Welcome to NIST

Building and Fire Research Laboratory

Building Environment Division

Piotr A. Domanski
Leader, HVAC&R Equipment Performance Group

NIST at a Glance

Gaithersburg, MD

Boulder, CO

NIST Mission: To promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.

- **~ 2,900 employees**
- **~ 2,600 associates and facility users**
- **~ 1,600 field staff in partner organizations**
- **~ 400 NIST staff serving on 1,000 national and international standards committees**

Building and Fire Research Laboratory NIST

NIST facilities

Advanced Measurement Laboratory

Courtesy HDR Architecture, Inc./Steve Hall ©Hedrich Blessing

Center for Nanoscale Science & Technology

©Robert Rathe

NIST Center for Neutron Research

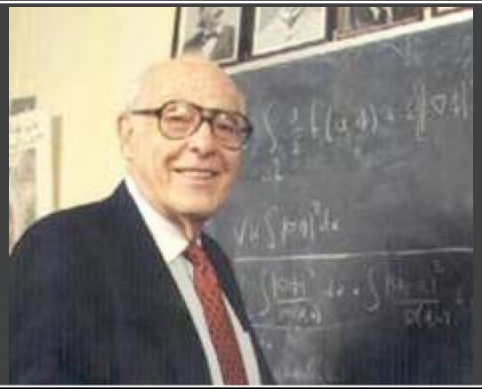
Advanced Chemical Sciences Laboratory

NIST has... ...world-class staff

Jan Hall
2005 Nobel Prize
in Physics

Eric Cornell
2001 Nobel Prize
in Physics

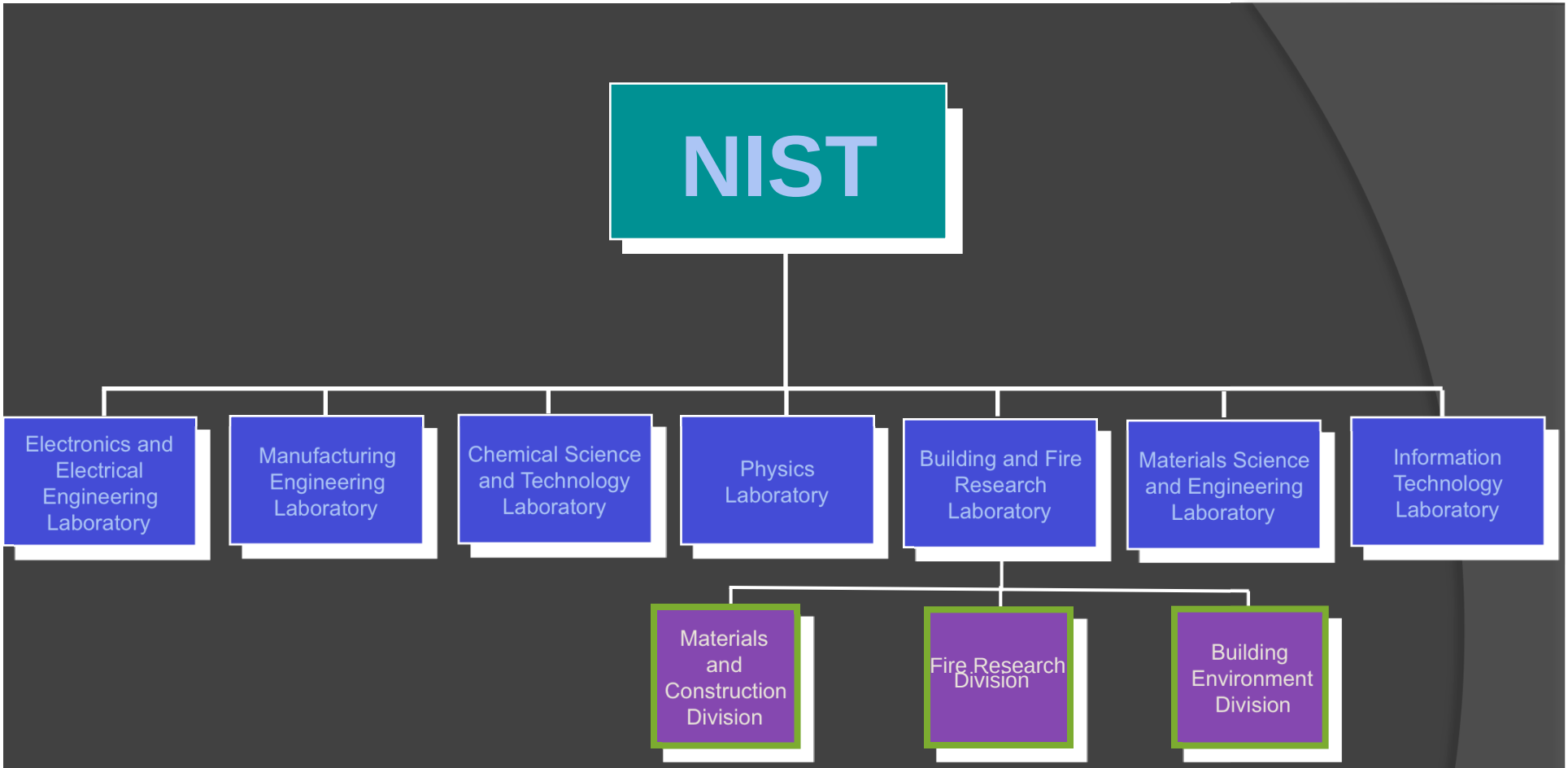
Bill Phillips
1997 Nobel Prize
in Physics



