International Workshop on Advances in Cool Roof Research Workshop Summary

Lawrence Berkeley National Laboratory (LBNL)
Heat Island Group

Thursday, July 28th & Friday, July 29th
DoubleTree Hotel Berkeley Marina, Berkeley, CA

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http://coolroofs2011.lbl.gov

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Day 1: Thursday, July 28th, 2011

Session 1: Benefits of cool roofs

“Benefits of cool roofs” **- Dr. Ronnen Levinson, Deputy Leader at LBNL-Heat Island Group,** presented on the need for cool roofs, their physical properties, as well as the economic, environmental, and social benefits. The presentation focused on how cool roofs benefit:

1) Building owners, by reducing A/C demand, thus costs, in air conditioned buildings and improving thermal comfort in non-air conditioned buildings.
2) Cities, by reducing the ambient air temperature, thus reducing the formation of ground level-ozone, peak power demand through reduced air-conditioning use, and subsequent fossil fuel emissions from surrounding power plants.
3) The planet, by mitigating global climate change by offsetting the heating effect of CO_2 in the atmosphere.

Dr. Levinson pointed out that the most important properties that make a cool roof “cool” in the sun are its ability to effectively reflect the invisible “near-infrared” radiation that makes up nearly half of sunlight, and its high thermal emittance. He concluded by stating that the energy savings associated with cool roof retrofits has a present value of $11 billion.

Following his presentation, Dr. Levinson was asked to quantify the climate change mitigation effect of a cool roof. He responded that 100 m^2 of flat white roofing can offset 10 tons of atmospheric CO_2 at the conclusion of a 15-20 year cool roofs campaign.

“The best solar solution for cool white rooftops” **- Michelle Meier, Rooftop Product Manager at Solyndra,** followed with a very engaging presentation about the positive benefits of coupling Solyndra’s cylindrical solar photovoltaic tubes with a cool roof. According to Ms. Meier, the tubes gather energy from the reflected sunlight, increasing the amount of sunlight the PV tubes can convert into usable electricity. Specifically, 20-30% of the solar yield comes from the reflected sunlight, thus less reflection results in less power. Thus the system and the cool roof have to stay clean in order to maintain the efficacy of the panels. The system is designed for large, flat, white commercial rooftops, although there have been installations on pitched roofs (uncommon and not recommended).

Session 2: Current state of knowledge on natural weathering

“Natural weathering practices” **- Rich Slomko, Global Testing Manager at Atlas, Inc.,** led the second session in a discussion about current natural weathering testing practices. He discussed how Atlas is able to test different roofing products in various climates using the Equatorial Mount with Mirrors for Acceleration water spray (EMMAQUA). The EMMAQUA is a device that accelerates natural weathering of roofing products and has the ability to track the sun on its full axis. The EMMAQUA also has a temperature control mechanism that prevents samples from melting in the sun and freezing at night. Slomko also noted that wind is the primary vehicle of deposition and that arid climates create an ideal environment for wind delivery of natural and man-made dust. However, in Arizona, the dust accumulation is typically made of fine particles and does not typically accumulate on samples. The Atlas test sites in various climates were chosen for benchmarks, not to test the effects of pollution in cities.

Session 3: Technical review of accelerated soiling & weathering procedures

“Current accelerated weathering practices” **- Sean Fowler, Technical Marketing Specialist at Q-Lab,** began the session with a description of its weatherability testing services, including natural and accelerated laboratory testing performed at Q-Labs testing sites in Miami, FL and Phoenix, AZ. According to Fowler, Q-Lab specializes in material durability testing equipment and services. Q-Lab utilizes several weathering testing tools to simulate the aging process of samples. The company uses the Q-Sun Xenon Arc to simulate the degradation from the full solar spectrum. Additionally, Q-Lab uses its UV Fluorescent Weathering Tester to perform other lamp aging tests which produce faster results, very stable spectrum, minimal maintenance, simple calibration, and low costs relative to using Q-Sun Xenon Arc. In Fowler’s conclusion he notes that the Q-Sun Xenon Arc is best for testing lightfastness/color degradation, while the UV Fluorescent Weathering Tester is best for polymer degradation.

“Introduction to accelerated aging” **- Dr. Hugo Destaillats, Staff Scientist at LBNL-Heat Island Group,** presented an update on the LBNL Heat Island Group’s Advanced Surfaces project. The project’s objective is to better understand the deposition of soiling on building envelope materials and develop laboratory methods to mimic natural aging processes for roof and PV surfaces. The project’s goals are to create an accelerated soiling and weathering method for roofs and PVs, to incorporate the methods into international standards and to learn how to develop roofs and PVs that stay clean. Dr. Destaillats explained that the group is currently conducting accelerated laboratory testing on 100 roofing materials from 40 industrial partners. A collection of the roofing materials were also sent out for natural aging at the Cool Roof Rating Council (CRRC) sites in Ohio (temperate climate), Arizona (hot and dry), and Florida (hot and humid) for three years. In addition to testing on the collected roofing samples, Dr. Destaillats said they analyzed the aged solar reflectance ratings on roofing products listed in the CRRC’s Rated Products Directory. They noted that products aged in Florida had huge decreases in solar reflectance compared to products aged in the hot and dry climate of Arizona. The results from this analysis are informing the laboratory accelerated weathering experiments.

