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Cold produce cases such as these make supermarkets among the most energy-intensive commercial buildings.

Refrigeration accounts for half or more of supermarket energy consumption, and compressors and condensers account for 60–70% of the energy used for refrigeration. The rest is consumed by display and storage cooler fans, display case lighting, evaporator defrosting, and anti-sweat heaters used to prevent condensate from forming on doors and outside surfaces of display cases.

The Annex 26 participants recently completed analytical and experimental investigation of several candidate refrigeration and HVAC system design approaches, including these:

- Distributed compressor systems—small parallel compressor racks are located close to the food display cases they serve, significantly shortening the connecting refrigerant line lengths.
- Secondary loop systems—one or more central chillers are used to refrigerate a secondary coolant (e.g., brine, ice slurry, or CO_2) that is pumped to the food display cases on the sales floor.
- Self-contained display cases—each food display case has its own refrigeration unit.
- Low-charge direct expansion systems—similar to conventional multiplex refrigeration systems, these use improved controls to limit charge.

Means to integrate supermarket HVAC and refrigeration systems have been investigated as well. One approach is to use heat pumps to recover refrigeration waste heat and raise it to a sufficient level to provide store heating. Another involves using combined heating and power (CHP) to integrate the refrigeration, HVAC, and power services in stores. Other methods, including direct recovery of heat rejected by refrigeration equipment for space and water heating, have also been examined.

The results of the Annex 26 work programs are available in a recently published report compiled by ORNL for IEA (see www.ornl.gov/sci/engineering_science_technology/Annex26/reports.htm/). Principal observations from the report include these:

- Several relatively new refrigeration systems offer total equivalent warming impact reductions of 60% or more.
- Traditional direct-heat-recovery approaches can cover 40–100% of store heating needs, depending primarily on climate and the relative size of coincident heating loads and heat rejection loads.
- Integrating heat pumps with the refrigeration heat rejection system can cover 100% of store heating needs.
- Integrating CHP systems with refrigeration systems has the potential to meet a store's heating needs and much of its electric power needs.

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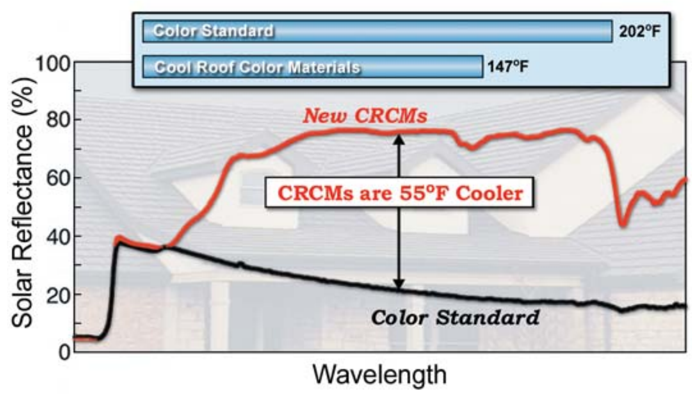
Sponsor: DOE/EERE Building Technologies Program

Color Your Roof Cool with Revolutionary Color Pigments

A new roofing product is about to revolutionize the building industry, bringing relief to homeowners and utilities alike. Cool roof color materials (CRCMs) made of complex inorganic color pigments will reduce the amount of energy needed to cool buildings, helping utilities reduce hot-weather strain on electrical grids by slashing summertime peak loads.

The California Energy Commission (CEC) has ORNL and Lawrence Berkeley National Laboratory (LBNL) working collaboratively on a 3-year, $2 million project with the roofing industry to develop and produce the new reflective, colored roofing products. Their aim is to make CRCMs a market reality in the homebuilding industry within 3 to 5 years. A roof covered with this special paint absorbs less solar energy and can reduce air-conditioning costs by 20%, which in turn will lead to national energy savings of about 0.5 to 2 quads per year by 2010. For tile, painted metal, and wood shake, the goal is products with over 45% reflectance. For residential shingles, the goal is a solar reflectance of at least 35% to 40%.



Comparative heat buildup and solar reflectance in cool roof color materials and standard roofing materials.

