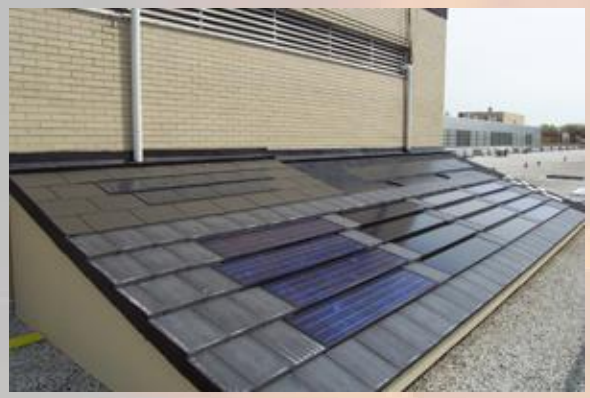

Measurement Science for Building Energy Technologies

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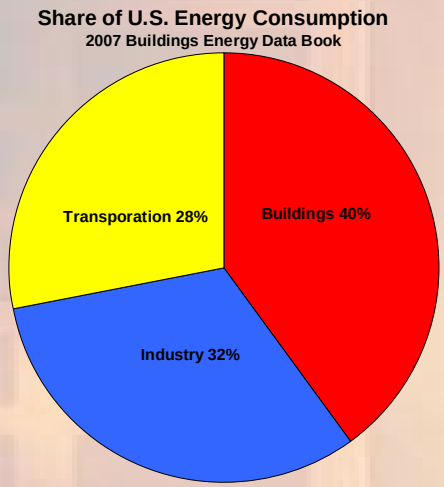
Energy Impact Associated with U.S. Buildings

- Buildings account for 40% of all energy consumption
- Buildings are responsible for 37% of CO_2 emissions
- Buildings represent the largest single user of electricity, 72%
- Buildings use 84% of their life cycle energy during their operation



Greatest potential in retrofitting and renovating existing buildings

- •Replacement rate roughly 1% per year

New buildings are also extremely important

- •34 million new homes projected 2005-2030
- •48% increase in commercial building floor space

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Net Zero Energy Buildings

Definition

Buildings that consume no more energy than they produce over a defined time interval – typically one year

The Challenge

The energy consumption of a given building can usually be reduced 20 to 40% using best practices in the design, construction and operational phases of a building

The goal of Net Zero Energy Buildings can only be achieved through the introduction of innovative building energy technologies

Measurement science is needed to enable the development and deployment of building energy technologies

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Measurement Science for Building Energy Technologies

The term ***measurement science*** includes:

- Development of performance metrics, measurement methods, predictive tools, reference materials, data, and artifacts
- Evaluation and/or assessment of technologies, systems, and practices
- Development and/or dissemination of technical guidelines and basis for standards, codes, and practices

Why is it difficult to develop the required measurement science?

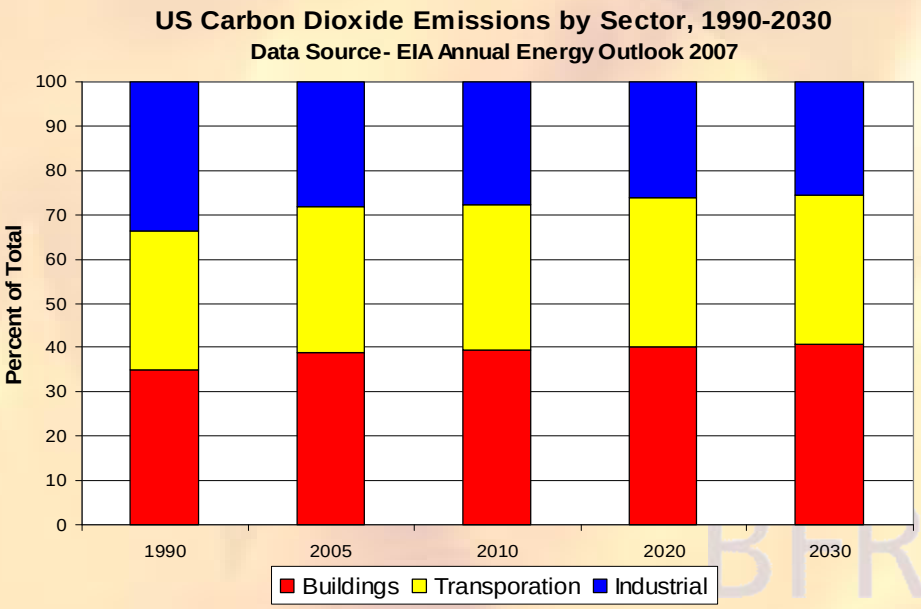
- Buildings are complex systems of interacting components
- Measures of performance on individual components are idealized
  - Fail to capture complexities of actual buildings
  - Fail to capture dynamic interactions of multiple subsystems
- Measurement science that supports innovation in building energy technologies often fails to capture “installed” performance

