SUMMARY REPORT

Background

The U.S. Department of Energy's (DOE) Building Technologies Program (BTP) supports the research and development of technologies that reduce buildings' energy consumption through programs such as the Building Envelope and Windows Research and Development (R&D) Program. Within the Building Envelope and Windows R&D Program, advances in building envelope technologies offer many opportunities for energy conservation. DOE regularly holds both a Building Technology Stakeholder Engagement Workshop in order to inform stakeholders of current DOE projects and gathers stakeholder feedback to help assess its current projects/technologies and to aid in advising the prioritization of future projects. This meeting was called specifically for activities within the Building Envelope R&D Program. A list of invited stakeholders is located in the Appendix of this report.

The purpose of this Stakeholder Engagement Workshop is to document the input received regarding the DOE Building Envelope R&D Program in regard to possible future directions of the program. The DOE appreciates receiving input based on our stakeholders' personal experience, individual advice, information, or facts regarding this topic. It is not the object of this stakeholder plan to document or indicate any group position or consensus. Rather, it was the Department's object to seek as many recommendations as possible from all individuals at the Building Envelope R&D Program Stakeholder Engagement meeting.

Meeting Objectives/Purpose

1. To provide DOE's Building Envelope R&D Program stakeholders with an overview of the program's goals, research agenda, and current R&D activities.
2. To seek stakeholder feedback on DOE Building Envelope Technology R&D priorities in order to:
    a. Advise program direction
    b. Identify other areas of importance to consider in R&D focus
3. To provide an opportunity for stakeholders to interact and form partnerships for possible future collaborations.

I. Opening Remarks

Walt Zalis brought the meeting to order and welcomed participants at 1:00 p.m. He thanked those in attendance for their interest and work in the Building Envelope R&D Program and went over the objectives for the meeting. He also discussed the expected outcomes:

- A report that will advise future Building Envelope R&D Program priorities
- Potential new R&D focus areas for consideration

Mr. Zalis then shared the ground rules for the meeting with the participants:

- Time is limited—please be brief and to the point.
- With limited time, our goal is to gather new input. There is no time to fully resolve differences of opinion and perspective.
- Please, only one speaker at a time.
- Please note your questions on the back of your packet. If time does not permit, any unanswered questions will be collected and followed up on via email.
- Please return to the meeting on time following our 15 minute break. We will need to start work within our breakout groups as soon as possible.

II. Presentations

Alexis Abramson, the Emerging Technology Program Manager for the DOE Building Technologies Program, provided the first of five opening presentations. Researchers then followed with presentations on projects in a number of different technology areas including advanced insulation, advanced roof coatings and phase change materials. A brief overview of each presentation is provided in Table 1.

Table 1. Building Envelope Workshop Presentations

Presentation	Presenter	Project Purpose/Technical Objective
		OPENING PRESENTATIONS
Strategic Analysis of Emerging Technologies – Envelope	Alexis Abramson, DOE	An introduction to the Building Envelope Prioritization Tool, which aims to provide an objective comparison of new and existing technologies/measures. It estimates potential energy savings and costs of conserved energy using a widely accepted methodology and validated sources of input.
Overview of Envelope R&D Program Presentation	Marc LaFrance, DOE	An overview of current Building Envelope R&D Program projects. This workshop seeks input from stakeholders on envelope R&D to assess current projects and provides an opportunity to provide input on high priorities.
Overview of Oak Ridge National Laboratory (ORNL) Building Envelope Activities	Andre Desjarlais, ORNL	Envelope R&D at ORNL focuses on roofs and attics, cool roofs, vacuum insulation panels, and advanced insulations (insulation research, air barriers, phase change materials [PCMs], and foundations).
Cool Roof Activities at Lawrence Berkeley National Laboratory (LBNL)	Ronnen Levinson, LBNL	The LBNL Heat Island Group works on advanced surfaces, California roof reflectance, Cool Communities, global cooling of India, next-gen materials, and the United States-China Clean Energy Research Center-Building Energy Efficiency consortium.
International Energy Agency (IEA) Technology Roadmap – Buildings Envelope	Nathalie Trudeau, IEA	Collaboration with stakeholders to define and analyze available technologies; develop a vision for technology deployment; and assess policy, financial, and related needs.
		ADVANCED INSULATION PERFORMER PRESENTATIONS
Contributing to Net Zero Building: Highly Energy Efficient EIFS Wall Systems	Aaron Seitz, Dow Corning	To develop a wall system that integrates vacuum insulation technology with the Exterior Insulated Façade System (EIFS) to deliver a commercially viable wall system up to R-40.
Advanced Insulation for High Performance Cost-Effective Wall, Roof, and Foundation Systems	Stéphane Costeux, Dow Chemical	To explore and develop high-performing insulation with: • Increased R/inch, with a target of >7.5/inch, with little or no loss over time • Low impact on environment, utilizing no HCFCs or (HFCs) (mainly CO_2) • Good fire performance (target class A)