“LBNL accelerated aging protocols” **- Dr. Mohamad Sleiman, Staff Scientist at LBNL-Heat Island Group,** described the current version of the Advanced Surfaces project’s laboratory accelerated aging protocols for roofing materials. Current cool roof rating programs require three years of natural exposure, therefore accelerated aging protocols have the potential to increase the speed of development and production of high-performance stay-clean roofs to the market. To mimic natural soiling in the lab, Dr. Sleiman’s group first exposes the samples to artificial weathering (moisture, temperature fluctuations, and UV) in a commercially available weathering device. Next, an aqueous mixture of salts, clays and iron oxide, humic acid, and soot hydrosol are sprayed onto the samples, which are then subsequently dried under an infrared lamp. Finally, the samples are weathered again. Between each stage of the process, the degradation of solar reflectance (SR) is noted. Dr. Sleiman reported that the group found that the initial weathering stage slightly modified the effect of subsequent soiling on SR but that increasing the duration of the final weathering stage from 24 to 72 hours did not affect the loss of SR. However, he noted that changes in SR are dominated by soiling and modified by weathering. This protocol allowed the group to accurately mimic three years of natural exposure in just three days of simulation.

"Accelerated aging apparatus" **- Dr. Yoshinori Kitsutaka, Professor of Architecture and Building Science at Tokyo Metropolitan University,** presented on an accelerated test method for the soiling of walls from rain and dust deposition. Dr. Kitsutaka's group ran outdoor exposure tests for six months on a variety of different wall samples including cement lithin, acrylic emulsion lithin, acrylic emulsion coatings, autoclaved aerated concrete, mortar, and porcelain tile. In addition, they conducted laboratory (accelerated) tests (18 cycles) using "substitute-dust" which is a mixture of hydrophobic black carbon, yellow ocher, kanto ioam, and silica. Dr. Kitsutaka found that there was a high correlation between the outdoor exposure (flowing rain with dust) and the accelerated aging test (simulated flowing rain with dust using the substitute-dust mixture).

"Durability of several coatings – natural and accelerated exposure" **- Dr. Kenji Motohashi, Professor of Engineering and Architecture at Shiabura Institute of Technology,** shared results from a study that informed the accelerated aging test method for paints in standard JIS K 5602:2008. He explained that accelerated testing, specific to water-based fluoropolymers, is currently very popular in Japan. Dr. Motohashi noted that according to the study, the SR was reduced primarily through soiling, but gloss retention values of the samples gradually decreased under accelerated aging.

Lunch Break: Presentation on global cooling and white roofs

"White roofs to cool your building, your city, and (this is new!) cool the world" **- Dr. Arthur H. Rosenfeld, Former California Energy Commissioner and Distinguished Scientist Emeritus at LBNL,** spoke about the benefits of white roofs, specifically their global cooling benefit. Dr. Rosenfeld stated that converting 100 square meters of gray roofs to white, offsets the emission of 10 tons of CO_2. More reflective surfaces absorb less solar heat and thus transmit less heat back into the environment. Dr. Rosenfeld emphasized that white roofs are the single most cost-effective existing strategy to mitigate climate change.

"Regional climate consequences of large-scale cool roof and photovoltaic array deployment" **- Dr. Dev Millstein, Postdoctoral Fellow at LBNL-Heat Island Group,** presented his research on computer-based modeling of the climate impact of large-scale cool surfaces and solar panel deployment. To simulate these patterns, Dr. Millstein modeled various surface albedos for urban areas and a desert region to understand the climate feedbacks to the atmosphere. His study used a fully coupled regional climate model to investigate feedbacks between changes in surface albedo and surface temperature, precipitation levels, and cloud cover. He found that increased urban surface albedo from cool surfaces leads to significant cooling and can reduce emissions of around 3.3 gigatonnes CO_2. Furthermore, Dr. Millstein's coupled land-atmosphere modeling demonstrates regional differences in temperatures and wind patterns due to albedo changes. Accordingly, he found that reductions in surface albedo from the simulated introduction of massive photovoltaic arrays in a desert region would slightly increase local temperatures but affected wind patterns within a 300 km radius.