John Cahn
1998 National Medal of
Science

Anneke Sengers
2003 L'Oréal-UNESCO
Women in Science Award

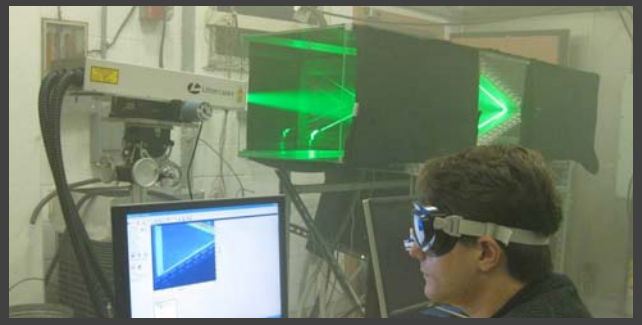
Debbie Jin
2003 MacArthur
Fellowship



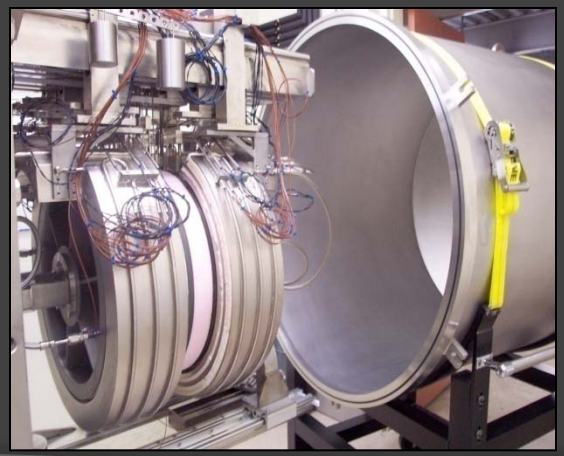
Measurement Science for Net-Zero Energy Buildings

What Constitutes Measurement Science?

