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

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

HIGHLIGHTS

- On January 23, 04 in Houston, Akbari gave a presentation on colored cool roofs and heat-island technologies in the “Rebuilding the unity of health and the environment: The Greater Houston Metropolitan Area” workshop sponsored by the Institute of Medicine’s Roundtable on Environmental Health Sciences, Research, and Medicine.
- On January 23, 04 in Houston, Akbari and Mayor Bill White of Houston discussed development of a cool-roof/ heat-island reduction program for Houston.
- On January 24 and 27, 04 at the ASHRAE Anaheim meeting, Akbari and Desjarlais organized two ASHRAE seminars on “California PIER program: Energy efficiency innovations” and “Advances in Cool Roofing,” respectively.
- We continue to work with tile, granule, and shingle manufacturers to develop cooler products, focusing this month on (a) cool glazes for clay tiles, (b) cool acrylic coatings for concrete tiles, and (c) coatings for granules.
- The Four Seasons Construction Co. decided not to allow ORNL and LBNL to demonstrate cool-colored asphalt shingles on their development in Sacramento.

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
Planning for March 4, 2004 PAC meeting started. A draft agenda was prepared and distributed to PAC members.
- 2.4 Development of Cool Colored Coatings
 - 2.4.1 Identify and Characterize Pigments with High Solar Reflectance
We are using measurements of the optical properties of tints (mixtures of colors with white) to develop a model predicting the performance of mixtures. We continue to revise our pigment characterization draft paper, and hope to complete it in February.
 - 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
(No activity.)
 - 2.5 Development of Prototype Cool-Colored Roofing Materials
 - 2.5.1 Review of Roofing Materials Manufacturing Methods
We are still working to arrange a visit to a cedar shake roof-manufacturing plant.
 - 2.5.2 Design Innovative Methods for Application of Cool Coatings to Roofing Materials
We continue to work with tile, granule, and shingle manufacturers to develop cooler products, focusing this month on coatings for granules. We have characterized the performance of both homogenous (single granule color) and heterogeneous (multiple granule colors) shingles from several manufacturers, and have used these results to suggest further recipes for granule coatings.
 - 2.5.3 Accelerated Weathering Testing
Akbari discussed with our industrial partners the development of a plan for accelerated testing of cool colored materials.
- 2.6 Field-Testing and Product Useful Life Testing
The Four Seasons Construction Co. decided not to proceed with ORNL and LBNL in demonstrating cool-colored asphalt shingles. We are approaching the marketing departments of the shingle manufacturers who are PAC members in hopes of attracting other homebuilders.
 - 2.6.1 Building Energy-Use Measurements at California Demonstration Sites
ORNL shipped two instrumented sandwich panels to Evans Construction. Each panel contains calibrated thermometry and a heat flux transducer for monitoring temperatures and heat flow through the north and south-facing roofs of the fourth demonstration home. Construction crews will cut the panels into the roof deck once the roof framing is finished. ORNL personnel have scheduled the first week of March to complete setup of

the data acquisition system for the first three homes and to run wiring for the second C style house. However, Mike Evans stated that inclement weather continues to delay framing of the fourth house. Therefore, we may be working on the homes after the PAC meeting scheduled the first week in March.

ORNL will coordinate Joe Riley's work for applying a topcoat finish with cool-colored coatings to one of the two installed tile roofs. Riley will complete the work while ORNL personnel are working at the demonstration site provided the weather is clear and the ambient air temperature stays above 50°F. Wim Boss of SMUD will scheduled use of a high lift for helping to install a weather station atop the roof of the C-style home located second from left as you turn into Cavalli Hills.

2.6.2 Materials Testing at Weathering Farms in California

The William Harrison Corp. received an order for additional "sure grip" sub-assemblies for placing additional concrete and clay tile samples in the exposure rack sets located in seven different CA climate zones.

2.6.3 Steep-slope Assembly Testing at ORNL

Simulations calculating variable ventilation rates in attics with both soffitt and ridge vent openings were made using AtticSim. Using a constant ventilation rate is the simplest approach to simulating attic heat flows. However, thermal buoyancy can affect the surface temperatures of the attic enclosure, which in turn affects the radiosity heat exchanges in the enclosure. We implemented an algorithm in AtticSim to account for the time-dependent temperature driven buoyancy and wind driven forces driving attic ventilation (contact W. Miller for further details).

We simulated an attic with R-19 h•ft²•°F/Btu ceiling insulation, ridge oriented east-west, roof slope of 4-in of rise per 12-in of run and with fixed ventilation rates of 2.4, 0.5 and 0.0 air changes per hour (ACH). We also ran a variable ventilation simulation for comparison against results for the fixed rates. Increasing the ventilation from no air exchange to a variable rate having an annual average of 2.9 ACH caused the ceiling heat flux to drop 12% of the heat flow simulated in the sealed attic. Highest attic air temperature occurs with the sealed attic, Figure 1. Increasing the air exchange dropped the bulk attic temperature, which makes good physical sense. The greater the air exchange in the attic the less will be the thermal storage of heat. Parker, Fairey and Gu (1991) measured attic ventilation rates using short term sulfur hexafluoride tracer gas. Their results under normal summer wind and thermal conditions in Cape Canaveral, Florida yielded an average of 2.7 ACH over a three-day period with variation from 0.5 to 4.5 ACH. Therefore, the variable ventilation flow yielding an annual average 2.9 ACH (Fig 1) is realistic. The variable ventilation flow had variations from 0.2 to 10 ACH. Therefore, the code appears consistent with literature data, and will be further formulated and validated against data acquired from the demonstration homes.