Measurement Science for Building Energy Technologies

Net Zero Energy Buildings require a holistic approach to both energy technologies and measurement science

Measurement Science - Technical Approach

- Enable Building Energy-Use Reduction through In-Situ Performance Measurements
- Enable Energy-Use Reduction through the Embedded Intelligence in Building Controls
- Provide Measurement Science for Emerging Building Energy Technologies
- Develop Carbon Footprint Metrics/Tools for Building Sustainability Performance Evaluation



Enable Energy-Use Reductions Through In-Situ Performance Measurements

- **Develop measurement techniques to assess envelope integrity**

  Outcome: Improved methods to detect gaps in walls and roofs through which unwanted heat flow occurs

- **Improve measurement of ventilation rates and indoor air contaminants in buildings**

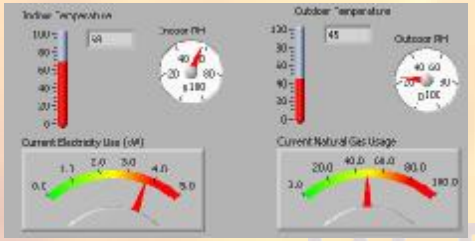
  Outcome: Ventilation control strategies can be implemented based on actual need instead of general guidelines, thus saving energy by ventilating only when necessary

- **Enhance measurement of refrigerant loss in vapor compression systems**

  Outcome: Detection of inefficient performance of air-conditioning and heat pump systems in the field

- **Optimize measurement systems for energy information centers**

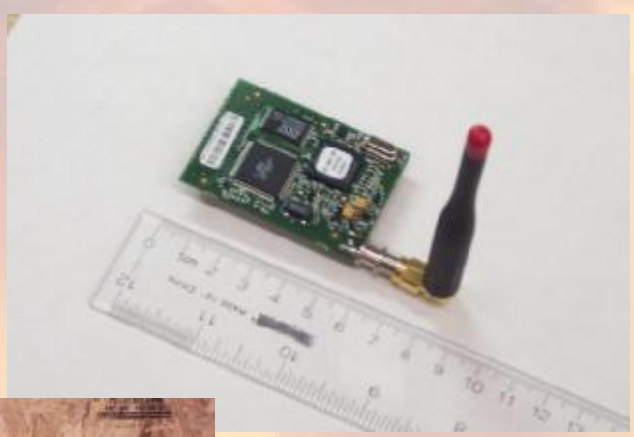
  Outcome: Affordable monitoring systems that provide information to occupants regarding energy consumption, knowledge that has been shown to reduce energy use in buildings