Affordable Super Building Insulation by CO_2 Foaming Process	Arthur Jing-Min Yang, Industrial Science & Technology Network, Inc.	An affordable super building insulation by CO_2 foaming process without HFCs and with higher R value.
ADVANCED ROOF COATINGS PERFORMER PRESENTATIONS		
Bio-Based Thermochromic Intelligent Roof Coating	Ben Wen, United Energy & Environment (presented by DOE)	To develop and demonstrate a waste-cooking-oil-based thermochromic smart roof coating technology that can autonomously respond to temperature changes by adjusting the light transmission.
Nano-Enabled TiO_2 UV Protective Layer for Cool-Color Roofing Application	King Wang, Nanotrons	Optimize and scale up SiO_2-coated TiO_2 (SiO_2 @TiO_2) nanocrystal synthesis and functionalization in aqueous solution to formulate 10 gallon waterborne clear UV protective nanocomposite coating material. Evaluate developed coatings on aluminum for cool roof applications. Establish environmental requirements for the proposed UV protective coatings.
Global Cool Cities Alliance (GCCA)	Kurt Shickman, GCCA (presented by DOE)	GCCA is dedicated to advancing policies and actions that increase the solar reflectance of buildings and pavements as a cost-effective way to promote cool buildings and cool cities, and to mitigate the effects of climate change through global cooling.
PHASE CHANGE MATERIALS PERFORMER PRESENTATIONS		
Shape-Stable and Highly Conductive Nano-Phase-Change Materials	Jue Lu, Technova Corporation (presented by DOE)	Develop a new thermal energy storage (phase-change) material that complements high heat storage capacity with desired shape stability, durability, thermal conductivity, scalability, economy, sustainability, and versatility for use toward enhancing the energy efficiency of buildings and other systems.
Development of Low-Cost, Bio-Based Phase Change Material for Building Envelopes	Ramin Abhari, Syntroleum Corporation	Develop a manufacturing process that achieves step-reduction in cost of PCMs for building envelopes

III. Workshop Presentation Stakeholder Feedback

Participants were asked to rate the importance and value of the project within each of the workshop presentations given. The average rating for each project is listed in Table 2.

Table 2. Workshop Presentation Stakeholder Feedback

Presentation/Project	Presenter	Average Rating
Strategic Analysis of Emerging Technologies – Envelope	Alexis Abramson, DOE	4.38
Overview of Envelope R&D Program	Marc LaFrance, DOE	4.55

Presentation		
Overview of ORNL Building Envelope Activities	Andre Desjarlais, ORNL	4.70
Cool Roof Activities at LBNL	Ronnen Levinson, LBNL	4.21
International Energy Agency Technology Roadmap – Buildings Envelope	Nathalie Trudeau, IEA	3.67
Contributing to Net Zero Building: Highly Energy Efficient EIFS Wall Systems	Aaron Seitz, Dow Corning	3.94
Advanced Insulation for High Performance Cost-Effective Wall, Roof, and Foundation Systems	Stéphane Costeux, Dow Chemical	4.03
Affordable Super Building Insulation by CO_2 foaming process	Arthur Jing-Min Yang, Industrial Science & Technology Network, Inc.	3.48
Bio-Based Thermochromic Intelligent Roof Coating	Ben Wen, United Energy & Environment	3.43
Nano-Enabled TiO_2 UV Protective Layer for Cool-Color Roofing Application	King Wang, Nanotrons	3.52
Global Cool Cities Alliance (GCCA)	Kurt Shickman, GCCA	3.86*
Shape-Stable and Highly Conductive Nano-Phase-Change Materials	Jue Lu, Technova Corporation	3.47
Development of Low-Cost, Bio-Based Phase Change Material for Building Envelopes	Ramin Abhari, Syntroleum Corporation	3.47

1 = very low, 2 = low, 3 = undecided, 4 = high, 5 = very high
**Due to late entry, this presentation only had seven respondents.*

Workshop Comments on Stakeholder Presentations

- Address the modeling, measurement and verification, and product testing needs for each technology area presented.
- Include more application-oriented research.
- Include the following technology areas in future BTP workshops: retrofits, specialty insulation, and air movement within buildings.
- Emphasize the distinction between current and future technologies throughout the workshop.
- One participant noted that, while the presentations focused on future technologies, the breakout discussions focused on barriers to the use of current technologies.
- To reduce barriers to easy adoption of new technology, the U.S. government should permit more trials of new products on its buildings.

