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To: Chris Scruton (CEC)
From: Steve Wiel
Subject: **Cool Roof Colored Materials**: Monthly Progress Report for May 2004
CC: Hashem Akbari, Paul Berdahl, Andre Desjarlais, Bill Miller, Ronnen Levinson

A summary of the status of Tasks and Deliverables as of May 31, 2004 is presented in Attachment 1.

HIGHLIGHTS

- The project team prepared and submitted an article on "Cool Roof Colored Materials" for the upcoming ACEEE meeting.
- We have prepared a draft paper "*Special Infrared Reflective Pigments Make a Dark Roof Reflect Almost Like a White Roof*" to be presented in the upcoming THERM IX meeting.
- We continue to work with tile, granule, and shingle manufacturers to develop cooler products.
- In June, we will receive several cool shingles to present to the developers of the demonstration houses for their selection.

Tasks

1.1 Attend Kick-Off Meeting
This Task is completed.

1.2 Describe Synergistic Projects
This Task is completed.

2.1 Establish the Project Advisory Committee (PAC)
This Task is completed.

2.2 Software Standardization
(No activity.)

2.3 PAC Meetings
(No activity.)

2.4 Development of Cool Colored Coatings

2.4.1 Identify and Characterize Pigments with High Solar Reflectance
Our two pigment papers have been peer reviewed and will be submitted to /Solar Energy Materials & Solar Cells/ next month.

We are working with a Japanese firm to characterize some novel black and gray cool pigments. The cool gray coating received from Japan is very interesting. The composition of the coating is unknown, so we subjected it to x-ray diffraction analysis. The coating contains a mixed metal oxide of iron and chromium, and has been lightened with titanium dioxide (rutile). A third crystalline component was observed but not yet identified.

We continue to develop a model and software predicting the reflectance of paint mixtures.

2.4.2 Develop a Computer Program for Optimal Design of Cool Coatings
See Task 2.4.1.

2.4.3 Develop a Database of Cool-Colored Pigments
We are improving the database.

2.5 Development of Prototype Cool-Colored Roofing Materials

2.5.1 Review of Roofing Materials Manufacturing Methods
(No activity. Near completion.)

2.5.2 Design Innovative Methods for Application of Cool Coatings to Roofing Materials
Our activities this month focused on development of cool shingles. A recently produced cool dark brown prototype (solar reflectance 0.21) very closely matches a conventional brown shingle (solar reflectance 0.11), and we hope to increase the solar reflectance of the prototype to 0.25.

2.5.3 Accelerated Weathering Testing
Akbari and Berdahl had further discussions with our industrial partners about the development of a plan for accelerated testing of cool colored materials.

2.6 Field-Testing and Product Useful Life Testing
Stephen Daues of Mercy Housing is awaiting samples of cool-colored shingles for making a color selection for the field demonstration proposed at White Rock Village.

Efforts have begun to develop engineering applications for applying cool-colored pigments to cedar shakes.

New concrete and clay tile samples prepared by US Tile, MonierLife Tile and Shepherd Color Company and by Joe Riley of American Rooftile Coatings were placed at six of the seven weathering sites in California.

2.6.1 Building Energy-Use Measurements at California Demonstration Sites
ORNL personnel visited the Cavalli Hills site and installed pyranometers on the two A-style homes having concrete tile roofs. We could not install the data acquisition system on the fourth demonstration house because stucco crews were still finishing the exterior walls of the home. The DAS was left with Wim Boss of SMUD, who will install the logger once the crew has completed the finishing work. SMUD installed both house and HVAC power transducers; however, the measurements do not appear correct and we are waiting for SMUD to troubleshoot installation and or instrument problems.

Stephen Daues of Mercy Housing showed ORNL personnel the new demonstration site for testing asphalt shingle roofs with and without cool colored pigments. Mercy Housing is building White Rock Village, a rental community consisting of 180 affordable family apartments in El Dorado Hills, approximately 25 miles east of Sacramento and within about 10 miles of the Cavalli Hills demonstrations. White Rock Village is a 12-acre site located adjacent to two residential properties. The one is a recently completed 344-unit apartment development, and the other is a planned 12 acre residential community. The White Rock Village complex has several of its planned 11 apartment buildings framed, and one or two buildings will be roofed every few weeks starting in June, 2004. Figure 1 shows an elevation view for one of the 11 apartment buildings.