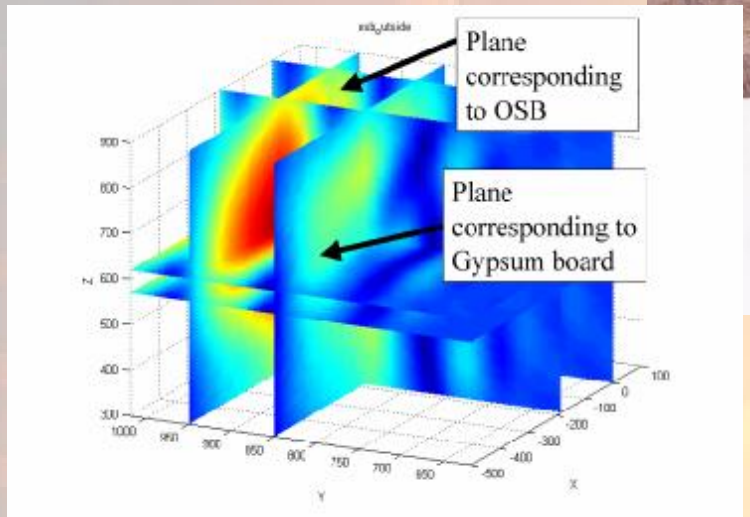


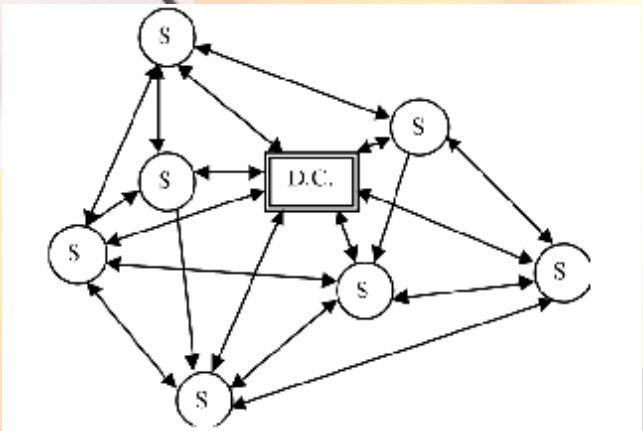
Sensors for Improved Building Monitoring

NIST is exploring novel sensor technology that could be used as part of monitoring systems to determine energy consumption in buildings:

- Radar to evaluate integrity of thermal envelopes
- Wireless sensors
- Data management issues



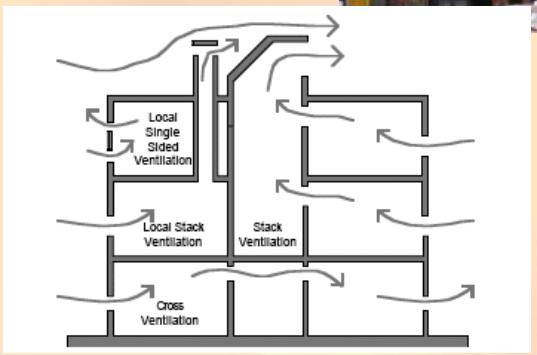


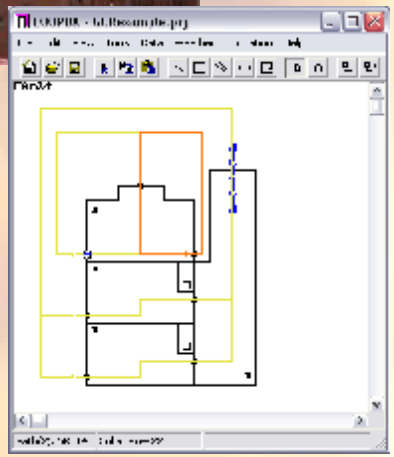


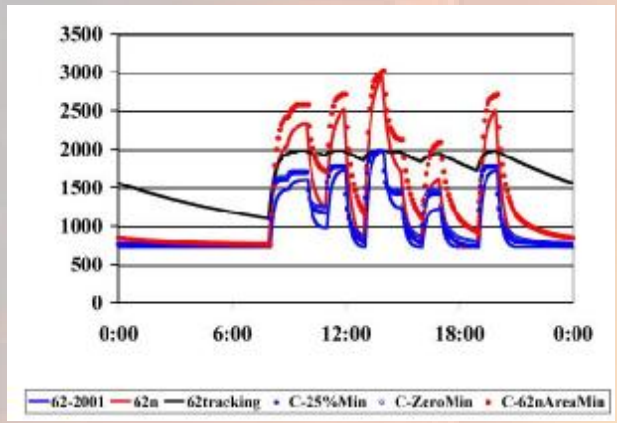
Energy Efficient Ventilation Strategies

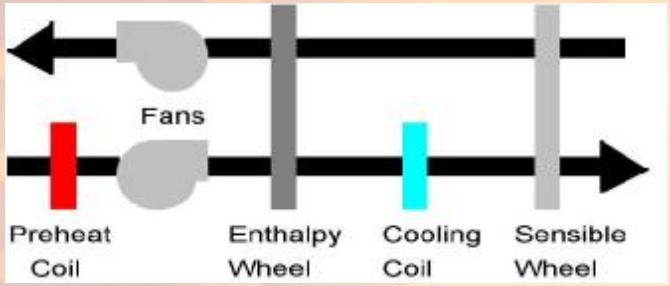
NIST has been developing simulation methods, design guidance and tools, technology assessments of strategies, and standards to provide adequate ventilation in an energy efficient manner.

