

NIST's Building Energy Research Program

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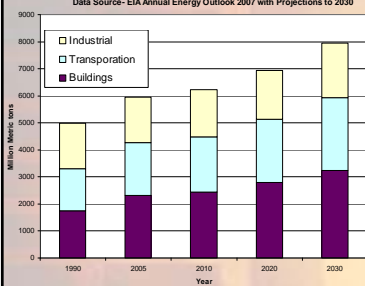


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Energy/Climate Change-Driven Challenges



US Carbon Dioxide Emissions by Sector, 1990-2030 (million metric tons)
Data Source- EIA Annual Energy Outlook 2007 with Projections to 2030

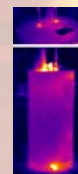


- U.S. spends \$508 B/year in energy costs for operation and use of constructed facilities
- Buildings are the largest contributor (37 percent) of CO₂ emissions in end-use operations, followed by the transportation and industrial sectors
- An additional 7-8 percent of U.S. CO₂ emissions are attributable to cement production
 - 1 ton of cement produces 1 ton of CO₂
 - 130 million tons of cement are used in construction each year
- CO₂ emissions associated with buildings may be reduced through
 - Energy conservation measures
 - Substitution of renewables for fossil-fueled generation
 - Efficiency improvement and/or CO₂ sequestration in fossil fired power plants
 - Substitution of flyash for calcinated material

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NIST Energy Success Stories

- **Renewable Energy**
 - Developed testing and rating procedures used throughout the solar thermal industry.
 - **Energy Efficiency**
 - Development and Maintenance of Test Procedures for all Covered Appliances*.
 - Provides Thermal Conductivity Traceability for Building Insulation through SRMs.
 - Led the Search for Alternative Refrigerants used in Heating/Cooling Equipment.
 - Developed First Draft of ASHRAE's "Energy Standard for Buildings Except Low-Rise Residential Buildings".
 - Developed Methodology (adopted by ASTM) to Assess Air Tightness of Commercial Buildings.
 - Played Major Role in the Development of Communication Standards for Building Automation and Control Systems (BACnet)*.
 - Support of IEA through leadership/participation in Annexes 17, 25, 40, 42, and 47*.
 - **Assessment Tools**
 - Developed NBSLD, a Pioneering Building Energy Simulation Tool that Laid the Foundation to DOE-2, BLAST, TARP, and Energy 10*.
 - Instrumental in U.S. Green Building Council's (LEED) Building Rating System.
 - Development of Building Life-Cycle Cost (BLCC) and Building for Environmental and Economic Sustainability (BEES) Methodologies*.
- * Denotes Support from DOE

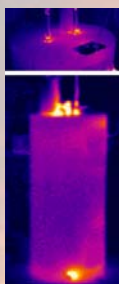
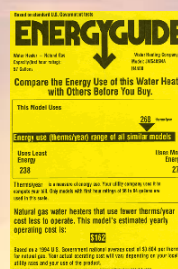


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Improved Efficiency Appliance Standards

For over two decades, NIST has supported the DOE program by developing and maintaining test and rating procedures for

- Heat pumps and air-conditioners
- Water heaters
- Refrigerators/freezers
- Dishwashers
- Washers/dryers
- Transformers
- Transformers/Electric Motors



Infrared imaging shows regions of heat loss from a water heater (a) top of tank, (b) side of tank.

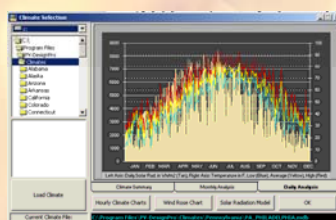
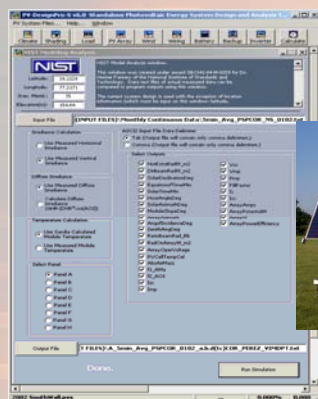
Energy Efficiency of Appliances – enabling energy savings, reduced operating costs, and consumer awareness via standard DOE testing and rating procedures.

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Photovoltaic Measurements and Models

NIST Provides Data for Photovoltaic

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



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Refrigerant Heat Transfer Enhancement

NIST's fundamental nanofluids heat transfer research is laying the foundation for reduced cooling costs in buildings

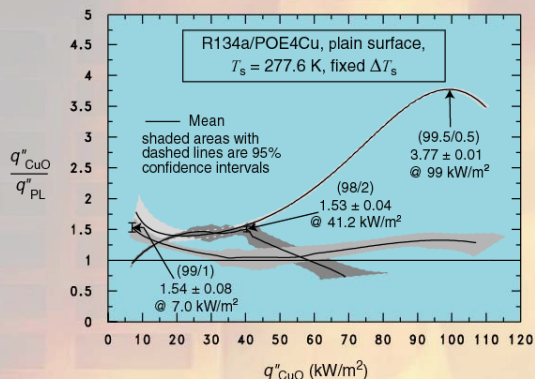
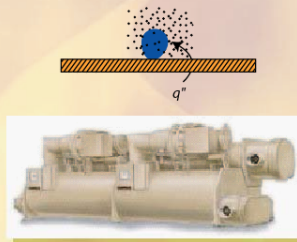