Session 4: Influence of natural aging on roofing materials

"3-year study of aged solar reflectance of field-applied coatings" - Jim Leonard, Founder of Elastomeric Roofing Systems, Inc. and Former President of Reflective Roof Coatings Institute, began the session with a presentation on a study of the solar reflectance (SR) of field-applied roof coatings. The study examined the effect of aging on SR as related to roof substrate type and texture, roof coating chemistry, and film thickness. Three types of roof coating were examined – two acrylics and one polyurethane. Several samples were prepared for each of the coatings and naturally exposed in three climate zones (south-east, west, and mid-west). Solar reflectance was measured at one half, one, two, and three years (data collected per ASTM C-1549). The study found that, consistent with other studies, the south-eastern climate (Florida) had the highest SR degradation caused by soiling from mildew growth and dirt. Samples in the western climate (Phoenix) experienced SR degradation from dirt soiling. Lastly, samples in the mid-west (Minneapolis) had the least amount of SR degradation over time. Leonard concluded with lessons learned, including:

- Substrate texture and chemistry showed relatively small effects on new and aged SR.
- Neither substrate texture nor chemistry nor the combining influence of both factors produce aged SR values less than the present Energy Star and CEC accepted minimums.
- RRCI recommends the CRRC consider reducing the natural testing exposure time for aged results of field-applied coatings to one year.

Asked whether decreases in SR are being studied on a horizon longer than three years, Mr. Leonard remarked that the samples in each of the three sites remain in place and they continue to generate data. However, he expects that the trend of declining SR would slow and bottom out after three years.

"Weathering from a titanium dioxide manufacturer's perspective" - Dr. John Edwards, Senior Research Scientist at Huntsman, gave a presentation on weatherability from a TiO_2 pigment manufacturer's perspective. His presentation centered on the role of TiO_2 pigment in weathering as well as its use as a self-cleaning surface. TiO_2 has three properties that make it an apt white or cool roof pigment. First, TiO_2 provides coloration and opacity/hiding in a range of systems. Secondly, TiO_2 can help to increase solar reflectance thus reduce surface temperatures. Lastly, TiO_2 absorbs UV radiation, providing protection or enabling self-cleaning. More specifically, photoactive TiO_2 particles in the binder promote free radical attack at the surface of the system. Inorganic dust remains but the "glue" can be destroyed, therefore reducing the adhesion force between the particles and the surface. When it rains, these particles are washed away and the surface is rejuvenated. Overall, TiO_2 is one of the best chemicals to apply to cool and white roofs due to its ability to increase solar reflectance while also self-cleaning.

"Methodology of dirt pickup resistance testing vs. exterior durability: Statistical analysis of a predictive test" - Dr. Joe Rokowski, Elastomeric Roof Coatings Group Leader and Principal Research Scientist in R&D at Dow Construction Chemicals, presented on Dow's predictive Dirt

Pickup Resistance (DPUR) test method and how it compared to their collection of naturally exposed roofing samples. Dow's primary outdoor exposure testing facility is 6.5 acres, and includes roughly 30,000 material panels, over 120,000 test areas, plus over 50 rooftops. In addition to the main exposure facility, Dow has 12 other exposure sites across the globe. Samples at these test sites are naturally exposed and tested for their efficacy in dirt pickup resistance (DPUR). Dr. Rokowski and his team experimented with several accelerated soiling test methods to mimic the natural exposure from their test facilities but have not been particularly pleased with the results. They caution that location effects are critical when designing accelerated soiling tests.

"Next generation cool white roof coatings" - **Jerry Petersheim, Business Development Engineer in the Fluoropolymer Group at Arkema Inc.**, discussed the next generation of white roof coatings. He talked about how the weathering properties of PVDF fluoropolymers are derived from the carbon-fluorine bonds that compose them. According to Arkema, the "stay-clean" advantages of these fluoropolymers include their crystalline structure, smooth surface properties, and inhospitality to fungal growth (see full presentation for descriptions of each property). Petersheim demonstrated the self-cleaning properties of the PVDF by showing two nine year-old samples from Florida (PVC membrane, fluoropolymer-based cool white metal roof); while the PVC membrane was very badly soiled, the fluoropolymer-based white metal roof was pristine. Petersheim concluded with a graph to show the annual cooling energy savings of a fluoropolymer cool white roof coating and an elastomeric acrylic coating in Arizona – there was a 60% difference in energy savings, owing to the fact that the fluoropolymer coating was shown to be 20% more reflective than the non-PVDF coating. The presentation nicely demonstrated how the next generation of "self-cleaning" cool roof materials will be able to maintain a high solar reflectance for longer than conventional cool roof coatings.

Session 5: Technical review of accelerated biological growth procedures

"Development of an accelerated testing protocol by improved understanding of reflectance degradation" - **Dr. Meng-Dawn Cheng, Leader of the Atmospheric and Aerosol Science Team in the Environmental Sciences Division at Oak Ridge National Laboratory**, presented on the development of an accelerated exposure testing protocol for building envelope materials through improved understanding of reflectance degradation. The objectives of the testing protocol are to understand how selected environmental factors degrade surface reflectance and to use this knowledge to develop a set of operating parameters that can be controlled experimentally. An additional goal is to integrate the set of parameters into an accelerated testing protocol to be tested against current environmental testing practices, which test selected roof materials both in a natural and laboratory accelerated test setting. One test in seven sites across California yielded very interesting results:

- the change of roof reflectance was cyclical with smaller dust amounts during wet seasons;
- the composition of roof particles produced contamination profiles for sites;
- loss of solar reflectance was primarily from dusts and particles from man-made sources; and
- chromium, iron compounds, and soot contributed to changes in solar reflectance.