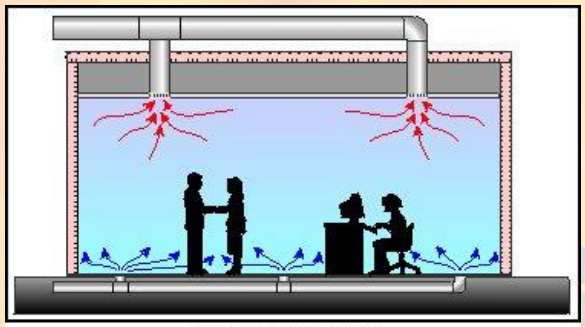
- Carbon dioxide based demand controlled ventilation
- Natural and hybrid ventilation
- Dedicated outdoor air systems
- Displacement ventilation







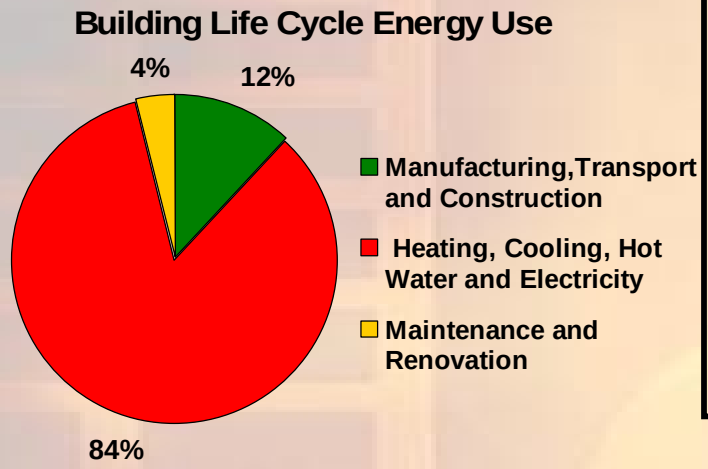




Displacement ventilation.

Enable Building Energy Use Reductions Through Embedded Intelligence

NIST Virtual Cybernetic Building Testbed



- **Determine the number and type of sensors required to detect building equipment faults and control errors**
  Outcome: Technical basis for determining the type, number and location of sensors
- **Develop fault detection metrics/tools for heating, cooling ventilating, and air-conditioning (HVAC) equipment**
  Outcome: Eliminating of faults/control errors
- **Develop hierarchical analysis techniques that can determine when an apparent fault in one piece of equipment is the result of component failure earlier in the process stream**
  Outcome: Increased confidence in fault detection
- **Develop supervisory control techniques based on autonomous, intelligent agents that can optimize system performance**
  Outcome: Substantial energy use reduction through more efficient control of building systems

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Automated Fault Detection and Diagnostics for Residential Heat Pump

NIST is developing Fault Detection and Diagnostic methodologies for residential air-conditioning and heat pump systems that ensure a quality initial installation and sustained efficiency throughout the lifetime of the equipment.