References:

Parker, D.S., Fairey, P.W., and Gu, L. 1991. "A Stratified Air Model for Simulation of Attic Thermal Performance," pp. 44-69, *Insulation Materials: Testing and Applications*, 2nd Volume, ASTM STP 1116, R.S. Graves and D.C. Wysocki, Eds. Philadelphia, PA: American Society for Testing and Materials.

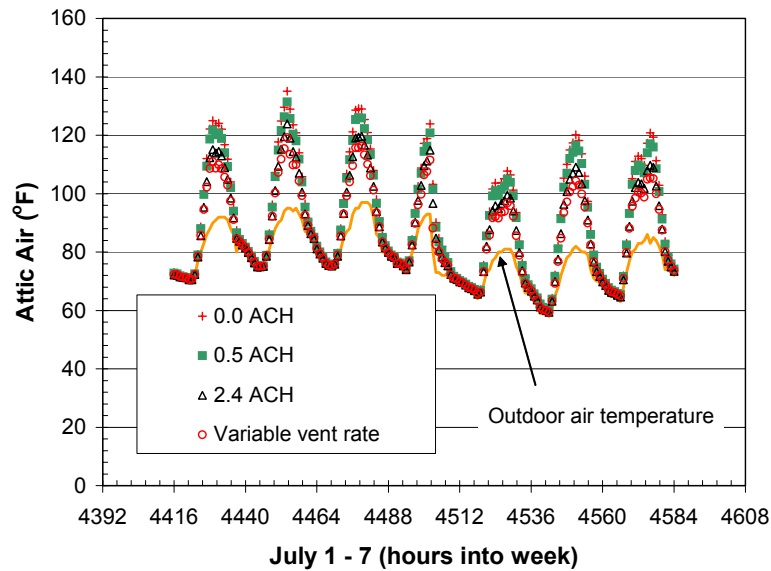


Figure 1. Attic air temperature calculated for several different ventilation rates.

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

On January 23, 04 in Houston, Akbari gave a presentation on colored cool roofs and heat-island technologies in the “Rebuilding the unity of health and the environment: The Greater Houston Metropolitan Area” workshop sponsored by the Institute of Medicine’s Roundtable on Environmental Health Sciences, Research, and Medicine.

On January 23, 04 in Houston, Akbari and Mayor Bill White of Houston discussed development of a cool-roof/ heat-island reduction program for Houston.

On January 24, 04 at the ASHRAE Anaheim meeting, Akbari and Jenkins (absentee) chaired an ASHRAE seminar on “California PIER program: Energy efficiency innovations.” At the same seminar, Akbari made a presentation titled “Cool Roof Colored Materials.”

On January 27, 04 at the ASHRAE Anaheim meeting, Desjarlais chaired an ASHRAE seminar on “Advances in Cool Roofing.” The seminar covered the following topics: Desjarlais, “Simplified tools to estimate energy savings of roofing systems;” Loyer (from Ferro), “How color pigments can save energy;” Nixon (Shepherd Color), “Advances in infrared blocking pigment technologies;” Kriner (Metal Construction Assoc.), “Energy efficiency, durability, and sustainability of metal roofs;” and Turnbull (PG&E), “Implications of California’s new energy code on the use of cool roofing.”

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 01/31/2004
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 01/31/2004
2.3	PAC meetings <i>Deliverables:</i> <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		50% (3/6)
2.4	Development of cool colored coatings					
2.4.1	Identify and Characterize Pigments with High Solar Reflectance <i>Deliverables:</i> <ul style="list-style-type: none"> • Pigment Characterization Data Report 	6/1/02	6/1/02	12/1/04		~75%
2.4.2	Develop a Computer Program for Optimal Design of Cool Coatings <i>Deliverables:</i> <ul style="list-style-type: none"> • Computer Program 	11/1/03	11/1/03	12/1/04		~5%
2.4.3	Develop a Database of Cool-Colored Pigments <i>Deliverables:</i> <ul style="list-style-type: none"> • Electronic-format Pigment Database 	6/1/03	7/1/03	6/1/05		~15%
2.5	Development of prototype cool-colored roofing materials					
2.5.1	Review of Roofing Materials Manufacturing Methods <i>Deliverables:</i> <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	Design Innovative Methods for Application of Cool Coatings to Roofing Materials <i>Deliverables:</i> <ul style="list-style-type: none"> • Summary Coating Report • Prototype Performance Report 	6/1/02	6/1/02	12/1/04		~35%
2.5.3	Accelerated Weathering Testing <i>Deliverables:</i> <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 01/31/2004
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		55%
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		40%
2.6.3	Step-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		35%
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		~ 10%
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 01/31/2004
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		56% (20/36)
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		