Figure shows refrigerant/oil boiling heat transfer improvement with addition of nanoparticles

A mixture containing 0.5% of nanoparticles improved the boiling heat transfer coefficient of R134a up to 275%



Potential impact - A 1% improvement in chiller efficiency would reduce U.S. electrical energy consumption by 320 billion kWh

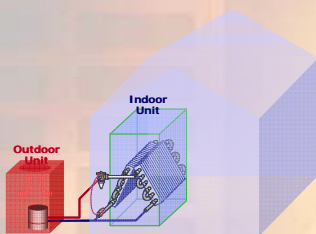
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Automated Fault Detection and Diagnostics for Residential Heat Pump

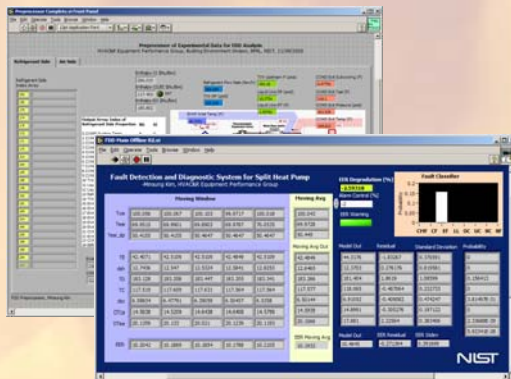
NIST is developing Fault Detection and Diagnostic methodologies for residential air-conditioning and heat pump systems that ensure a quality initial installation and sustained efficiency throughout the lifetime of the equipment.

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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Simulation Tools for HVAC Equipment

NIST develops software tools that facilitate designing optimized equipment.

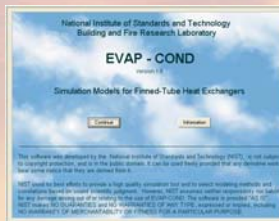
Goals:

- Increased energy efficiency
- Lower cost products
- Faster time to market

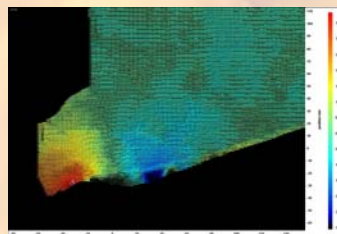
REFLEAK predicts a composition shift of zeotropic refrigerant mixtures due to sequential leaking and recharging. Composition shifting typically results in degradation of efficiency.



Simulation of an entire air-conditioning system to estimate the effect of design changes upon efficiency.



EVAP-COND predicts the performance of finned tube heat exchangers.



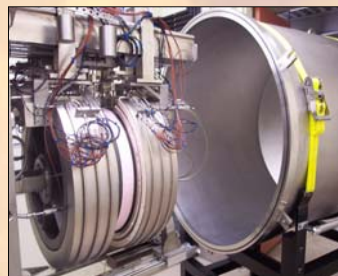
Particle Image Velocimetry (PIV) is used to characterize the air flow distribution through finned tube heat exchangers.

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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/>)



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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

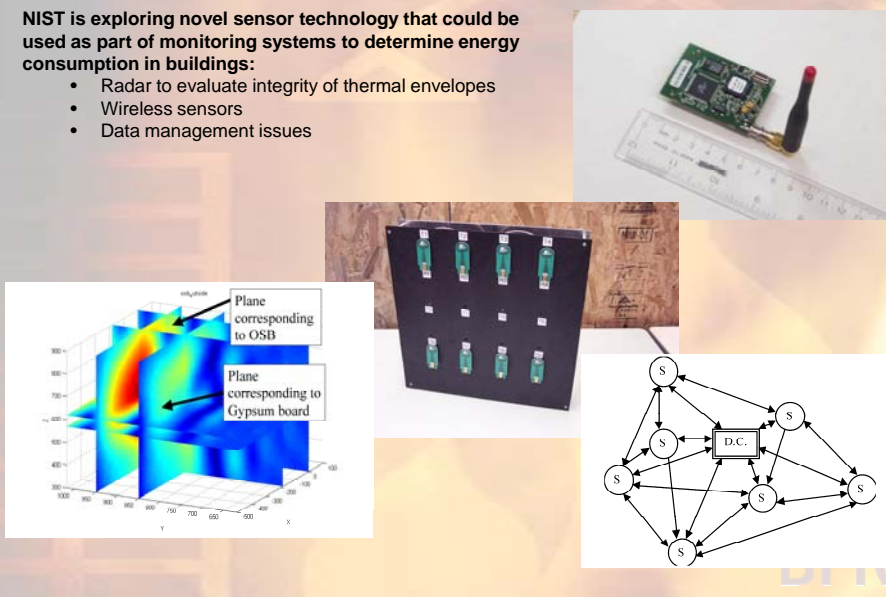


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Sensors for Improved Building Monitoring