Goals:

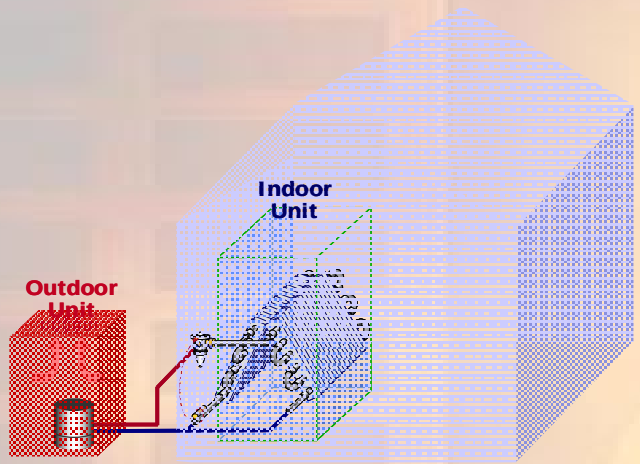
Quality initial installations

Greater thermal comfort

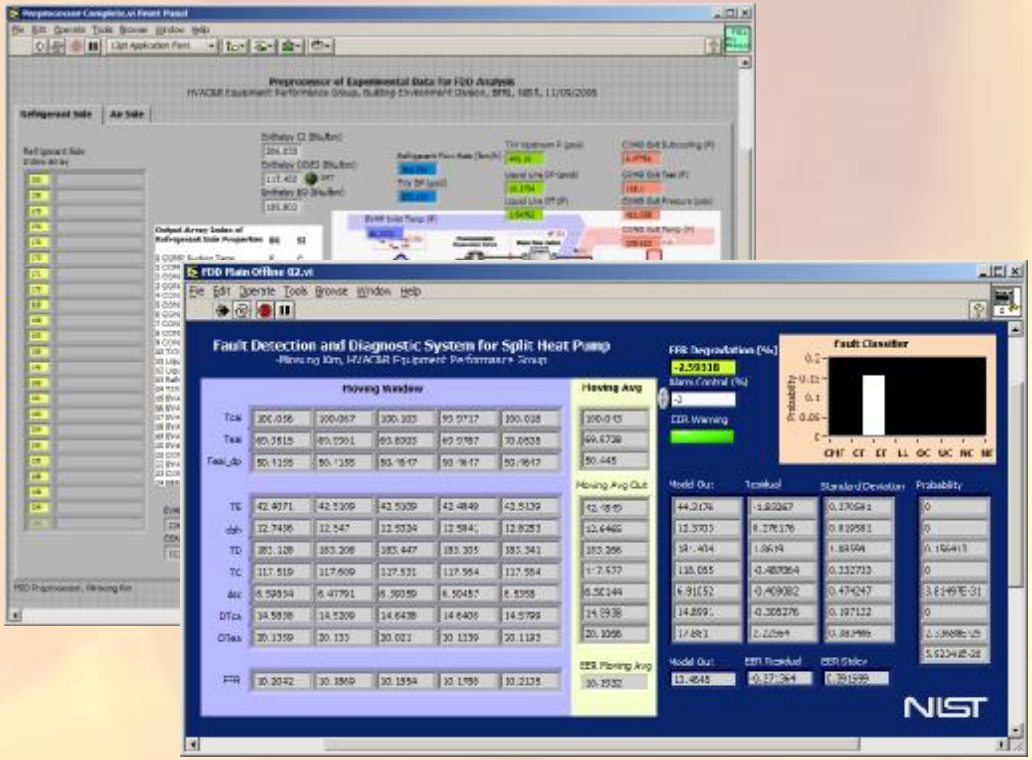
Reduced refrigerant emissions

Increased energy efficiency

Reduced life-cycle operating costs



Residential split-system heat pump



System analysis and fault classifier

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Measurement Science for Emerging Building Energy Technologies

NIST's Photovoltaic and Lighting Research Facilities

- **Develop/characterize novel techniques to simulate the solar spectrum indoors**

  Outcome: Removal of significant barrier to widespread deployment of photovoltaic systems – uncertainty in module power rating measurements

- **Develop the measurement science, methods of test, and performance metrics for solid state/organic light-emitting diode technologies and stationary fuel cell units**

  Outcome: Accelerated commercialization of energy efficient lighting products and fuel cell units with combined heat and power capabilities

- **Develop measurement science to quantify 3-D performance of innovative insulation**

