden on the roof designer to make the right decisions.

There's also an added cost, according to Ibrahim, because you need an underlayment between the air barrier and the membrane, likely adding a metal deck to the assembly. "Now you are talking about increasing cost simply to accommodate a white roof! I could take a convertible and adapt it for Alaska," he jokes, "but you start opening the door for potential problems."

Martin Grohman, the sustainability director at the roofing manufacturer GAF, said that condensation issues aren't limited to white roofs. "You'd get laughed out of the room if you tried to argue that a dark-color roof is self-drying; it's a roofing assemblies question." Managing condensation should be a consideration for both black and white roofs, he argues, and there is no free pass with choosing black.

## Longevity of Reflectivity

(/sites/buildinggreen.com/files/articles/dirtyroof.jpg)

The reflectivity of cool roofs fades over time due to soiling and weathering, requiring periodic maintenance.

*Photo: AP Photo, Matt Rourke*

Cooling effects of roofs can fade over time due to soiling and weathering, and the roof will become less effective at both mitigating the urban heat-island effect and reducing cooling loads.

However, some materials age better than others, according to Ronnen Levinson, coauthor of an LBNL study on the topic (http://escholarship.org/uc/item/4n18r135#page-4) . Levinson told *EBN* that the research shows "the fluorinated polymer coatings stay clean; the loss of solar reflectance is quite small, and nothing grows on it." Spray elastic roof coatings applied in the field performed relatively poorly. "They do not resist soiling, and there is a substantial loss of both reflectance and thermal emittance," says Levinson. Although other life-cycle impacts of fluoropolymers should be considered, durability and service life are key to choosing sustainable roofing products (see Better Choices in Low-Slope Roofing (http://www2.buildinggreen.com/article/better-choices-low-slope-roofing) ).

Most manufacturers now provide three-year aged SRI values for their products, but the LBNL study argues that the metrics used often overestimate the solar reflectance of many "spectrally selective" materials, such as darker-tinted roofing products. The U.S. Department of Energy recently funded a project to help LBNL researchers develop a lab process that mimics three years of aging, which they hope will soon be ASTM approved.

ERA, which represents manufacturers of both black and white EPDM, however, has leveraged the argument (http://www.epdmroofs.org/attachments/clean_1am_analysis_of_lbnl%20article%20finalfinal.pdf) that maintenance costs often go unaccounted for and that studies promoting white roofs have ignored the likelihood of reduced solar reflectance values from dirty roofs. Another facet of its longevity argument is that black EPDM has been demonstrated to last more than 35 years in the field and up to 50 years in heat aging studies, while white roofs have not been around long enough to demonstrate a 20-year lifespan, though heat aging tests from GAF (http://www.gaf.com/Commercial_Roofing_Systems/EverGuard_TPO/Correlating_Accelerated_Laboratory_Field_and_Thermal_Aging_TPO_Membranes.pdf) suggest a white TPO membrane of 2.0 mm thickness would last 44 years.

GAF's Martin Grohman argues the consensus about lifespan is generally favorable. "Cool roofs experience less expansion and contraction and therefore probably will have a longer service life," he says. He acknowledges that white roofs need cleaning, but whether reflective or not, "every roof needs a maintenance program."

## Snow Accumulation

Even snow accumulation is a topic of debate. Craig Tyler from Carlisle Syntec wrote in the November 2013 edition (http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCMQFjAA&url=http%3A%2F%2Fwww.carlislesyntec.com%2Fdownload.aspx%3FfileID%3D4977&ei=rnSOU6nKLI_gsASXsYCABA&usg=AFQjCNHfBcpj05Temf-t7VR_DeILuH-HXQ&bvm=bv.68235269,d.cWc) of *The Construction Specifier* that, since the darker color of traditional roofs means they absorb more UV radiation, "it helps melt snow and prevent ice buildup in colder temperatures." Meanwhile, Hashem Akbari and Mirata Hosseini of the Heat Island Group argue in a report (http://www.academia.edu/5416909/Cool_Roofs_and_Snow) that in northern climates, dark roofs will be covered by snow—which of course is highly reflective itself—so wintertime heating penalties associated with cool roofs are much lower than sometimes assumed. Snow may add to the overall R-value of the roof, depending on the thickness and density, they argue.

"I've heard anecdotal evidence that snow will stay longer on top of a cool roof," says Dev Millstein, but most of those who spoke with *EBN* did not view snow accumulation as a make-or-break issue.

## Reflected Radiation and Glare

Researchers have also asked what effect reflective roofs might have in urban settings where solar radiation from shorter buildings could be absorbed by the walls of adjacent buildings, or reflected into windows (see More Questions Than Answers in Report on Reflective Pavements (http://www2.buildinggreen.com/article/more-questions-answers-report-reflective-pavements) ).

