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

A summary of the status of Tasks and Deliverables as of April 30, 2004 is presented in Attachment 1.

HIGHLIGHTS

- We have begun downloading field data from the A-style and C-style homes having roofs with standard brown color. Homes with cool roofs are expected online soon.
- We are collaborating with a Japanese scientist visiting LBNL's Heat Island Group to identify and characterize cool pigments produced by Japanese firms.
- We continue to work with tile, granule, and shingle manufacturers to develop cooler products. Our recent efforts have focused on increasing granule and shingle reflectance, with particular attention to helping manufacturers produce cool shingles for a demonstration site in colors that match conventional (hot) shingles.
- John Goveia and Phil Dregger of Technical Roof Services have offered their respective homes to demonstrate cool-colored asphalt shingles and wood shakes. Goveia's home has composition shingles and Dregger has a wood shake roof. Both individuals have approached neighbors who are willing to participate in testing pairs of homes in shingle and wood shake roofing.

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

Minutes of the March 4 meeting were prepared.

2.4 Development of Cool Colored Coatings2.4.1 Identify and Characterize Pigments with High Solar Reflectance

Our two papers on pigments (also online at <http://CoolColors.LBL.gov>) are undergoing peer review prior to submission to a journal. We expect to revise and submit the papers in June.

We are collaborating with a Japanese scientist visiting LBNL's Heat Island Group to identify and characterize cool pigments produced by Japanese firms. One such pigment identified is an inorganic black that appears to perform at least as well as previously characterized mixed-metal oxides.

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 Materials2.5.1 Review of Roofing Materials Manufacturing Methods

(No activity.)

2.5.2 Design Innovative Methods for Application of Cool Coatings to Roofing Materials

Our activities this month focused on development of cool shingles. We evaluated 35 prototype shingles made with cool granules, and also examined shingles that use conventional (hot) granules, but are sprayed with a cool topcoat. We noted that multiple spectrometer measurements are required to properly characterize the reflectance of shingles with variegated surfaces (e.g., blends).

We also examined wood shake products that have been coated with cool paints.

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

Several new parties are interested in working with us to demonstrate cedar shake shingles and composition shingles with cool colored pigments. John Goveia of Technical Roof Services has offered his own home for the study of wood shakes and has convinced an adjacent neighbor to also install new wood shakes. John lives in Martinez, CA and has a weather station next to his home. However, Goveia wants assurance that the cool colored roofing materials have no unfavorable effect on fire resistance.

Phil Dregger of Technical Roof Services is interested in offering his house for demonstrating composition shingles. Stephen Daues works with the Mercy Housing regional office in Sacramento. He is building a complex in El Dorado Hills that has the

potential for at least one cool roof manufacturer demonstration. The new construction site offered by Daues may be a better opportunity than the offer from Dregger. The complex is well underway with construction of 11 apartment buildings. The buildings are 6000, 6500 and 7000 square feet, 2 story dwellings. We will need product by June 1st for two of the 6000 square foot buildings. One or two buildings will be roofed every few weeks starting around the end of May 2004. The smaller buildings require about 80 squares and the larger 7000 square foot building will need about 142 squares (the required roofing material is disproportional to the roof area because of design differences). Daues stated we could have more than two roofs, if we have product with and without cool colored pigments of the same color. To finalize the agreement we need products for Daues to view and make a selection. Daues said he would welcome demonstrating shingles from GAF, Elk and CertainTeed on six units! W. Miller will meet with Daues and visit the field site while in California in May.

However, there are important questions that we cannot answer until the shingle manufacturers' step up to the table and provide us with some products and technical support. Attachment 2 contains a communication from Phil Dregger that shows the range of issues that need to be resolved regarding colors, cost and warranties.