  Outcome: Development of insulation technologies with 10X current performance

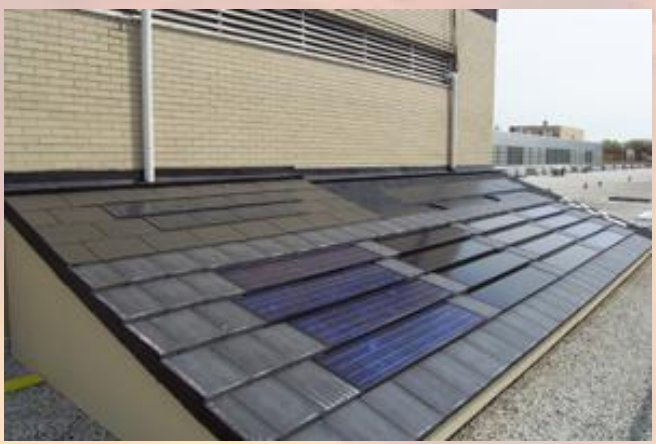
- **Develop characterization techniques for amorphous industrial waste stream products**

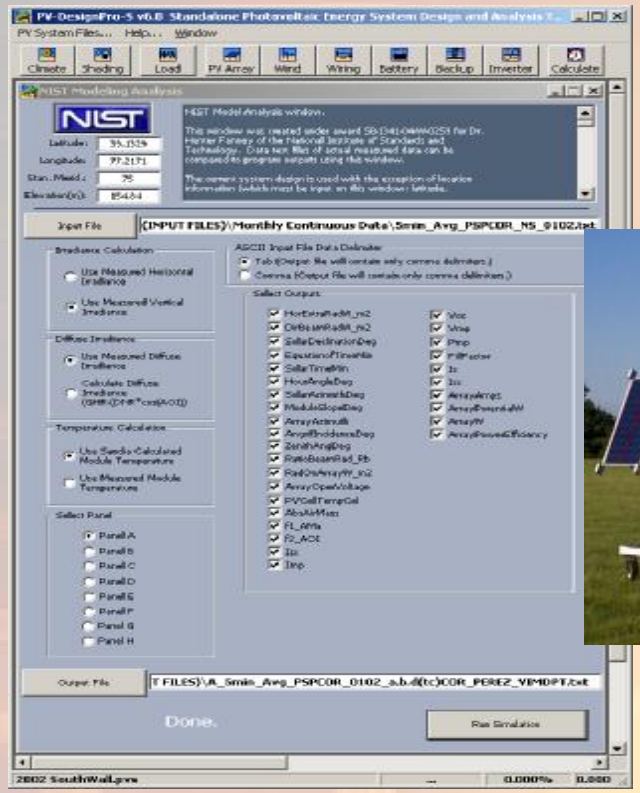
  Outcome: Reduced energy use and CO_2 emissions during cement production

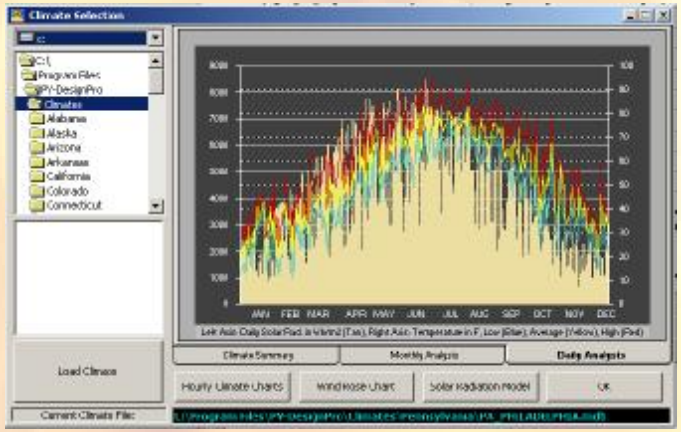
Photovoltaic Measurements and Models

NIST Provides Data for Photovoltaic

- Technology Comparisons
- Improvement/Validation of Simulation Models
- Improved Measurement Techniques