- Reference Data
- Reference Materials
- Measurement Methods
- Methods of Test
- Test Beds
- Predictive Tools
- Performance Metrics
- Comparison Studies
- Assessment of Technologies
- Information Models
- Protocols
- Technical Guidelines



Heat Exchanger Air Flow Distribution Measurements



High-Temp Guarded-Hot-Plate

Outdoor Solar Test Facility

Building and Fire Research Laboratory NIST

Net-Zero Energy Buildings Measurement Science Workshop (*)

- Held at NIST on October 29th 2009
- Approximately 100 attendees
  - Private Sector - A.O. Smith, BSC, Rheem, United Technologies, Certainteed, Owens Corning, Johnson Controls, DuPont, Honeywell, Climatemaster
  - Academia – Carnegie Mellon, Penn State, Va Tech, Univ of Nebraska, Univ of Central Florida (FSEC), Drexel
  - National Laboratories - ORNL, PNNL, NREL, LBNL
  - Associations – ASHRAE, ACCA, NFRC, USGBC, ICF, ACEEE, NAHB, AHRI

(*) *National Science and Technology Council, 2008. " Federal R&D Agenda for Net-Zero Energy, High-Performance Green Buildings"*

National Research Council, Laboratory Assessments Board, 2008 recommendation

Building and Fire Research Laboratory NIST

Workshop Breakout Topics

- Whole Buildings Integrated Energy Performance
- Building Envelope Energy Reduction
- Intelligent Buildings
- Building Equipment Energy Reduction
- Onsite Energy Generation

Building and Fire Research Laboratory NIST

Workshop Breakout Topics

- Whole Buildings Integrated Energy Performance
- Building Envelope Energy Reduction
- Intelligent Buildings
- Building Equipment Energy Reduction
- Onsite Energy Generation

Intelligent Buildings Breakout Session

Major Technical Challenges

- **Advanced Control Systems**
  - Tools, information models, and standards are lacking.
- **Design Risk**
  - Insufficient experience and demonstration of new technologies lead to high investment risk.
- **Information Sharing**
  - Lack of collaboration and central knowledge base in the building industry.
- **Fault Detection**
  - Data on fault detection and frequency is limited.
  - Poor understanding of faults on energy use.
- **Systems Complexity**
  - Systems are difficult to configure and maintain (not intuitive).
- **Occupant/Building Interface**
  - Fundamental understanding is lacking (e.g., psychological, societal issues).

Building and Fire Research Laboratory NIST

Intelligent Buildings Breakout Session

Priority Measurement Needs

- Test beds that enable standardized evaluations of intelligent building technologies.
  - Capability would enable evaluation and validation and provide comparison basis.
  - Scope/functional requirements need to be specified to address industry needs
  - Defining/implementing components of testbeds and operating parameters

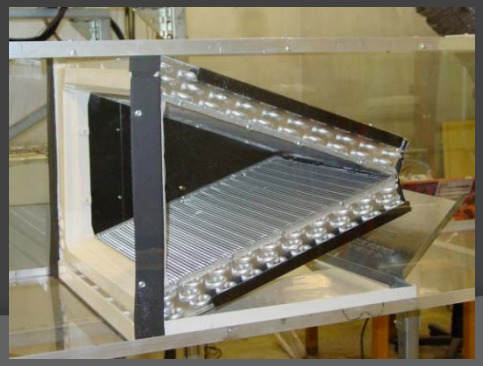
- **Automated tools for commissioning (Cx) for** components, systems and buildings.
  - Tools that automate multiple phases of Cx, during design, construction, and operation are needed.
  - Fault detection and diagnostic tools; data, methods, algorithms, and tools for automated response (correction) of faults
  - Detailed case studies involving components, subsystems, and systems demonstrating benefits of commissioning.
  - Development of models, methods, algorithms, and tools

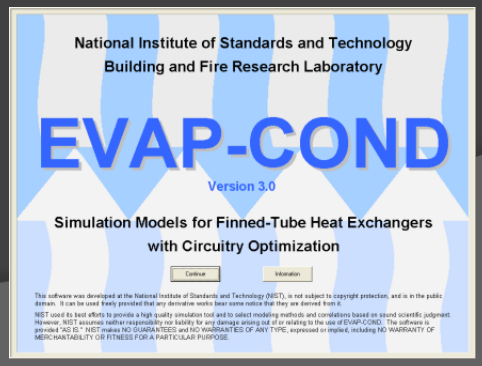
Building and Fire Research Laboratory NIST

Building Equipment Breakout Session

Major Technical Challenges

- Cost vs. Value
  - Lack of incentives --- building owners not paying for energy, building occupants not paying for equipment.
- Uniform Performance Standards/Metrics
  - Manufacturers/builders need metrics that capture value added associated with their products.
- Fault Detection and Diagnosis (FDD)
  - FDD automated commissioning is being hampered in the market by sensor costs and technology development.
- Conflicting Protocols and Standards
  - Conflicting interests creates inconsistency in protocols/interoperability standards.