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



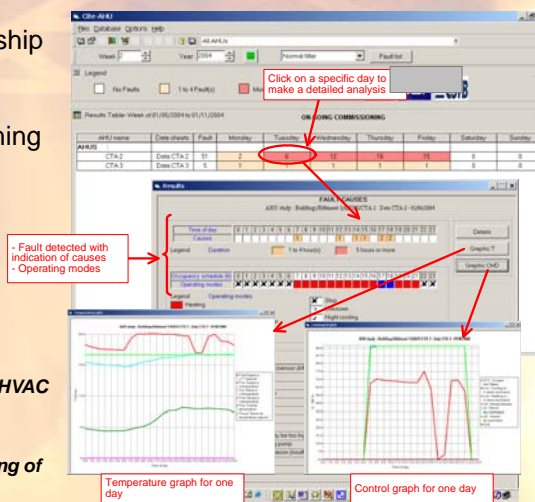
HVAC Commissioning Tools

NIST provides technical leadership in International Energy Agency Annexes addressing technical barriers to effective commissioning of building control systems

- Information Modeling
- Automated Commissioning tools
- Cost-benefit analysis and persistence measurement methodologies

IEA Annex 40 - Commissioning of Building HVAC Systems for Improved Energy Performance

IEA Annex 47 - Cost Effective Commissioning of Existing and Low Energy Buildings



Prototype AHU commissioning tool developed by NIST and CSTB

HVAC Fault Detection and Diagnostics

NIST has pioneered the development of embedded measurement and analysis techniques to detect faults in HVAC equipment and controls

- **APAR** – Air Handler Performance Assessment Rules
- **VPACC** – VAV box Performance Assessment Control Charts
- Unique laboratory facilities to emulate building systems
- Collaboration with control system manufacturers to test results in commercial products



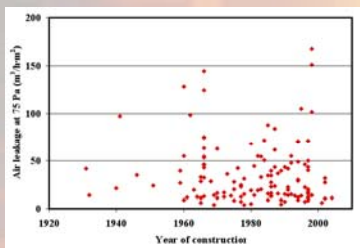
NIST Virtual Cybernetic Building Testbed Facility – Used to conduct research in automated fault detection and other aspects of integrated building control systems

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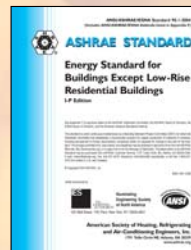
Energy Impacts of Envelope Airtightness

For over two decades, NIST has pursued energy savings opportunities through improvements in commercial building envelope airtightness.

- Development of test procedures
- International database of airtightness measurements
- Design guidance for envelope airtightness
- Simulation of energy impacts
- Technical support of air barrier requirements in energy efficiency standards



Envelope airtightness versus year of construction; shows no trend towards newer buildings being tighter.

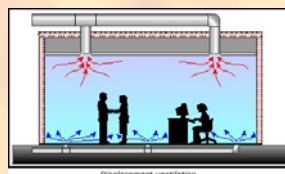
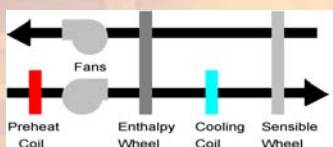
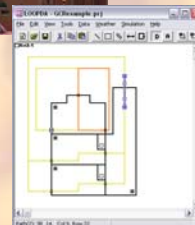
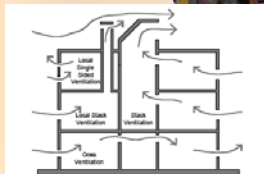
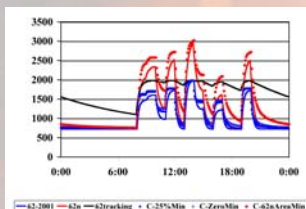


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Energy Efficient Ventilation Strategies

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.

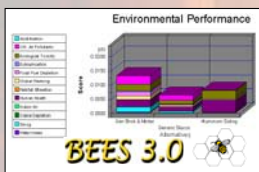
- Carbon dioxide based demand controlled ventilation
- Natural and hybrid ventilation
- Dedicated outdoor air systems
- Displacement ventilation



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Sustainability Assessment Tools

- BEES 3.0
 - 22,000 users
 - 530,000 BEES website "hits" since 2003
- BEES is major element of two federal preferred procurement programs
 - USDA Bio-Preferred Program created by 2002 Farm Bill
 - U.S. EPA Environmentally Preferable Purchasing Program created by Executive Order
 - Major "green building" rating systems incorporating BEES approach (LEED, Green Globes)



The BEES (Building for Environmental and Economic Sustainability) software brings a powerful technique for selecting cost-effective, environmentally-preferable building products.

Sustainability Assessment – enabling science-based selection of cost-effective, environmentally preferable building products through incorporation in major U.S. "green building" rating systems



Contact Information

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