Figure 1. Elevation view for a two-story apartment building in the White Rock Village complex being built by Mercy Housing and Brown Construction.

Daues of Mercy Housing, Miller of ORNL, Akbari of LBNL and Neiswonger and Shelby of Brown Construction, the contractor building the complex, talked through the details of the instrumentation setup for the demonstration. Daues wants to select a roof color and requested sample products be sent for his review and approval. Akbari wrote GAF, Certainteed and Elk and requested they forward samples of their best cool colored shingles to LBNL. Akbari has received materials from Elk and Certainteed and awaits a response from GAF.

Plans continue for demonstrating cedar shake roofs with cool pigments on homes located in Martinez, CA. John Goveia of Technical Roof Services has offered his house for demonstrating cedar shake roofing with cool pigments. John has a neighbor also willing to install new wood shakes on an adjacent home. However, Goveia needs information about the effect of cool colored materials on the fire resistance of cedar shakes. The issue must be resolved for code officials to approve permits for Goveia and his neighbor to install the new roof materials. Therefore, Steven Harris of the Cedar Shake & Shingle Bureau, Goveia of Technical Roof Services, Miller of ORNL and Ken Loye and Bob Blonski of Ferro discussed and developed an approach for developing cedar shakes that meet Class B fire code and have high solar reflectance.

New non-weathered cedar shakes have a solar reflectance of about 0.53 and in the near infrared spectrum the reflectance is almost 0.80. Homeowners however prefer the new shakes to weather to a brownish gray color, which requires about 3 years of exposure and after which the solar reflectance levels out at about 0.36. If a brownish gray color could be applied during the application of fire retardants, then shakes could be offered consumers that have a weathered appearance but also a high reflectance. Steve Harris stated that the cedar shakes are placed under vacuum in a chamber and fire retardants are forced under about 100 psi of pressure into the wood. Adding cool colorants to the

application of retardants would completely coat the shakes and hopefully yield a weathered shake with high solar reflectance. Fire resistance of the shake will probably be most affected by the binder used in the paint system. Blonski of FERRO asked Steve Harris to check with the International Accreditation Service (IAS), who conducts the fire resistance testing, to see if test data is already available for the common complex inorganic pigment iron oxide red. FERRO will apply their brownish gray color pigments to cedar shakes to develop a high solar reflectance.

2.6.2 Materials Testing at Weathering Farms in California

New concrete and clay tile samples prepared by US Tile, MonierLife Tile and Shepherd Color Co and by Joe Riley of American Rooftile Coatings were placed at six of the seven weathering sites in California. ORNL personnel could not complete the work at the Richmond site and requested support from LBNL to install the new samples and make reflectance and emittance measurements of existing samples.

Solar reflectance and emittance measures were collected for the painted metals and clay tiles being exposed at all weathering sites. All painted metal samples had a very dusty appearance with the worst soiling observed for samples exposed in Colton, which showed the larger loss of reflectance as compared to El Centro and McArthur (Fig. 2). The crisp and clear alpine climate of McArthur showed the lowest loss of reflectance (Fig. 2).

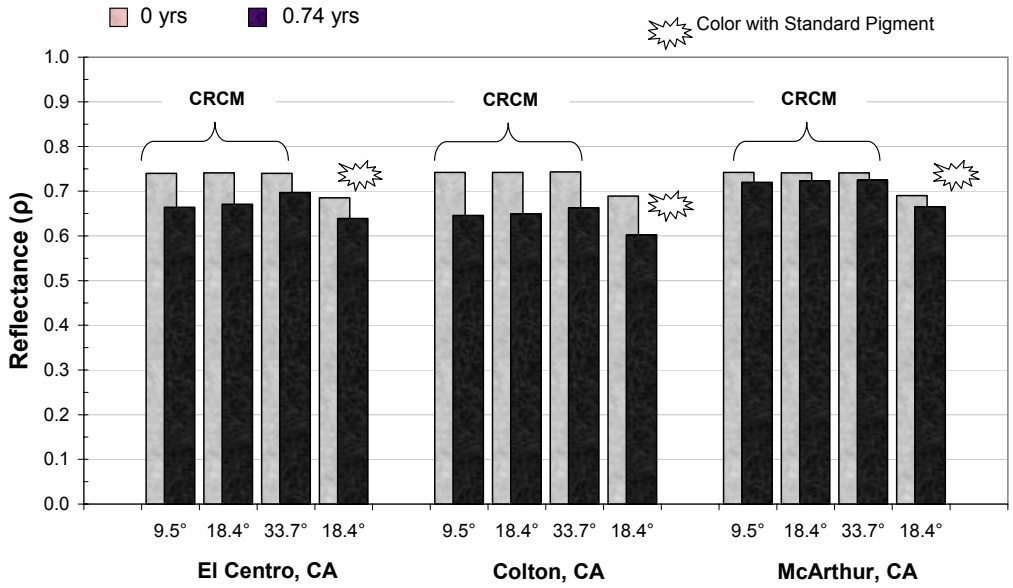

Figure 2. White painted metals with polyvinylidene fluoride base coat.