"Performance of roofing materials as related to microbial and chemical characterization of atmospheric depositions and roof fouling" - Dr. Susan Pfiffner, Research Associate Professor in the Department of Microbiology at the University of Tennessee, Knoxville, spoke about the performance of roofing materials as related to microbial and chemical characterization of atmospheric depositions and roof fouling. Her research objective is to determine how surface contamination and weathering affect the roof material reflectance and emittance, the relevance of roof soiling toward the promotion of energy efficiency and product marketing, as well as further understanding the biological component of aging. The research project used data from samples studied in seven sites in California, in which roof tiles were weathered for 1.5 and 4 years. Pfiffner retrieved the fouling deposition from the samples for analysis. She concludes that roof tile microbial biomass is related to tile composition or surface structure. PLFA and Quinone profiles showed diverse microbial communities, and expanded microbial analyses will include cultivation and molecular analysis for in-depth community membership and phylogenetic identification.

Session 6: Discussion of accelerated aging protocols

Day 1 concluded with a discussion in which participants relayed their experiences with natural and accelerated aging of roofing materials. Participants were also asked for feedback and suggestions pertaining to the accelerated aging protocols proposed by ORNL and LBNL.

Discussants identified several issues with the current accelerated aging methodologies. One problem was that tests are conducted at too many sites with differing test conditions in each, such that any predictive model for a given site has its own level of uncertainty. To that effect, John Edwards expressed concern that many different natural processes are not represented in the current data. A participant described the critical task as being able to define the test environment accurately and understand that those circumstances do not hold in all cases.

Another participant wondered whether it made most sense to test in the Southeastern U.S., where conditions are most hot and humid, or in urban areas with high levels of greenhouse gas emissions and air pollutants. Ingo Joedicke pointed out that biological growth has become a problem on a national scale, and wondered whether microbes are building resistance to specific treatments. Craig Smith also aired concern over whether any algae treatments would be effective without damaging the roofs to which the microbes bind. Santiago Blanco contended that ponded water on rooftops was the most damaging factor for roofs, but that this factor may not be adequately reflected in current experimentation. One participant wondered whether having black photovoltaic cells mounted on rooftops counteracts the benefits of cool roofs.

An industry participant stressed the need to expedite protocols for accelerated aging modeling; quicker modeling would enable the creation of a database to compare to field-tested products, thereby making laboratory and natural settings complementary. Joshua New echoed this point, noting that data are particularly scarce for extended timeframes. Joseph Fay indicated that soiling may be affected by the degradation of the materials over time, which necessitates data much longer-term than LBNL's three-year data and possibly in excess of 20 years.

It was further noted that laboratory testing should not fully replace field testing, since outdoor data is needed to verify results from the lab setting as well as to test the durability of the materials. Another participant commented that the necessary data appears to exist to enable the industry to at least begin to develop self-cleaning technology, which the participant considers to be the next step.

One group of discussants composed a list of suggested modifications to current protocols:

1. Incorporate a screening method for long time frames, on the order of decades
2. Collect more data points
3. Increase cooperation between groups, particularly with respect to natural aging
4. Extrapolate current data to new and future materials
5. Guarantee the quality of the material beyond the three-year mark
6. Complete added prototyping and screening
7. Reduce the timeframe of accelerated aging protocols

Day 2: Friday, July 29th, 2011

Session 1: Cool Roof Organizations & Projects

"Global Cool Cities Alliance" - Kurt Shickman, Director at Global Cool Cities Alliance (GCCA), kicked off the second day with an overview of the goals and initiatives of the Global Cool Cities Alliance. GCCA was launched in 2010, with a mission of advancing policies and actions that increase the solar reflectance of buildings and pavements as a cost-effective way to promote cool buildings, cool cities, and global cooling. GCCA's objectives, in support of its mission, are to engage with local and regional governments, foster corporate leadership, develop building codes and pavement specifications, and establish a hub/clearinghouse of cool surface research and information. Finally, Shickman discussed the long term priorities of the organization, including the development of a collaborative network of cool material implementers, standard cool material monitoring protocols, and advanced building codes and pavement specifications.

"San Jose cool city pilot project" - Doug Davenport, Program Manager at LBNL, presented on LBNL's new partnership with the City of San Jose. The partnership is planning a cool city pilot project. The goal of the project is to create a pilot area to research urban heat island mitigation and sustainable urban development to address:

- urban livability, public health, energy efficiency
- emerging technology testing and demonstration
- state and local policy and incentives development
- workforce development
- community and market transformation

The short-term goal of the pilot project is to establish city-based testing infrastructure for implementing cool surface technologies, practices, and planning. To get involved, contact Haley Gilbert (LBNL Heat Island Group): HEGilbert@lbl.gov

"100 cool cities: Lay of the land, standards and double standards" - Dr. Hashem Akbari, Professor at Concordia University, first discussed a global effort to install cool surfaces in 100 of the largest cities in the world. The effort already has more than 10 member cities. Professor Akbari outlined the next steps to promote the effort including, additional city recruitment and developing key resources/tools to aid with recruitment and implementation of city efforts (a detailed land use database; model implementation programs; coordinated work with government entities at various levels/scales; a feedback system; model regional energy codes, standards, guidelines; and demonstration projects).