(/sites/buildinggreen.com/files/articles/central-library.jpg)

The Richard Riordan Central Library in Los Angeles chose a tan colored cool roof in consideration of what would be visually acceptable for its high-rise neighbors.

*Photo: Climate Resolve*

ORNL's Desjarlais says "The theory makes sense," but aside from a very dense urban context, he "wonder[s] how often it would actually be a problem."

From Levinson's point of view, it's a case-by-case issue. "If you have two buildings of different heights, then certainly you should think about increasing the albedo of the shorter building." One obvious solution to the glare problem, according to Levinson, is to use a colored cool roof instead of a highly reflective white.

In terms of the reflected radiation being absorbed by adjacent buildings, Levinson guesses the effect probably is not that large anyway. "We know that if you have two homes at the same the height with a roof slope of 20°, the cross talk between those two roofs is pretty minimal. About 6% of energy that is reflected will be received by the pitched roof of the neighboring building."

### *Reflective façades*

These issues might be more pronounced with reflective façades, but it is also an area of uncertainty.

There are several examples of reflective façades causing glare and heat problems, most notoriously the Walt Disney Concert Hall in Los Angeles, where glare from the stainless steel panels caused the indoor temperature of nearby condos to increase by 15°F. Another example is the Vdara Building in Las Vegas that reflected from its concave glazing what the media termed a "death ray," which gave guests enjoying the hotel pool accelerated sunburns.

These façades, however, were not designed with sustainability in mind. Other studies indicate that utilizing reflective façades properly can result in cooling benefits. In a study published in ResearchGate (http://www.researchgate.net/publication/235989619_Experimental_measurement_of_cool_facades%27_performance_in_a_dense_urban_environment) , researchers at Université de La Rochelle in France tested the effects of a dark brown paint with a reflectivity of 0.38 and an emissivity of 0.86 by applying it to the façades of a reduced scale model of "urban canyon morphology"—a 10 m × 20 m terrace of concrete tiles with concrete empty tanks representing reduced-scale buildings. They found that, compared to the blocks painted with the standard brown paint, the "streets" between the rows of buildings with reflective façades had a reduced surface temperature up to 34.7°F, and the buildings experienced a reduced indoor air temperature of 10%. There was a slight cooling-load penalty of about 1% for adjacent buildings with non-reflective façades, but the researchers considered it minimal and noted that it was probably so low because the reflective buildings effectively kept temperatures lower overall.

(/sites/buildinggreen.com/files/articles/Walt_Disney_Concert_Hall.jpg)
The Walt Disney Concert Hall had to take steps to mitigate the reflectivity of its steel façade after it became obvious that it was responsible for raising indoor air temperatures in an adjacent apartment building.
*Photo: Geographer. License: CC BY-SA 2.5. (http://creativecommons.org/licenses/by-sa/2.5/)*

## Is There More to This Debate?

With trade associations, major manufacturers, and researchers all looking at the same (albeit flawed) data and coming to different conclusions about what to many is a noncontroversial choice, *EBN* had to ask: is there more to this debate than meets the eye?

We put that question to several experts, none of whom were willing to go on the record, citing the need to avoid offending colleagues. Two themes emerged, however.

Even for companies that make both white and black roofing products, there might be large investments in equipment used to make black roofing. Departments within companies sometimes function independently and might feel a need to protect their market share, providing a counterintuitive motive for a manufacturer that makes white roofing to question the wisdom of cool roofs across all climates.

An overall reaction against one-size-fits-all prescriptions also seemed to be a factor. "We are restricting the options of roof designers, architects, and building owners with these policies," ERA's Ellen Thorp told *EBN*, referring to regulations that require cool roofs. Those regulations also affect roofing manufacturers' bottom lines.

## Evolution of Rating Systems

Whatever the driving motivations, it is clear the debate is having an effect on practice, possibly reflected in recent evolutions of green building rating systems.

In the LEED for New Construction 2009 rating system, projects can earn a point for covering at least 75% of the roof with high SRI values, with credit also offered for green roofs. The basics have not changed a lot in LEED v4, with no consideration in the credit for climate specifics, but there is a greater emphasis on three-year aged SRI values. According to Theresa Backhus of the U.S. Green Building Council, cool façades were considered in one earlier draft of LEED v4, but the option was later removed because commenters said "the market was not ready."

In Green Globes, materials with high SRI values can help gain points for the mitigating the heat island effect, but only in ASHRAE Climate Zones 1–5. Green Globes also gives credit if at least 75% of opaque surface area on the east and the west façade has an SRI of 29 or greater.

For comparison, ASHRAE 90.1-2010 requires cool roofs in climate zones 1–3 but contains exceptions for low-slope metal buildings and asphalt membranes.

