Measurement Science Workshop for Net Zero Energy Buildings

Preliminary Summary

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Net Zero Energy Buildings Measurement Science Workshop

- Held at NIST on October 29th.
- 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
- Facilitated by Energetics Incorporated
- Two keynote presentations
  - Dru Crawley – Department of Energy
    - “Getting to Zero-Energy in Commercial Buildings: Key Measurements to Support R&D”
  - Danny Parker – Florida Solar Energy Center
    - “Zero Energy Homes: Measurement Science to Meet Expanding Research and Performance Goals”
- Workshop Report in Preparation
  - Final Report to be published February/March 2010
Why is Building Energy Consumption Important?

The combined residential and commercial buildings sectors is the largest consumer of energy in the U.S.

- 40% of U.S. Primary Energy Consumption
- 72% of U.S. Electricity
- 55% of U.S. Natural Gas

Source: 2007 Buildings Energy Data Book. Tables 1.1.3, 1.2.3, 1.3.3

Source: 2008 EIA Annual Energy Outlook

Total U.S. Energy Consumption
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
Workshop Objectives/Breakout Topics

- Gain Perspective on Trends/Drivers/Challenges Associated with Net Zero Energy Buildings
- Identify Critical Technologies/Approaches to Achieve Net Zero Energy Buildings
- Identify/Prioritize the Measurement Science Needed to Enable Net-Zero Energy, High-Performance Buildings

Breakout Topics

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

High-Temp Guarded-Hot-Plate

Heat Exchanger Air Flow Distribution Measurements

Outdoor Solar Test Facility
Measurement Science Need Example: Develop methods of test/performance metrics that capture residential water heater performance

Over the last 30 years, NIST has worked with DOE and ASHRAE to develop test methods that rate the energy efficiency of water heaters under typical loads.

Measurement Science Solutions:


Rating Methods have helped DOE set national appliance efficiency standards.
Onsite Energy Production Breakout Session

Major Technical Challenges

- **High Capital Costs**
  - First cost deters adoption, life-cycle cost rarely computed, externalities not considered.

- **Output reliability:**
  - Actual performance fails to meet rated/projected performance.

- **Risk Perception**
  - Lack of installed performance data, installation standards, familiarity all increase perceived risk.

- **Storage for Energy Generation**
  - Currently challenged by high cost, low capacity, and unknown long term reliability.

- **Existing Housing Stock**
  - Existing buildings were not built with consideration of on-site power generation.
Onsite Energy Production Breakout Session

Priority Measurement Needs

- Comprehensive predictive performance tools. Widespread acceptance of onsite energy benefits which are difficult to evaluate.
  - Descriptive models of equipment
  - Metrics to quantify benefits
  - Testing and evaluation of available equipment to establish performance maps
  - Representative performance data through evaluation of sample building sets
  - Validation of predictive tools

- Representative thermal and electrical profiles
  - Data is needed for space cooling, heating, hot water, and plug loads
  - Data does not exist and establishing representative building for evaluation is challenging
  - Statistical study of well monitored representative buildings is needed
  - Without representative/actual values models will struggle to predict actual measured performance
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 Frequency
- 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).
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
Whole Buildings Breakout Session

Major Technical Challenges

- **Integration**
  - Design, analysis, and operation are not effectively integrated.

- **Cost-Effectiveness**
  - Cheaper may be perceived as more important than ‘better.’

- **Test Methods**
  - Static, obsolete test methods require development of new approaches (e.g., performance maps).

- **Validation of Energy Cost Savings**
  - Real data, not model predictions, are lacking to validate actual savings.

- **IAQ Control**
  - Useful (measurable, quantitative) criteria for IAQ control is lacking.
Whole Buildings Breakout Session

Priority Measurement Needs

- **Equipment ratings/performance maps that support** whole-building simulation during design.
  - Methodologies to obtain required information without undue burden.
  - Define parameters, ranges, number of points (ambient conditions, degradation/depreciation over time); develop degradation rating test method.

- **Accurate, affordable, low maintenance sensing and measurement technologies for IAQ.**
  - Better occupancy sensors.
  - “Better,” smaller, cost-effective sensors for VOCs, etc.
  - The use of open, standard protocols that permit seamless Integration with building automation systems (BACnet, ZigBee, Modbus, LonWorks, etc.)
  - Methodologies that take into consideration actual building operation.
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 Envelope Breakout Session

Major Technical Challenges

- **Codes and standards:**
  - Fragmented code adoption impedes achievement of benefits.

- **Building diagnostics:**
  - Lack of measurement techniques to identify building energy losses.

- **Benchmarks:**
  - Lack of expense-to-benefit tools makes it difficult to justify investments.

- **New materials:**
  - Research on advanced insulation is complex, high risk, or non-existent.

- **Building metrics/ratings:**
  - Lack of metrics that capture innovative building envelope technologies.
Building Envelope Breakout Session

Priority Measurement Needs

- **In-situ measurements to capture thermal resistance of building envelope components/assemblies.**
  - Algorithms to capture thermal resistance of assemblies from IR image data
  - Comparative studies to quantify level of accuracy for well characterized walls.

- **Accurate wireless sensors/transducers.**
  - Temperature, relative humidity, power, and heat flux.
  - Low power
  - Long life.
  - Low cost.
  - Common protocol to feed into data management systems
  - Standard test protocols to evaluate sensors/transducers.
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