The new CRCMs contain mixtures of chromic oxide and ferric oxide. The materials look dark in color yet reflect most of the sun's energy. How can dark roofs reflect as much energy as white roofs, or even more? The trick is in the eye of the beholder. Solar radiation consists of ultraviolet, visible, and infrared

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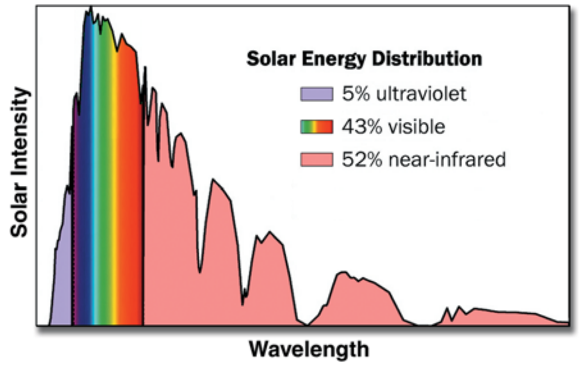
(IR) energy, but our eyes see only the visible portion. White roofs reflect most of the visible light spectrum, which mixes together to look white to our eyes, while dark roofs absorb most of the visible light, looking dark. Most solar energy, however, is in the IR region, which is not visible. CRCM roofs reflect more than 60% of the IR solar energy that strikes them.

Traditional roofing materials absorb or reflect IR light along with visible light. By reflecting the IR light independent of the visible light, the CRCMs reduce the total amount of solar energy absorbed without changing the amount of visible light reflected, hence retaining the roof color while cooling the roof. CRCMs offer other advantages over traditional roofing materials. They are available in a range of colors and resist fading better than standard materials.



Distribution of solar energy in the ultraviolet, visible, and near-infrared wavelengths.

Several metal roof manufacturers have successfully introduced CRCMs in their painted metal roof products. The additional cost of the CRCMs is only about 5¢ per square foot of finished product, which pays for itself within 3 years in energy savings. The architectural appeal, flexibility, and durability of CRCM-coated metal roofs are steadily increasing their market share. Historically metal roofs have held only about 3% of the residential market. From 2000 to 2002, the sales volume doubled to 6%, making metal roofs the fastest-growing residential roofing product.

ORNL and LBNL are collaborating with pigment manufacturers to reduce the sunlit temperatures of cedar shakes, clay and concrete tiles, and asphalt shingles, as well as metal roofing. ORNL is measuring the performance of CRCMs in the laboratory and in the field and will offer consumers information on the results. By showcasing the energy savings of CRCMs, they hope to accelerate the market penetration of these new products.

For more information, see http://coolcolors.lbl.gov/.

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Sponsor: California Energy Commission

Attic Handbook Offers Defense Against the Elements

Proper roof, attic and ceiling configurations are essential to good thermal, structural, and moisture performance, as well as energy efficiency, in homes. Many alternatives exist to configure these components, but some are unacceptable. ORNL researchers are preparing a *Residential Attic Handbook* that will provide practical information on designing and building the roof, attic, and ceiling to ensure the best possible approaches for protecting and enhancing residences, thus reducing energy consumption.

Attics need to be properly sealed and insulated against air exchange and heat exchange between indoors and outdoors. Attic ventilation protects against ice dams.

The *Residential Attic Handbook,* written by ORNL's Building Envelope Group (BEG), will help builders, contractors and homeowners ensure that every attic built is cost-effective and energy-efficient. Attics, ceilings, and roofs are key parts of the building. The ceiling is usually the location for much of the insulation that allows acceptable thermal performance. If the attic is sealed properly against air exchange between the indoors and outdoors, problems with moisture accumulation and wasted energy should be minimal.

Ice dams can form at the edges of roofs in cold, snowy climates if the attic is warm enough to melt the snow over it. The melt water flows to the edges, where it refreezes and forms dams. Additional melt water backs up under the roof covering and may leak into the attic. A way to avoid chronic ice dams is an attic ventilation system that keeps the roof over the attic as cold as the edges, preventing the formation of ice dams.

The thermal and moisture control configuration for attics in buildings along the Canadian border is not necessarily appropriate for areas such as the very hot, humid, hurricane-prone cooling zone of the southeastern coastal states, or even for moderate climates. Consequently, the *Residential Attic Handbook* features attic configurations for all three climate zones.

The roof is a building's main defense against the elements and the loss of heating and cooling energy. Structural integrity is a prerequisite for achieving long-term good thermal and moisture performance. Roof structures frequently fail in

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