IV. DOE's Building Envelope Research Portfolio Feedback

Participants evaluated DOE's Building Envelope Research Portfolio by rating each project on the following criteria:

- The importance of the research presented
- The appropriateness of DOE's role in supporting the research
- The relevance of the research to industry's needs

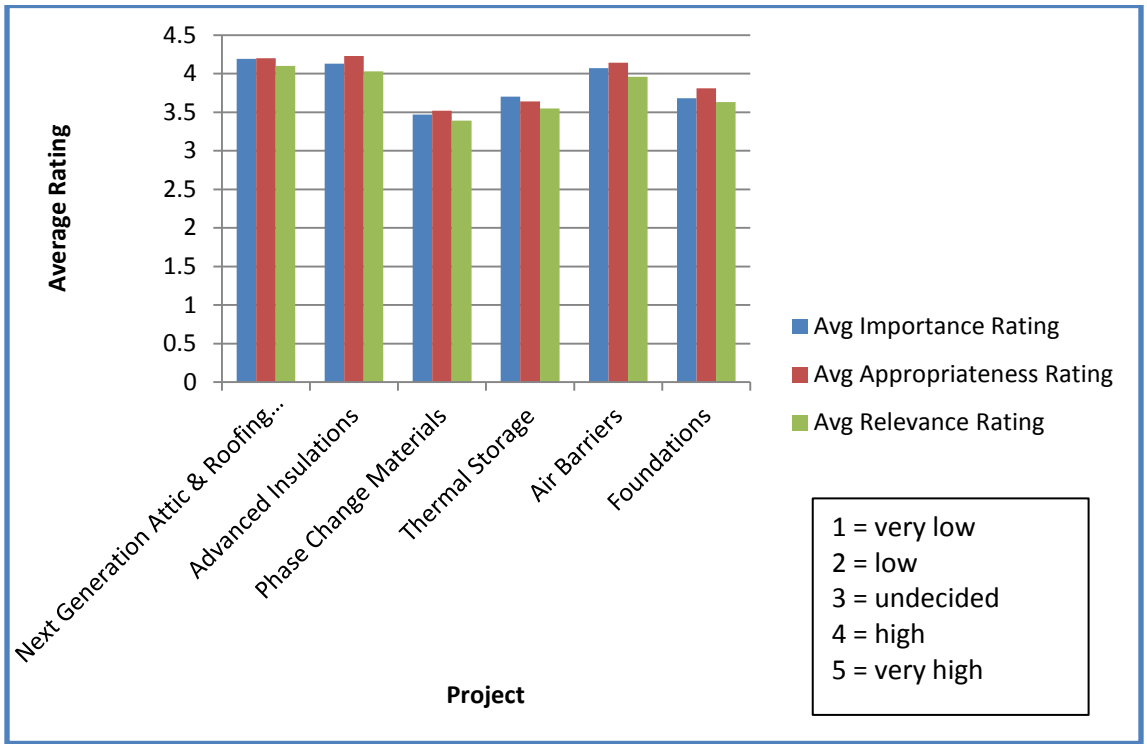
Average ratings on the importance, appropriateness, and relevance of each technology area are depicted in Table 3 and Figure 1.

Table 3. U.S. Department of Energy Building Envelope Research Portfolio Feedback

Technology	Average Importance Rating	Average Appropriateness Rating	Average Relevance Rating
Next Generation Attic and Roofing Systems	4.19	4.20	4.10
Advanced Insulations	4.13	4.23	4.03
Phase Change Materials	3.47	3.52	3.39
Thermal Storage	3.70	3.64	3.55
Air Barriers	4.07	4.14	3.96
Foundations	3.68	3.81	3.63

1 = very low, 2 = low, 3 = undecided, 4 = high, 5 = very high

Figure 1. U.S. Department of Energy's Building Envelope research portfolio: average ratings