Building Equipment Breakout Session

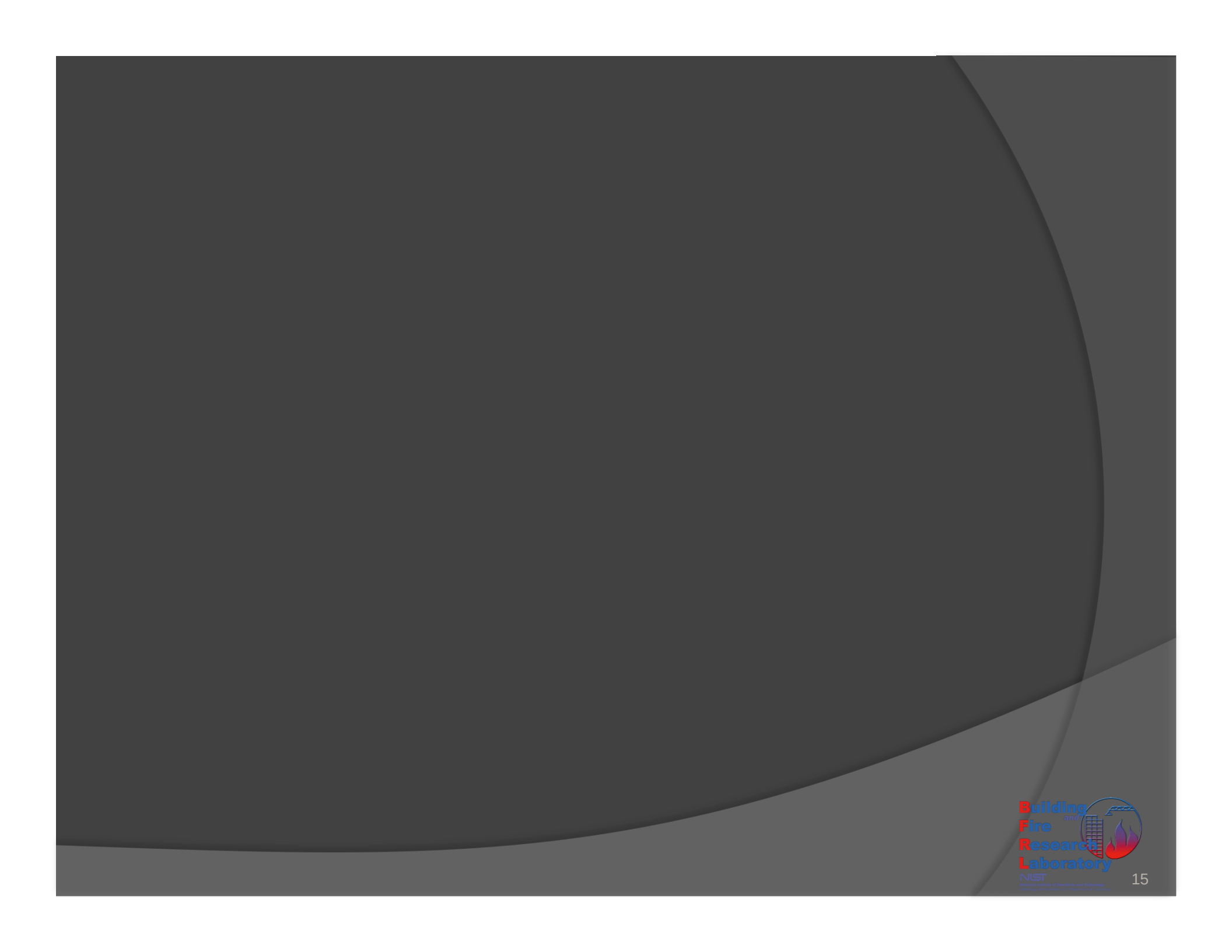
Priority Measurement Needs

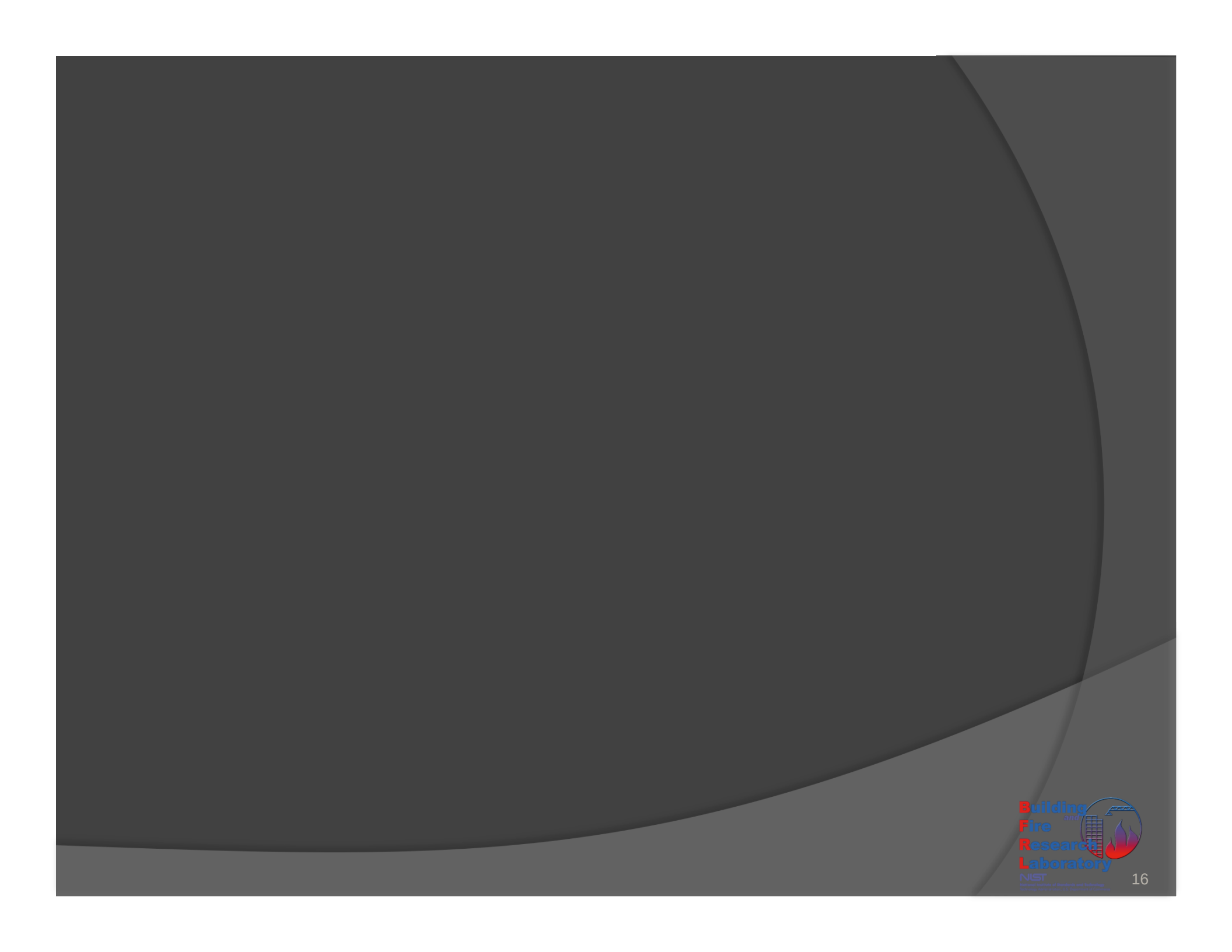
- **Update/develop methods of test and performance rating procedures for building equipment.**
  - Ratings need to reflect actual performance.
  - “Actual use” has not been accurately characterized; in some cases.
  - Methods of test for emerging technologies do not exist
  - Linkage needed between testing/rating results and building simulation models
- **Continuous comparison of measured vs. projected performance.**
  - Sensor technology, mapping methods, and FDD schemes
  - Effective user interface/technology
  - Installation, maintenance, commissioning all affect performance.