2.6.1 Building Energy-Use Measurements at California Demonstration Sites

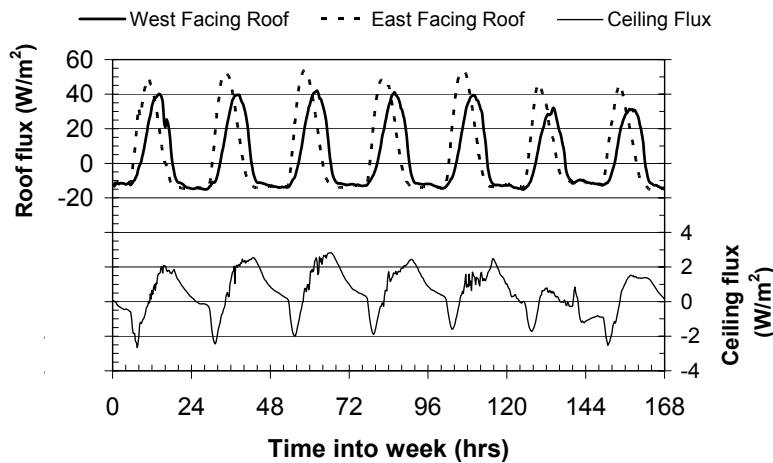
On May 13, ORNL personnel will install a data acquisition system and connect instrument wiring for the fourth demonstration house provided the stucco crews have finished the exterior surfaces of the home. Rinkydink Builders installed Custom-Bilt Metals "ultra-cool" painted metal shake on the fourth home, and will help us repair and attach thermocouples for measuring the surface temperature of the "ultra cool" metal shake roof.

We have begun downloading field data from the A-style and C-style homes having roofs with standard brown color. Figure 1 displays the roof and ceiling heat flux for a full week starting on April 23, 2004; multiples of 24 on the abscissa represent midnight for each successive day. The A-style house with concrete tile on battens has its roof ridge oriented north south, so the recorded fluxes are for east and west facing roof sections. The irradiance from the rising sun is incident first on the east-facing roof and later strikes the west roof. Therefore, the flux hitting the east roof leads that measured on the west roof (Fig. 1a) with the peak flux occurring about 3 hours earlier than that seen for the west-facing roof. Notice the consistency of the data as seen by the nearly identical readings during the late evening hours around midnight. The ceiling heat flux is a minimum around 8 am and peaks at about 7 pm. The houses have insulated concrete form (ICF) walls, and the thermal mass of the walls is delaying the occurrence of peak flux penetrating into the house from the walls and roof. The ceiling flux remains positive (meaning heat penetrates into the house) from about noon until about 1 am for the first five days of the week (Fig. 1a).

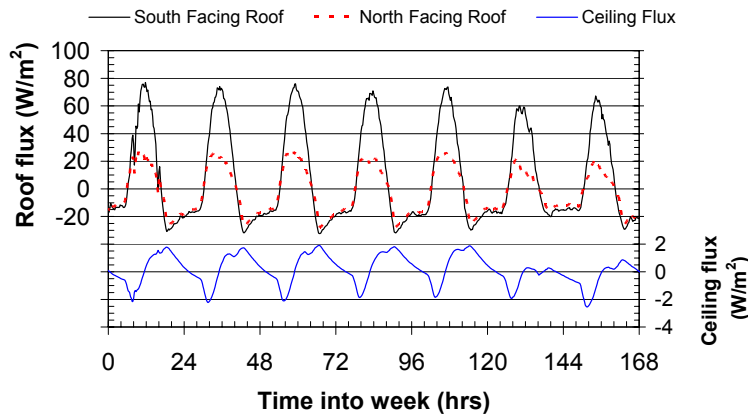
Results for the C-style house differ from those for the A-style home because the ridge is oriented east west and the painted metal roofs face almost directly north and south. The heat flux penetrating the south facing roof is therefore significantly higher than that observed on the north roof because the south roof is almost normal to the sun's incident rays while the north roof receives mostly diffuse radiation (Fig. 1b). The ceiling flux is a minimum at about 8 am and peaks around 7 pm. Observe that the ceiling flux penetrates

into the conditioned space from about noon until midnight (Fig. 1b), which indicated the need of comfort cooling from the air-conditioning system.