V. DOE Expert Meeting Feedback

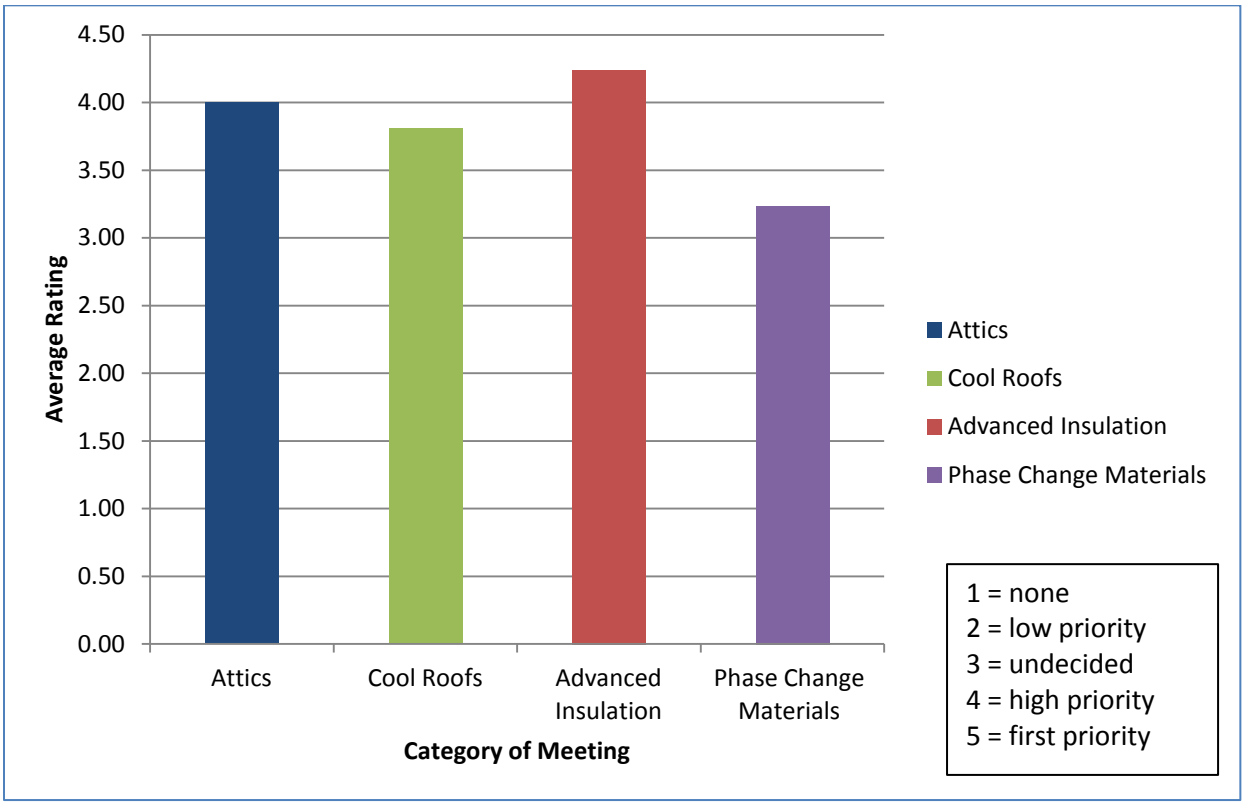
Participants ranked proposed building envelope technology expert meeting topics based on priority. As Table 4 and Figure 2 illustrate, participants rated the proposed advanced insulation expert meeting as the highest priority and the phase change materials expert meeting as the lowest.

Table 4. U.S. Department of Energy Building Envelope R&D Expert Meeting Feedback

Possible Meeting	Average Priority Rating
Attics	4.00
Cool Roofs	3.81
Advanced Insulation	4.24
Phase Change Materials	3.23

1 = none, 2 = low priority, 3 = undecided, 4 = high priority, 5 = first priority

Figure 2. Priority for possible DOE-hosted Building Envelope R&D technical/policy expert meetings



Stakeholder recommendations: Topics for future expert meetings

- Air barriers

VI. Meeting Logistics

Stakeholders evaluated the logistics of this and future workshops:

- Meeting length: 55% of respondents stated the workshop was of appropriate length, but another 42% desired a longer meeting.
- Meeting frequency: 53% of respondents prefer annual meetings; 26% desired semiannual meetings; and the remaining 21% prefer biannual meetings.
- Program communications: The average rating for the effectiveness of program communications was a 3.80, based on a scale of 1 (poor) to 5 (very good).