## Do Cool Roofs Belong in Codes?

Despite the debate, municipalities and states across the nation (http://coolroofs.org/resources/rebates-and-codes) —including New York City, Los Angeles, and Chicago—have started to require cool roofs in codes and standards or to incentive them through loans and rebates.

(/sites/buildinggreen.com/files/articles/solar%20on%20white%20roof.jpg)

This Walmart in Mountainview, CA combines a rooftop solar array with a cool roof.

*Photo: Walmart; License CC BY 2.0 (http://creativecommons.org/licenses/by/2.0/)*

Jacobson—the researcher who suggests reflective roofs could contribute to global warming—told *EBN* one of his concerns was that "if your goal is to make everything white, then that means you are not installing solar panels." Since solar panels "keep the air in the [building] cool and generate electricity to displace fossil fuel" this should make the use of white roofs "obsolete." However, because solar photovoltaic panels are more efficient at cooler temperatures, others have argued that cool roofs contribute to increased efficiency (http://coolroofs.org/documents/711CoatNCoolFMJArticle.pdf) .

Andre Desjarlais, who generally advocates for cool roofs, expressed a similar sentiment: "I got a little irritated when California added a cool roofs requirement to its building codes." Desjarlais authored a paper arguing that ballasted systems can provide performance equal to that of cool roofs, and he told *EBN* that consumers should be able to choose modified bitumen roofs if their greatest priority is a long service life. "Not that I don't believe in cool roofs," he says, "but there are other things you can do as well, and they should be given equal credit."

But Levinson says most regulations do allow exemptions that might have comparable cooling benefits. "If you don't want to use a high-reflectance roof because you want to use a different category of roofing product then, OK, recognize that most standards allow you to take other steps to improve energy efficiency," such as installing a radiant barrier. Solar panels are also an acceptable substitute in all of the policies *EBN* reviewed.

**Cool Roofs: Pros and Cons**

Cool Roofs: Pros and Cons

| Issue | Challenges | Opportunities |
|---|---|---|
| Energy costs in northern climates | Owners risk paying more during heating season, depending on design. | Savings can be achieved in almost any location when accounting for demand charges, time-of-use pricing, attic makeup, etc. |
| Urban heat-island effect | There is no direct evidence that cool roofs have reduced urban temperatures in the U.S. so far. | Scientists have noted local cooling effects in modeling and some field studies. |
| Global temperature | If adopted universally, cool roofs might actually cause net global warming due to new air circulation patterns, although only hypothetical models have supported this effect. | Localized cooling effects could translate to a strategy for combating global warming. |
| Condensation | White roofs appear to have greater condensation risk, and less drying potential, than black. | Greater attention to moisture management and air-barrier detailing can mitigate risk while offering other benefits. |
| Longevity | Cool roofing is relatively new (20+ years) so true service life is unknown. | Cool roof properties can be maintained with proper maintenance and service life could be longer in part due to fewer temperature extremes. |
| Effects on adjacent buildings | Reflectivity might raise the cooling loads of adjacent buildings. | Research shows that increased temperatures for adjacent buildings are minimal; more daylight might even be useful. |
| Codes | Some codes and standards are one-size-fits-all, even in climates and projects where cool roofs are not a good fit. | On the whole, cool roofs are, however, an inexpensive way to save money in virtually all U.S. climates. |

### *Still a good bet*

In colder climates or in urban conditions where condensation or glare might be an issue, greater expertise and attention to detail might be required of architects, engineers, roofing designers, and contractors in choosing and detailing cool roofs (or choosing another roofing option).

Solar panels—or a vegetated (green) roof—might be an even more sustainable roofing option, but they typically cost more. One of LBNL's most recent reports (http://www.epdmroofs.org/attachments/sproul-et-al_economic-comparison-of-white-green-and-black-flat-roofs-in-the-us.pdf) , featuring an economic life-cycle assessment of black,

(/sites/buildinggreen.com/files/articles/cool-roofs_800.png)

Source: BuildingGreen, Inc.

white, and green roofs, found that white roofs offered the best value, with a 50-year net savings of $25/m$^2$ ($2.40/ft$^2$). With cool roofs offering an economically comparable and usually more efficient alternative, they're a good fit for codes.

They're also usually in the owner's best interest. "I do not need to have a cool roof on every building everywhere," says Levinson. "But the science suggests that in warm, sunny places, it is good way to reduce solar heat gain and reduce energy use"—not to mention a way to achieve substantial savings on time-of-use electricity charges and demand charge savings.

"There really is an energy sweet spot where you can do a roof with R-24 insulation instead of R-30 if you use a reflective membrane, adds Martin Grohman. "Why argue against that? If I am taking the side of the property owner who wants the most cost-effective solution, then I can deliver that with a cool roof."

## Comments (0)

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