Pyranometer measurements of the solar irradiance are not yet available because we waited for Joe Riley to apply the topcoat finish to the third house with concrete tile. House and HVAC power measurements are not online either; we are still waiting for SMUD to install the power meters.



a). A-style home with Hanson's tile having standard chocolate brown color (R08E83)



b). C-style home with Custom-Bilt Metal's Country Manor Shake having standard brown color (R08E83)

Figure 1. Heat flows measured through the roof and ceiling for a) the A-style home with concrete tile (ridge running north and south), and b) the C-style home with painted metal shakes (ridge running east and west).

2.6.2 Materials Testing at Weathering Farms in California

Joe Riley of American Roof Tile Coatings and ORNL personnel will visit the exposure sites in May, make reflectance and emittance measurements and install concrete and clay tile samples prepared by US Tile, MonierLife Tile and Shepherd Color Co and by Joe Riley.

We developed a file of current weather data from the California Irrigation Management Information Systems (CIMIS) database. The current weather data for the seven CA climatic zones will be used to estimate the effects of climate on the loss of reflectance for the roof samples.

2.6.3 Steep-slope Assembly Testing at ORNL

The Cool Metal Roof Coalition (CMRC) requested information on the energy benefits of cool colored pigments applied to polyvinylidene fluoride (PVDF) metal roofing. They asked ORNL to run simulations for Florida, Texas, Vermont and Colorado climates for a house having both soffit and ridge venting. Roof slope was set at 18.4° and the ridge vent was oriented east-west. To estimate the energy savings for these climates we ran our code AtticSim based on two scenarios:

1. energy savings for cool colored metal products already on the open market, and
2. energy savings for products achieving an ultimate reflectance goal of 0.60.

The CMRC provided measures of reflectance and emittance of painted PVDF metal products with and without the cool colored pigments.

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

Project staff provided information on our cool roofing project to Mr. John Bell, who is writing an article for Journal of Property Management. Also, circulating among the project team members are an article on "Cool Roof Colored Materials" for the upcoming ACEEE meeting, and "Special IR Reflective Pigments Make a Dark Roof Reflect Almost Like a White Roof," for the upcoming THERM IX meeting.

Levinson delivered a talk at LBNL summarizing our pigment characterization activities since 2001. The presentation is online at <http://CoolColors.LBL.gov>.

On April 23, Akbari and several industrial partners (Elk, MCA, Custom Bilt Metal, Certainteed, BASF, MonierLifetile, and American Rooftile Coatings) attended the meeting of Emerging Technology Coordinating Council and presented results and cool roofing materials for demonstration. Present at the meeting were representative from California utilities (PG&E, SCE, SGE, SDGE) and Chris Scruton and Nancy Jenkins from California Energy Commission.

2.7.2 Market Plan (No activity.)

2.7.3 Title 24 Code Revisions (No activity.)

Management Issues

- We are reviewing our project plan in response to the received comments at the PAC meeting.