Similar results were also observed for the clay tile samples exposed at the same weathering sites. Data for both the painted metal and the clay tile show that the roof slope does slightly affect the loss of reflectance (Fig. 2). Testing at the slope of 8-in of rise per 12-in of run (33.7º slope) has less reflectance loss as compared to testing at 2-in of rise per 12-in of run (9.5º) for all three exposure sites (Fig. 2). Exposure occurred primarily

during the wetter winter months in California; however, precipitation is not believed to be the dominant player, especially when one considers that El Centro has less than 2-in of annual rainfall! Rather wind may be causing the differences in loss of reflectance as roof slope changes from 9.5º to 33.7º.

We are developing a file of airborne contaminant data, which shows significant amounts of crustal elements, sulfates and total carbon around the Los Angeles and San Diego areas. Less airborne contaminants are seen in northern CA, which is consistent with our results showing cleaner samples in McArthur than those exposed near urban developments.

2.6.3 Steep-slope Assembly Testing at ORNL

An error was discovered in the attic simulations conducted last period for the Cool Metal Roof Coalition (CMRC). AtticSim uses an algorithm published by Martin and Berdahl (1984) for calculating the sky temperature. AtticSim was inadvertently coded to reset the sky temperature to the outdoor ambient temperature. As a result the radiation heat transfer from the exterior roof to the sky was under-predicted because the summertime sky temperature is about 10ºF cooler than is the outdoor ambient air temperature. The coding error caused the ceiling heat flux penetrating the ceiling to be overestimated by about 20% for simulations conducted for a house with R-19 ceiling insulation in Miami, FL. The mistake was corrected and simulations rerun for inclusion in the draft paper to be published by ORNL and LBNL.

2.6.4 Product Useful Life Testing

Akbari discussed with our industrial partners the development of a plan to design an experiment for testing the useful life of cool colored materials.

2.7 Technology transfer and market plan

2.7.1 Technology Transfer

The project team prepared and submitted an article on "Cool Roof Colored Materials" for the upcoming ACEEE meeting.

The draft paper "*Special Infrared Reflective Pigments Make a Dark Roof Reflect Almost Like a White Roof*" was reviewed by Akbari, Levinson, Berdahl, and Wiel of LBNL, Kriner of the Metal Construction Association, Scichili of BASF and Loyle of FERRO. Reviewer comments along with corrections to simulations are being written into the paper.

On May 11, Akbari attended a meeting in San Rafael to discuss the application of cool roofs and heat island mitigation technologies for improvement of air quality in San Joaquin Valley.

On May 12, Akbari presented the Cool-Colored Roofing Materials at the LBNL 2004 Director's Review of the Environmental Energy Technologies Division.

On May 19, Akbari gave a one-hour presentation in Fresno on the potential of Heat Island Mitigation technologies for savings energy and improving air quality in Fresno.

2.7.2 Market Plan

(No activity.)

2.7.3 Title 24 Code Revisions
(No activity.)

Management Issues

- None

Attachment 1

Project Tasks and Schedules (*Approved on May 16, 2002*)

Task	Task Title and Deliverables	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 05/31/2004
1	**Preliminary Activities**					
1.1	Attend Kick Off Meeting *Deliverables:* • Written documentation of meeting agreements and all pertinent information (**Completed**) • Initial schedule for the Project Advisory Committee meetings (**Completed**) • Initial schedule for the Critical Project Reviews (**Completed**)	5/16/02	5/16/02	6/1/02	6/10/02	100%
1.2	Describe Synergistic Projects *Deliverables:* • A list of relevant on-going projects at LBNL and ORNL (**Completed**)	5/1/02	2/1/02	5/1/02	5/1/02	100%
1.3	Identify Required Permits	N/A		N/A		
1.4	Obtain Required Permits	N/A		N/A		
1.5	Prepare Production Readiness Plan	N/A		N/A		
2	**Technical Tasks**					
2.1	Establish the project advisory committee *Deliverables:* • Proposed Initial PAC Organization Membership List (**Completed**) • Final Initial PAC Organization Membership List • PAC Meeting Schedule (**Completed)** • Letters of Acceptance	6/1/02	5/17/02	9/1/02		100%
2.2	Software standardization *Deliverables:* • When applicable, all reports will include additional file formats that will be necessary to transfer deliverables to the CEC • When applicable, all reports will include lists of the computer platforms, operating systems and software required to review upcoming software deliverables	N/A		N/A		