Session 2: Existing cool roof standards & policies – international perspective

"European Union policies, programs and market" - Dr. Hashem Akbari, Professor at Concordia University, next delivered an overview of the cool roof policies, programs, and initiatives in the European Union. Dr. Akbari opened his presentation with the observation that cool roof technology is not prominent in Europe, owing to the lack of a legislative framework, cool roof standards, data (no information on products available in the European market), and knowledge. The EU Cool Roofs Council (ECRC) is attempting to break down these barriers by cultivating scientific knowledge and research with respect to cool roof technology, promoting the use of cool roof products in Europe, and by developing a product rating program. ECRC members are a multi-faceted group of partners and market adopters, as well as five laboratories across the EU that are focused on cool roof adoption. Currently Greece, Italy, the UK, and Germany are leading the way in adopting cool roof policies and programs; in Greece a program called "Building the Future" gives incentives for the application of 20,000 cool roofs on residential buildings. In the UK (BREEAM) and Germany (German Sustainable Building Certificate), ecological quality and sustainability certification standards include measures to incorporate cool materials into buildings to mitigate heat islands.

Asked whether Europe uses the same standards as the U.S., Dr. Akbari responded that the standards are largely similar across systems, but that the EU is working with the U.S. Department of Energy to adopt ASTM standards and formalize this consistency. In response to a question of whether he plans to promote cool roofs in Africa and the Middle East, Dr. Akbari noted that he is currently working with Kuwait and Saudi Arabia, and that Kuwait already has very strong building codes that incorporate cool roofs.

"Cool roofs – moving research into building codes: The Australian experience" - Tony Tanner, Director and Company Secretary at the Building Products Innovation Council (BPIC) in Australia, presented on Australia's current status of energy efficiency roofing policies, standards, and research programs. Tanner specifically described the Roof Tile Association of Australia (RTAA) Solar Absorptance research program, commissioned through the faculty of Engineering and Built Environment at the University of Newcastle. The program was charged with researching the thermal performance of tile and corrugated steel roofing products. The research was conducted from 2007 to 2010 and covered a wide range of climatic conditions. The program found that tile color and shape had the greatest effects on thermal performance; dark gray, flat tiles required 49% more cooling energy than light cream, shaped tiles.

"Cool roof standards in Japan" **- Toshiya Takahashi, Director of the Standardization Division at the Japan Paint Manufacturers Association (JPMA)**, presented on cool roof paint development and standardization in Japan. In Japan, cool roof paint production has grown 20% per year for the last seven years. This is mostly due to the direct influence of JPMA on the Japanese paint industry. Specifically, in 2004 JPMA started educating the industry on cool roof paints and formed a promotion committee to disseminate knowledge throughout the Japanese paint market. Then in 2006, JPMA helped create a standardization committee, which now has begun developing standards for a variety of cool roof painting materials (see slide 13 for an in-depth description of the different cool roof standards). In the future, JPMA hopes to accelerate an international joint project focused on cool roof demonstrations with other partner countries. For more information, visit the JPMA website at http://www.toryo.or.jp/eng/index.html.

"Cool roofs in India" **- Bipin Shah, President at WinBuild, Inc.**, discussed cool roof initiatives in India. He began his talk by demonstrating the acceleration of construction in India (projected $400 billion in construction spending by 2013). He showed that 90% of the Indian region would benefit from cool roof technology. Next, Mr. Shah gave an overview of the cool roof requirements that currently exist in India's various green building codes; among them, the Bureau of Energy Efficiency's Energy Conservation Building Code (ECBC-2007) requirement that any building project hoping to follow the prescriptive method of code compliance must have a cool roof. According to Mr. Shah, this is the first step in the right direction for cool roof adoption in India, but there is much more still to do. Other codes require that a minimum of 50% of a building project's total paved area (including parking) should have solar reflectance of 0.5 or higher. Furthermore, India's LEED Certification includes a cool roof option for fulfilling a heat island credit. He concluded with a few key take home points about cool roofs in India, most notably that cool roofs have potential to make a big difference in India due to its hot and humid climate, but that the materials must be durable and aesthetically appealing in order to gain consumer acceptance.