Building and Fire Research Laboratory NIST

NIST Accomplishments in FDD for Commercial HVAC Systems

- Laboratory facilities for testing FDD tools developed
- Embedded tools for FDD in AHUs and VAV boxes developed and tested
- NIST tools beginning to appear in commercial products
- California Title 24 references NIST developed FDD tools


Building and Fire Research Laboratory
NIST


Building and Fire Research Laboratory
NIST

A Final Thought-------

1929 Model A Ford
- Price $600
- MPG – 17
- Horsepower – 40
- Top Speed - 62
- Available Measures of Performance
  - Gas Gauge
  - Ammeter
  - Speedometer/Odometer
- Space Conditioning
  - Tilt Out Windshield
  - Roll Down Windows

2008 Chevrolet Corvette
- Price $36000
- MPG 19 City/28 Highway
- Horsepower 400
- Top Speed 172

- Available Measures of Performance
  - Inst MPG/Avg MPG/Oil Press/Oil Temp
  - Coolant Temp/AT Temp/Tire PSI @168 MPH
  - Oil Life Remaining
  - 455 Diagnostic Codes
- Space Conditioning
  - Five Different Air Delivery Combinations
  - Six Fan Speeds
  - Two Zones
  - Air + RH Control
  - Door/Hatch Ajar

1960 House
- Price $15,200
- Available Measures of Performance
  - Actual Temperature
  - Set Point Temperature

2008 House
- Price $269,500
- Available Measures of Performance
  - Actual Temperature
  - Set Point Temperature
  - Emergency Heat Light

Building and Fire Research Laboratory NIST

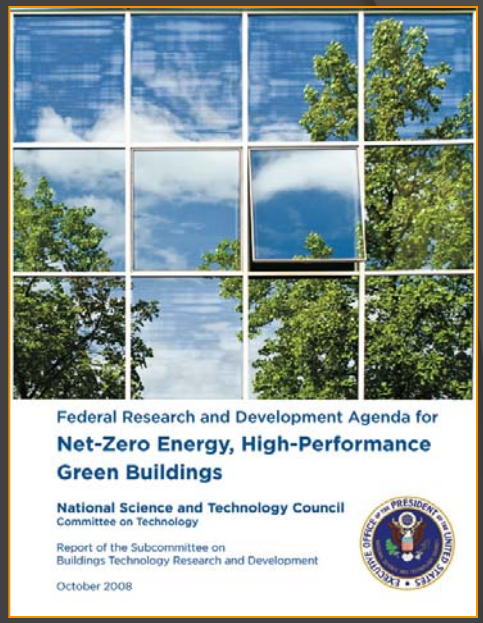
Measurement Science for Net-Zero Energy, High Performance Buildings

Building and Fire Research Laboratory NIST

Motivations for Workshop:

"Develop the enabling measurement science to achieve net-zero energy, high-performance green building technologies." One of five goals articulated in the *Federal R&D Agenda for Net-Zero Energy, High-Performance Green Buildings*

" Roadmaps for building energy technologies measurement science and standards should be developed and implemented……." *National Research Council of the National Academies Laboratory Assessments Board*



Provide Programmatic Guidance to NIST

Measurement Science to Enable Net Zero Energy Buildings
Priority of Identified Measurement Needs

Provide Guidance to Others

Needed Building Technologies/Tools/Approaches
Measurement Science