Project Tasks and Schedules (contd.)

Task	Task Title and Deliverables	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 05/31/2004
2.3	PAC meetings *Deliverables:* • Draft PAC meeting agenda(s) with back-up materials for agenda items • Final PAC meeting agenda(s) with back-up materials for agenda items • Schedule of Critical Project Reviews Draft PAC Meeting Summaries • Final PAC Meeting Summaries	9/1/02	6/1/02	6/1/05		67% (4/6)
2.4	Development of cool colored coatings					
2.4.1	Identify and Characterize Pigments with High Solar Reflectance *Deliverables:* • Pigment Characterization Data Report	6/1/02	6/1/02	12/1/04		~ 95%
2.4.2	Develop a Computer Program for Optimal Design of Cool Coatings *Deliverables:* • Computer Program	11/1/03	11/1/03	12/1/04		~ 25%
2.4.3	Develop a Database of Cool-Colored Pigments *Deliverables:* • Electronic-format Pigment Database	6/1/03	7/1/03	6/1/05		~ 35%
2.5	Development of prototype cool-colored roofing materials					
2.5.1	Review of Roofing Materials Manufacturing Methods *Deliverables:* • Methods of Fabrication and Coloring Report	6/1/02	6/1/02	6/1/03		~ 95%
2.5.2	Design Innovative Methods for Application of Cool Coatings to Roofing Materials *Deliverables:* • Summary Coating Report • Prototype Performance Report	6/1/02	6/1/02	12/1/04		~ 75%
2.5.3	Accelerated Weathering Testing *Deliverables:* • Accelerated Weathering Testing Report	11/1/02	10/1/02	6/1/05		~ 5%

Project Tasks and Schedules (contd.)

Task	Task Title	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 05/31/2004
2.6	Field-testing and product useful life testing					
2.6.1	Building Energy-Use Measurements at California Demonstration Sites *Deliverables:* • Demonstration Site Test Plan • Test Site Report	6/1/02	9/1/02	10/1/05		73%
2.6.2	Materials Testing at Weathering Farms in California *Deliverables:* • Weathering Studies Report	6/1/02	10/1/02	10/1/05		55%
2.6.3	Steep-slope Assembly Testing at ORNL *Deliverables:* • Whole-Building Energy Model ValidationPresentation at the Pacific Coast Builders ConferenceSteep Slope Assembly Test Report	6/1/02	10/1/02	10/1/05		55%
2.6.4	Product Useful Life Testing *Deliverables:* • Solar Reflectance Test Report	5/1/04	5/1/04	6/1/05		2%
2.7	Technology transfer and market plan					
2.7.1	Technology Transfer *Deliverables:* • Publication of results in industry magazines and refereed journal articles • Participation in buildings products exhibition, such as the PCBC Brochure summarizing research results and characterizing the benefits of cool colored roofing materials	6/1/03	6/1/02	6/1/05		~ 30%
2.7.2	Market Plan *Deliverables:* • Market Plan(s)	5/1/05		6/1/05		
2.7.3	Title 24 Code Revisions *Deliverables:* • Document coordination with Cool Roofs Rating Council in monthly progress reports • Title 24 Database	6/1/02	5/16/02	6/1/05		~ 10%

Project Tasks and Schedules (contd.)

Task	Task Title	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 05/31/2004
VII	Critical Project Review(s) *Deliverables:* • Minutes of the CPR meeting					
XII (C)	Monthly Progress Reports *Deliverables:* • Monthly Progress Reports	6/1/02	6/1/02	6/1/05		64% (23/36)
XII (D)	Final Report *Deliverables:* • Final Report Outline • Final Report	3/1/05		10/1/05		
	Final Meeting *Deliverables:* • Minutes of the CPR meeting	10/15/05		10/31/05		