"Progress of cool roof technology in China" **- Dr. Yang Shichao, Professor at Guangdong Provincial Academy of Building Research & Lin Changqing, Senior Engineer at the Research Institute of Standards & Norms**, presented on the progress of cool roof technology in China. According to Mr. Shichao and Mr. Changqing, China has very robust energy efficiency standards that incorporate cool roofs (for a list of these standards see slide 10). China began to research reflective thermal insulating coatings in 1992, and since then more than 50 companies have started manufacturing cool roof coatings. At the moment, Mr. Shichao and Mr. Changqing are focusing on testing differences in energy efficiency and comfort between buildings with white roofs and those with "common" roofs (see the specifics of this study on slide 18). Results are not yet available, as the test is ongoing.

Session 3: Existing cool roof standards & policies – USA perspective

"Cool Roof Rating Council's rating program and international efforts" **- Sherry Hao, Director at Cool Roof Rating Council (CRRC)**, began the session with an overview of the Cool Roof Rating Council's rating program. Ms. Hao walked through the CRRC's rating methodology it employs to devise its ratings, including the measuring equipment, the conditions at the weathering farms, and the test lab conditions (see slides 8-10 for specific details of equipment and test conditions, and slide 13 for test lab conditions). CRRC rating results are listed online in their Rated Products Directory and printed on CRRC product labels. CRRC is referenced by California building codes as well as several other national, state and municipal building code requirements. Additionally, the CRRC is building an international presence with involvement in Asia, Australia, Latin America, and the Middle East.

"California Title 24 – building energy code" - **Dr. Ronnen Levinson, Deputy Leader at LBNL-Heat Island Group**, presented on California's building energy efficiency code (Title 24, Part 6). Dr. Levinson began by discussing the history of California building standards. He then laid out California's policy goals which rely on tighter building standards, namely the Energy Action Plan, West Coast Governors' Global Warming Initiative, Green Building Initiative, and Climate Action Initiative. Dr. Levinson reviewed the various cool roof requirements including, building types, climate zones, roofing material, roof slope and radiative properties. Levinson went through the 2008 requirements for these various roof permutations (see slides 10-15). Dr. Levinson then addressed concerns over the use of integrated photovoltaic (PV) and solar thermal panels, noting that if the panels are integrated as a part of the roof then the roof is exempt from cool roof requirements. Similarly, current requirements consider ballasted and green roofs to be cool as long as the unit weight of the roof is at least 25 lb/ft^2. For more on Title 24, visit http://www.energy.ca.gov/title24/2008standards/index.html.

"Update on the International Code Council" - **Mike Ennis, Technical Director at the Single Ply Roofing Industry (SPRI)**, gave an update on international building codes. To start, Mr. Ennis noted the general trend that cool roofs are gaining increasing acceptance as a measure of energy conservation and heat island mitigation. Chapter 4 of the International Green Construction Code (IgCC) stipulates that 75% of roofing surfaces on buildings in certain climate zones must have an aged solar reflectance of at least 0.55, though it allows for vegetative roofs to be used as an alternative. Current proposals will expand cool roofs into the energy chapter of IgCC as well, which would reduce non-cool tradeoffs allowed on roofs. The 2012 International Energy Conservation Code (IECC) added cool roofs as an energy conservation measure, but also with exceptions for the portions of roofs that are used for solar panels, roof gardens, or for other specific uses. Mr. Ennis also touched on the proposed revisions to Title 24, which would ease standards so that more products would be in compliance with the cool roof requirements in exchange for tradeoff procedures that enhance building efficiency.

"One utility's experience with cool roofs" - **Peter Turnbull, Principal Program Manager at Pacific Gas & Electric (PG&E)**, closed the morning session with a discussion of PG&E's experiences relating to cool roofs. Mr. Turnbull pointed out California's record of successful energy efficiency, as per capita electricity consumption has remained roughly constant since 1976. In that period, PG&E programs have saved 135 million tons of CO_2 from being released into the atmosphere. Mr. Turnbull framed the present discussion by citing the Warren-Alquist Act, passed into law in 1975, which established the CEC and encouraged energy planning and forecasting. Since then, California's utilities revenues have decoupled from sales, since they are designed to be run at cost. This decoupling framework minimizes incentives for utilities to increase commodity sales, and permits today's investor-owned utilities to report earnings on the basis of their performance in energy efficiency programs. Mr. Turnbull showed a figure illustrating that utility programs are responsible for about the same GWh savings since the 1970s as building standards and appliance standards combined. Ideally, utilities could implement technologies that are simple, cheap, and accessible to consumers; Mr. Turnbull explained that while cool roofs do not fit this profile, there could be a case made for utilities to be interested in measures (such as cool roofs) that reduce peak load. Mr. Turnbull concluded by remarking that it is difficult to communicate the cool roof message, but that the cool roof requirements in codes and standards have been successful and are encouraging.