Stakeholder Recommendations: Program Communications

- Send out more news items, announcements, and updates via email.
- Conduct a public awareness campaign/outreach at the grassroots level.
- Place more emphasis on expert meetings.
- Participate in trade shows.
- Attend stakeholders' annual meetings.

VII. Workshop Breakout Groups

For the second half of the workshop, participants were asked to participate in five pre-determined breakout groups to identify objectives, problems, barriers, tasks, outcomes, and potential partnerships for various building envelope technology areas (advanced insulation, moisture analysis, air leakage, cool roofs/unvented attics, and slab edge/below grade modeling). The results of those breakout groups are listed in Tables 5–9.

Table 5. Topic 1: Advanced Insulation/Phase Change Materials Resistance

Focus Area	Stakeholder Feedback
Objectives	• Increase thermal mass cost effectively • Reduce energy use insulation thickness
Problems We Need to Solve	• Code acceptance • Unknown lifetime • Impact on variable environment • Customer motivation
Barriers	• Risks for early AEC • Cost (especially retrofit) • Location-specific needs
Tasks	• Increase energy prices • Test method development • Product development • Standard models • Develop guidelines
Desired Outcomes	• Reduce cost/risks
Potential Partnerships	• Europe • Use government buildings as an example • Code authorities

Table 6. Topic 2: Moisture Analysis

Focus Area	Stakeholder Feedback
Objectives	• Design methodology for moisture-tolerant and durable systems
Problems We Need to Solve	• Understanding consequences of imperfections • Multiple intersections of materials, products, trades, and time sequences • Understanding severe exterior and interior weather effects
Barriers	• Lack of good (and bad) two-dimensional and three-dimensional solutions • New and more complicated systems increase unknowns and risk of failure • Desire for prescription versus performance • Models address only perfect systems
Tasks	• Benchmarking of building/components needs to include faulty operation of systems, assemblies, components, and intersections
Desired Outcomes	• Methodology to model and evaluate imperfections

	• Methodology to determine drying time before material failure
Potential Partnerships	• N/A

Table 7. Topic 3: Air Leakage

Focus Area	Stakeholder Feedback
Objectives	• Eliminate leaks in buildings
Problems We Need to Solve	• Stop energy loss from leakage and associated moisture issues
Barriers	• Too many trades affect air leakage • Training and technical education • Research on where leaks are • Design tools and diagnostics • Durability • Climate zone • Integrated system approach
Tasks	• Develop simpler and low-cost system • Curriculum and certification • Monitoring • Field studies • Professional tool kit
Desired Outcomes	• Better design phase modeling • Eliminate air leakage • New and existing residential and commercial demonstrations • Standards and protocol • Stricter codes • Stage monitoring methods
Potential Partnerships	• Utilities • Government • Manufacturers • Trade associations

Table 8. Topic 4: Cool Roofs/Unvented Attics

Focus Area	Stakeholder Feedback

Objectives	• Cool roofs:
	  o "Super cool" roofs
	  o Climate specific assemblies
	  o Durability/service life
	  o Retention of reflectiveness
	• Unvented attics:
	  o Moisture control
	  o Cost of sealed attics
	  o No hydrothermal modeling tool

Problems We Need to Solve	• Education • Code enforcement (and codes) • Moisture

Barriers	• Code development • Technology • Market attraction/aesthetics
Tasks	• Within 5–10 years (commercial roof 15–20 year service life) • Development of accelerated aging program for roof membranes
Desired Outcomes	• Best practices/guidelines (not yet known—need research) • "Rating labels" (benefit)
Potential Partnerships	• Single Ply Roofing Industry • SFFA • Roof Coatings Manufacturers Association • Building Owners and Managers Association • National Roofing Contractors Association • National Association of Home Builders • Building Enclosure Technology and Environment Council/Building Enclosure Council • The Associated General Contractors of America • The Roof Assembly Ventilation Coalition

Table 9. Topic 5: Slab Edge/Below Grade Modeling

Focus Area	Stakeholder Feedback
Objectives	• Heat loss • Moisture load • Cost
Problems We Need to Solve	• Improve construction industry knowledge of how to build/retrofit a good foundation • Design basements for inevitable flooding (current materials are probably acceptable)
Barriers	• Modeling (thermal/moisture) • Testing • Instrumentation • Performance criteria
Tasks	• Develop measurement and modeling methods for sub-grade application
Desired Outcomes	• Updated building foundation design handbook (climate specific) • Better gutters/drainage
Potential Partnerships	• University of Minnesota • U.S. Department of Agriculture • U.S. Geological Survey • Big Ladder • NREL • ORNL • Building America • Weatherization Assistance Program