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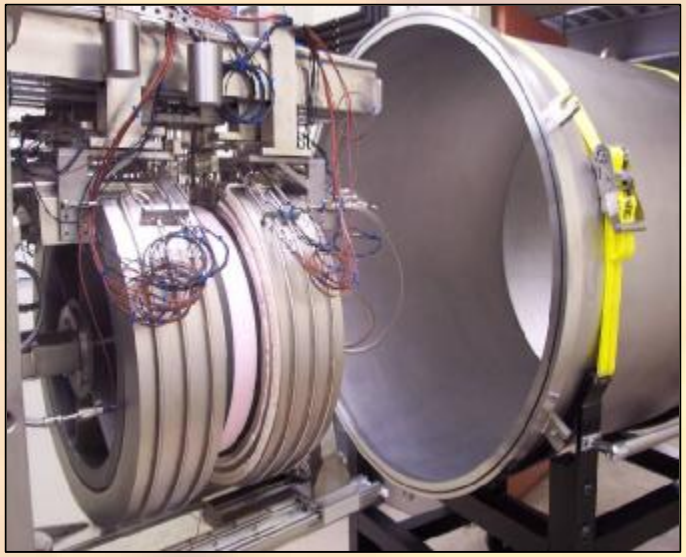
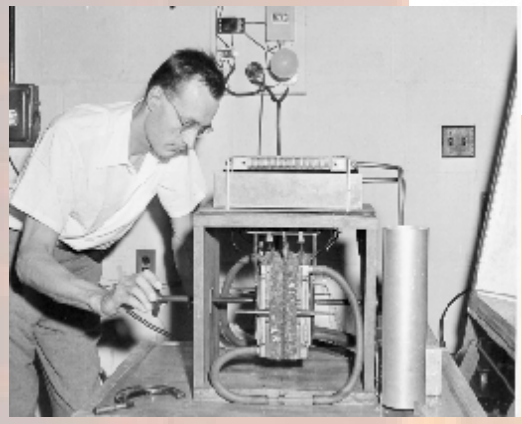
Thermal Insulation Measurements

Since 1912, NIST has provided thermal resistance measurements to the thermal insulation industry.

- 1-m Guarded Hot Plate (GHP) Apparatus
- 0.5 m GHP designed to test from 90 K to 900 K
- Vacuum Insulation Panels tested in calorimeter
- NIST Standard Reference Database 81 (http://srdata.nist.gov/insulation/)





Fuel Cell Performance Ratings

NIST is developing rating methodologies to help consumers gauge the performance of fuel cell systems for building applications

- •Residential Fuel Cell Units
- •Emergency Backup Fuel Cell Units
- •Combined Heat and Power Applications

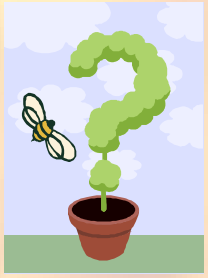
Develop Carbon Footprint Metrics and Tools for Building Sustainability Performance Evaluation

- **Develop carbon footprint databases**
  Outcome: Building industry stakeholders can link energy technology innovation to environmental benefits and costs at the building scale
- **Develop carbon efficiency metrics**
  Outcome: R&D investors can assess economic value of financing development and commercialization of new building technologies with measurable carbon reductions
- **Develop national carbon score carding metrics**
  Outcome: Carbon trading markets are informed with the traceable measurements essential to enable reporting of the building industry's carbon footprint
- **Develop national carbon score carding tools**
  Outcome: Communities and governments can readily track progress toward Net Zero Energy buildings

BEES

Building A vs. Building B

$20/ton carbon saved



$40/ton carbon saved

Measurement Science for Building Energy Technologies

Summary

- Buildings account for 40% of all U.S. energy consumption
- The Nation's electrical generation and distribution systems are increasingly challenged
- Net Zero Energy Building are being proposed as a solution
- Achievement of Net Zero Buildings requires development of innovative building energy technologies and measurement science

Net Zero Energy High Performance Green Buildings Workshop

National Science and Technology Council's Committee on Technology
Subcommittee on Buildings Technology Research and Development (BTRD)
Forrestal Auditorium (GE-086), Forrestal Building
U.S. Department of Energy, Washington, D.C.
May 15-16, 2008

Space is limited -Interested parties should immediately contact: David Rathbun drathbun@tms-hq.com

Objective - Provide stakeholders an opportunity to review and comment on the preliminary recommendations and conclusions of BTRD's draft report *Federal R&D Priorities for Net Zero Energy, High Performance Green Buildings*. Responsive to EPACT 2005 Section 913 (a)- (c)