Lunch Break: Presentation on the Albedo Satellite Project

"Albedo Satellite Project" - Dr. Federico Rossi, Associate Professor of Applied Physics at the University of Perugia, presented on the Albedo Project, which aims to offset CO_2 emissions by increasing the earth's average surface albedo. The atmospheric concentration of CO_2 is nearing 40% above preindustrial levels, an effect that the IPCC attributes principally to human activity. Dr. Rossi stressed that of traditional methods for global warming mitigation, the cheapest and least complex methods, such as green building, typically produce the best results. He warned that more complex geoengineering approaches are unproven, expensive, and irreversible. Dr. Rossi instead proposed a method of solar radiation management (SRM) that seeks to artificially enhance earth's terrestrial albedo, which would reduce global average temperatures and offset some CO_2 emissions. He demonstrated a model of CO_2 offset that accounts for the latitude, tilt angle, azimuth angle, surface solar albedo, time of day, and meteorological conditions of a given surface. This CO_2 offset estimation will have the supplemental effect of avoided CO_2 emissions by keeping buildings cooler. With one ton of CO_2 equivalent recently valued at €13 on the European Energy Exchange, carbon offsets could provide lucrative opportunities for albedo enhancement undertakings. Dr. Rossi also introduced plans for the AlbedoSat Project, in which a satellite would orbit the earth 15 times daily to periodically monitor the earth's surface albedo.

Session 4: Review of existing testing standards

"Mimicking natural exposure through accelerated ageing: Examples from ISO standardization for service life prediction" - Dr. Riccardo Paolini, Building Engineer in the Building and Environment Science and Technology Department at Politecnico di Milano, opened the afternoon session by discussing his group's methods for accelerated aging. Dr. Paolini presented background information on the International Council for Research and Innovation in Building and Construction (CIB), which collaborates with the International Organization for Standardization (ISO) to develop service life prediction protocols for buildings. The CIB and ISO test surfaces for mold-growing propensity as well as the length of time for which surfaces stay clean and above solar reflectance levels mandated by various building envelope standards. They are then able to give a service life prediction as an output, unlike any existing standard test method. Dr. Paolini went through the main points of the CIB W080 2010 Status Report (available online at http://cibworld.xs4all.nl/dl/publications/w080_wg3_report.pdf; see slides 7 and 8 for highlights). In its accelerating aging tests, CIB looks at hygrothermal behavior evolution, mold growth, soiling, and other such factors in assessing the durability of a surface. The resulting service life data are useful toward environmental product declarations, return-on-investment calculations, environmental and economic life-cycle analysis assessments, building management, refurbishment, and regulation. The next CIB W080 meeting will take place October 18th-21st, 2011 at the SB11 Conference in Helsinki, Finland: http://www.sb11.org/.

"The draft ASTM dirt pick-up resistance test method" - Steve Heinje, Technical Service Manager at Quest Construction Products, gave a presentation on a proposed method for surface soiling resistance. Mr. Heinje described the need for surfaces that are cosmetically acceptable, meet energy and reflectivity performance requirements, resist water and biological growth, and can be brought to market quickly. To this last point, Mr.Heinje pointed out that from start to finish, innovations in roof coating technology typically take more than five years to reach market. The American Society for Testing and Materials (ASTM) has established a dedicated task group for dirt pickup for polymeric roofing coatings. The group has already begun drafting a standard. The current proposed standard tests materials by submitting them to 1000 hours of UV light to weather the roof samples, soiling the samples using simulated dirt and burnishing, and finally washing the samples.

"Accelerated weathering methodology for cool roof coating materials" - Anthony S. Camarota, President and CEO at EPOX-Z Corporation, described his firm's methodology for accelerated weathering of cool roof coatings. Mr. Camarota described how the lack of an accelerated aging methodology for rating and listing cool roof coatings had slowed entry into this important market. Typical coating failures can be attributed to many factors, including defective manufacturing or equipment, owner negligence, and environmental conditions. This last factor could consist of pooling water, chemicals, solar radiation, or extreme temperatures, and may result in permeation of the coating by rain or water. EPOX-Z patterns its accelerated laboratory tests after natural cyclic conditions, both wet and dry, to better approximate true outdoor corrosive environments. These cyclic wet/dry corrosion tests have been shown to accurately predict one year of actual exposure to external conditions in 2,000 hours of laboratory testing.

Session 5: Discussion of development of standards for accelerated aging protocols

Day 2 concluded with a discussion of the development of national and international standards for accelerated aging protocols. Participants were asked to think of strategies for advancing accelerated aging protocols for roofing products into ISO and/or ASTM standards, bearing in mind their own experiences with these and other standards bodies.

Bipin Shah related his experiences with ISO standards for windows, which differ between North America and Europe. Accordingly, he stressed the importance of a coordinated international effort toward uniform standards. Kurt Shickman seconded this view, noting that at a global scale, having codes and standards is important, but that local versions come in "different flavors." He stressed that adoption of standards is a very different notion from enforcing those standards; the Global Cool Cities Alliance seeks to improve enforcement of standards across countries.

While it was discussed that ASTM standardization typically involves a consensus approval by the CRRC, Riccardo Paolini expressed a preference for ISO standards, noting that they had a higher probability of political success across governments. Hashem Akbari, however, encouraged participants to put together a technical committee to compose a draft of a standard that an ASTM task group could approve without CRRC intervention; once approved by ASTM, the standard would quickly be adopted by other bodies. Bipin Shah disagreed, contending that CRRC was in fact a quicker path toward approval.