- University of Tennessee
- University of Illinois

VIII. Wrap-Up and Next Steps

Overall, this workshop has demonstrated that the Building Technologies Program is aligned with stakeholders as evidenced by their feedback. Based on both the presentation and portfolio feedback, stakeholders appear to be very interested in advanced insulation, advanced roof coatings, and next generation attics, but show less interest in phase change materials. One participant questioned whether phase change materials might actually increase the energy consumption when a building is operated inefficiently.

DOE will take the workshop feedback on the Building Envelope R&D portfolio into consideration for future program decisions, as well as follow up on recommendations of the breakout groups with future technology specific meetings. DOE will also investigate the logistics behind an advanced insulation expert meeting, with another expert meeting in the future concerning attics and cool roofs.

Finally, DOE will continue to hold stakeholders workshops on a yearly basis or as necessary to gain stakeholder feedback. Comments on this report will be accepted at wzalis@energetics.com.

Appendix

List of Invited Stakeholders

Name	Organization
Ramin Abhari, P.E.	Syntroleum Corporation
Alexis Abramson	DOE
Fiona Aldous	Wiss, Janney, Elstner Associates, Inc.
Paul Berry	Dow Corning
Marcus V. A. Bianchi	Owens Corning
JP Braaten	Westech Building Products
Shana Bunker	The Dow Chemical Company
Dan Cautley	Energy Center of Wisconsin
Catherin Chappell	Heschong Mahone Group
Dane Christensen	National Renewable Energy Laboratory (NREL)
Walt Clevenstine	Bayer Material Science, LLC
Stephane Costeaux	The Dow Chemical Company
Charles Cottrel	North American Insulation Manufacturers Association
Laverne Dalgleish	Air Barrier Association of America
Joseph J. Deringer	Institute for the Sustainable Performance of Buildings
Andre Desjarlais	ORNL
Christopher Doyle	Institute for Building Technology and Safety
John Dulac	IEA
Elena Enache-Pommer	Dow Building Solutions R&D
Ali Fallahi	Fraunhofer CSE
John Faulkner	Weatherization Partners
Stanley D. Gatland II	CertainTeed Corporation
Michael Ginsburg	La Mirada Homes
Dianne Griffiths	Steven Winter Associates, Inc.
Lixing Gu	Florida Solar Energy Center
Douglas E. Harden	Atrium Corporation
Mark J. Henry	Butler Manufacturing
Jonathan Humble	American Iron and Steel Institute
Jeff Inks	Window & Door Manufacturers Association
David A. Johnston	EIFS Industry Members Association
Ron Judkoff	NREL
Achilles Karagiozis	Owens Corning
Neal Kruis	Big Ladder Software
Hartwig Kuenzel	Fraunhofer
Marc LaFrance	DOE
Ronnen Levinson	LBNL
Brian Lieburn	Dow Building Solutions – Dow Chemical Company
Wahid Maref	NRC Construction Portfolio – National Research Council Canada
Dudley McFarquhar	MGI McFarquhar Group Inc.
Ray McGowan	National Fenestration Rating Council
Roger G. Morse	Morse Zehnter Associates

Erik Murray	Wiss, Janney, Elstner Associates, Inc.
Pat Noonan	Knauf Insulation
Jerry Phelan	Bayer MaterialScience
David L. Roodiset	D&R Consultants
Patrick Roppel	Morrison Hershfield
William B. Rose	University of Illinois at Urbana-Champaign
Aaron Seitz	Dow Corning
Kevin Simmons	Pacific Northwest National Laboratory
Doug Smith	NanoPore
Mike Stellato	Star Consulting Group
Paulo Tabares	NREL
Nathalie Trudeau	IEA
Alfonso Vargas IV	JE Dunn Construction
Dr. King Wang	Agiltron, Inc.
Emma Weaver	Energetics Incorporated
Theresa Weston	Dupont Building Innovations
Tom White	CENTRIA
Teresa Williams	ORNL
Dr. Arthur Yang	Industrial Science & Technology Network, Inc.
Walt Zalis	Energetics Incorporated
Jensen Zhang	Syracuse University