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 04/30/2004
1	Preliminary Activities					
1.1	Attend Kick Off Meeting <i>Deliverables:</i> <ul style="list-style-type: none"> 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 <i>Deliverables:</i> <ul style="list-style-type: none"> 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 <i>Deliverables:</i> <ul style="list-style-type: none"> 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 <i>Deliverables:</i> <ul style="list-style-type: none"> 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 04/30/2004
2.3	<p>PAC meetings <i>Deliverables:</i></p> <ul style="list-style-type: none"> • 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	<p>Identify and Characterize Pigments with High Solar Reflectance <i>Deliverables:</i></p> <ul style="list-style-type: none"> • Pigment Characterization Data Report 	6/1/02	6/1/02	12/1/04		~92%
2.4.2	<p>Develop a Computer Program for Optimal Design of Cool Coatings <i>Deliverables:</i></p> <ul style="list-style-type: none"> • Computer Program 	11/1/03	11/1/03	12/1/04		~18%
2.4.3	<p>Develop a Database of Cool-Colored Pigments <i>Deliverables:</i></p> <ul style="list-style-type: none"> • Electronic-format Pigment Database 	6/1/03	7/1/03	6/1/05		~25%
2.5	Development of prototype cool-colored roofing materials					
2.5.1	<p>Review of Roofing Materials Manufacturing Methods <i>Deliverables:</i></p> <ul style="list-style-type: none"> • Methods of Fabrication and Coloring Report 	6/1/02	6/1/02	6/1/03		~95%
2.5.2	<p>Design Innovative Methods for Application of Cool Coatings to Roofing Materials <i>Deliverables:</i></p> <ul style="list-style-type: none"> • Summary Coating Report • Prototype Performance Report 	6/1/02	6/1/02	12/1/04		~70%
2.5.3	<p>Accelerated Weathering Testing <i>Deliverables:</i></p> <ul style="list-style-type: none"> • 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 04/30/2004
2.6	Field-testing and product useful life testing					
2.6.1	Building Energy-Use Measurements at California Demonstration Sites <i>Deliverables:</i> <ul style="list-style-type: none"> Demonstration Site Test Plan Test Site Report 	6/1/02	9/1/02	10/1/05		72%
2.6.2	Materials Testing at Weathering Farms in California <i>Deliverables:</i> <ul style="list-style-type: none"> Weathering Studies Report 	6/1/02	10/1/02	10/1/05		55%
2.6.3	Steep-slope Assembly Testing at ORNL <i>Deliverables:</i> <ul style="list-style-type: none"> Whole-Building Energy Model Validation Presentation at the Pacific Coast Builders Conference Steep Slope Assembly Test Report 	6/1/02	10/1/02	10/1/05		53%
2.6.4	Product Useful Life Testing <i>Deliverables:</i> <ul style="list-style-type: none"> Solar Reflectance Test Report 	5/1/04		6/1/05		
2.7	Technology transfer and market plan					
2.7.1	Technology Transfer <i>Deliverables:</i> <ul style="list-style-type: none"> 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		~ 20%
2.7.2	Market Plan <i>Deliverables:</i> <ul style="list-style-type: none"> Market Plan(s) 	5/1/05		6/1/05		
2.7.3	Title 24 Code Revisions <i>Deliverables:</i> <ul style="list-style-type: none"> 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 04/30/2004
VII	Critical Project Review(s) <i>Deliverables:</i> <ul style="list-style-type: none"> Minutes of the CPR meeting 					
XII (C)	Monthly Progress Reports <i>Deliverables:</i> <ul style="list-style-type: none"> Monthly Progress Reports 	6/1/02	6/1/02	6/1/05		64% (23/36)
XII (D)	Final Report <i>Deliverables:</i> <ul style="list-style-type: none"> Final Report Outline Final Report 	3/1/05		10/1/05		
	Final Meeting <i>Deliverables:</i> <ul style="list-style-type: none"> Minutes of the CPR meeting 	10/15/05		10/31/05		

Attachment 2
Questions asked by Phil Dregger of Technical Roof Services.

Bill - as we discussed, I am quite interested in participating in your program to monitor and compare the thermal performance of steep roof materials with experimental pigments to increase reflectance. However, to make a meaningful decision to participate or not, I need some clarification about what exactly your program requires and offers. Some example questions follow regarding asphalt shingles:

- **Shingles** - I assume the paired homes must agree to install the same new asphalt shingles. But what brand (Elk, Certainteed, GAF), type (three-tab, laminated, etc.), and color (brown, black, gray, green, etc.) of shingles can the homeowners choose from? I currently have charcoal gray/black, heavy laminated shingles by Elk.
- **Costs** - I understand the program offers to provide and install new asphalt shingle roofs at no cost to the homeowners? Please confirm that this offer includes ancillary costs such as for building permits and required flashings (side walls, chimneys, skylights, etc.). Will the program commit to replacing/repairing any existing landscaping that is damaged as part of the reroofing operations? Will the program pay for installing roof deck sheathing if the home currently has spaced sheathing (e.g., an existing wood shake roof)?
- **Warranties/Guarantees** - Most shingles come with limited manufacturer's materials warranties but what about labor guaranties? Will the program offer 2 or 3 year contractor labor guaranties? Who selects the roof contractor? Can the homeowner be provided with a list of two or three contractors and make the final selection?