Ronnen Levinson posed the question of whether we should be focused on international ISO standards that take a long time rather than national ASTM standards. Bipin Shah suggested a parallel approach so that the standards are uniform and do not create problems later on. An Australian colleague shared that Australia simply sets its own standards and looks to what other countries implement for ways to modify their national standards.

A CRRC representative said that while his organization does not necessarily have a dedicated group that can tackle soiling standards, it is one of the few places where all parties can come together in one place to discuss protocols. He emphasized quality, rather than speed, of standards as the priority, and said that the CRRC can get these standards into building codes.

Riccardo Paolini concluded by acknowledging the need to get to work immediately on adequate standards, leaving some wiggle room in drafts to accommodate changes that may arise during the potentially long process.

Presenters

First	Last	Affiliation	Email	Presentation Title
Hashem	Akbari	University of Concordia	HAkbari@ encs.concordia.ca	100 cool cities: Lay of the land, standards and double standards EU policies, programs & market (on behalf of EU-CRC)
Anthony	Camarota	EPOX-Z	Tony@epox-z.com	Accelerated weathering methodology for cool roof coating materials
Meng-Dawn	Cheng	Oak Ridge National Laboratory	ChengMD@ORNL.gov	Development of an accelerated testing protocol by improved understanding of reflectance degradation
Doug	Davenport	LBNL	DTDavenport@ LBL.gov	San Jose cool city pilot project
Hugo	Destaillats	LBNL-Heat Island Group	HDestaillats@LBL.gov	Aging of roofing surfaces: The "Advanced Surfaces" project
John	Edwards	Huntsman	John_L_Edwards@ huntsman.com	Weathering from a titanium dioxide manufacturer's perspective
Mike	Ennis	Single Ply Roofing Institute, Inc.	M.Ennis@mac.com	Update on the International Code Council
Sean	Fowler	Q-Lab Weathering Research Service	SFowler@q-lab.com	Current accelerated weathering practices
Sherry	Hao	Cool Roof Rating Council	SHao@energy-solution.com	Cool cohesion: Supporting codes and programs with a roof rating system
Steve	Heinje	Quest Construction Products	Heinje@ unitedcoatings.com	The draft ASTM dirt pick-up resistance test method
Yoshi	Kitsutaka	Tokyo Metropolitan University	Kitsu@tmu.ac.jp	Accelerated soiling test method for painted materials
Jim	Leonard	Reflective Roof Coatings Institute	Jim@ersystems.com	3-year study of aged solar reflectance of field-applied coatings
Ronnen	Levinson	LBNL-Heat Island Group	RMLevinson@LBL.gov	Benefits of cool roofs California Title 24 – building energy code
Michelle	Meier	Solyndra		The best solar solution for cool white rooftops

First	Last	Affiliation	Email	Presentation Title
Dev	Millstein	LBNL-Heat Island Group	DMillstein@LBL.gov	Regional climate consequences of large-scale cool roof and photovoltaic array development
Kenji	Motohashi	Shibaura Institute of Technology	MotoKen@ shibaura-it.ac.jp	Durability of several coatings - natural and accelerated exposure
Riccardo	Paolini	Politecnico di Milano	Riccardo.Paolini@ mail.polimi.it	Mimicking natural exposure through accelerated ageing: Examples from ISO standardization for service life prediction
Jerry	Petersheim	Arkema, Inc.	Jerry.Petersheim@ arkema.com	Next generation cool white roof coatings
Susan	Pfiffner	Oak Ridge National Laboratory	Pfiffner@utk.edu	Performance of roofing materials as related to microbial and chemical characterization of atmospheric depositions and roof fouling
Anna	Pisello	LBNL & Università degli Studi di Perugia	Pisello@crbnet.it	Solar radiation management for global warming mitigation
Joseph	Rokowski	Dow Construction Chemicals	JRokowski@dow.com	Methodology of dirt pickup resistance testing vs. exterior durability: Statistical analysis of a predictive test
Federico	Rossi	University of Perugia		Albedo Satellite Project
Bipin	Shah	WinBuild, Inc.	Winbuild.USA@ gmail.com	Cool roofs in India
Kurt	Shickman	Global Cool Cities Alliance	KurtShickman@ gmail.com	Global Cool Cities Alliance
Mohamad	Sleiman	LBNL-Heat Island Group	MSleiman@LBL.gov	Accelerated aging protocols for roofing materials
Richard	Slomko	Atlas MTT	RSlomko@atlas-mts.com	Natural weathering and the effects of soiling
Tony	Tanner	Roofing Tile Association of Australia	AJTanner@ rooftile.com.au	Cool roofs – moving research into building codes: The Australian experience
Peter	Turnbull	PG&E	PWT1@pge.com	Utilities, cool roofs, and energy efficiency
Kurt	Wood	Arkema, Inc.	Kurt.Wood@ arkema.com	Next generation cool white roof coatings