NIST's Role in Appliance Testing

Presentation for:

National Academies
Committee on Point of Use and Full Fuel Cycle Measurement
Approaches to Energy Efficiency Standards

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Presentation Overview

- History of NIST Involvement
- Role of NIST
- Emerging Test Method Issues
- Use of Source or Site Energy – Pros and Cons
- Possible Solution

History of NIST Involvement in Appliance Testing

- Since 1975, DOE and NIST have worked together to develop and codify test procedures for various types of appliances and equipment
- NIST (formerly NBS) involvement was established in Energy Policy and Conservation Act (EPCA), Pub. L. 94-163, as amended
  - requires that DOE prescribe testing, rating procedures, and minimum energy efficiency standards for residential appliances and commercial equipment
  - requires that NIST, in cooperation with DOE, develop new or amended test procedures for measuring the energy efficiency of residential and commercial equipment

NIST activities directed/funded by DOE Building Technologies Appliance Standards Program

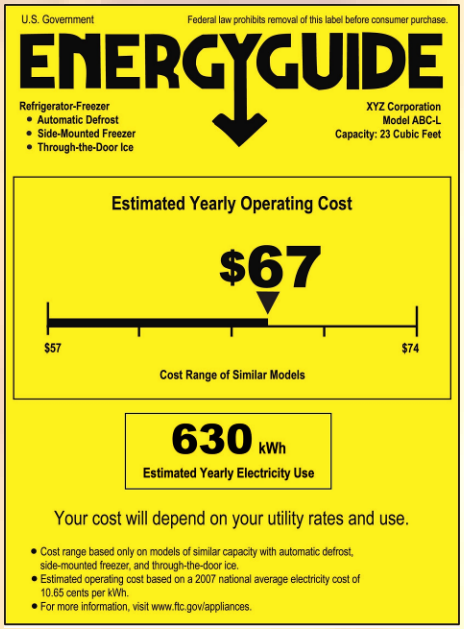
Covered Products

- Refrigerators, refrigerator-freezers, and freezers
- Room air conditioners
- Central air conditioners and heat pumps
- Water heaters
- Furnaces
- Dishwashers
- Clothes washers/dryers
- Direct heating equipment
- Kitchen ranges, ovens, and microwave ovens
- Pool heaters
- Television sets
- Fluorescent lamp ballasts/lamps/incandescent reflector lamps
- Showerheads, except safety shower showerheads
- Faucets/showerheads
- Water closets
- Urinals
- Electric motors and transformers

NIST's Role

Develop and maintain fair and equitable test procedures used by

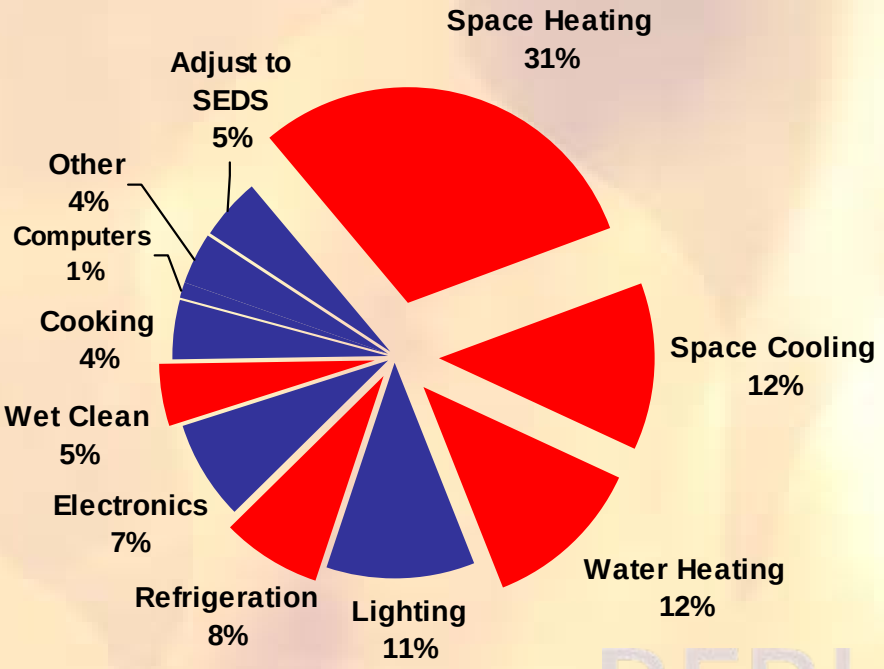
- Consumers to make informed purchasing decisions (FTC Energy Guide Label)
- DOE to set minimum efficiency standards
- Others outside of original EPCA mandate including
  - Energy Star Program
  - Utilities
  - Rebate programs
  - Carbon emission calculations



Methods of Test and Rating Procedures

Emerging Issues/Problems

- Selected Five Appliances
- Collectively Account for over 65% of Residential Energy Use
  - Water Heaters
  - Refrigerators/Freezers
  - Dishwashers
  - Heat Pumps/Air Conditioners



Source: 2007 Buildings Energy Data Book
U.S. Residential Buildings Primary Energy
End-Use Splits, 2005

Residential Water Heaters

Test Procedure History

1977 First Test Procedure Released

- Consisted of two independent tests
  - Recovery efficiency test
  - 48 hour standby loss test
- Results used to estimate annual energy consumption

1979 “First Hour Rating” Procedure Added to Test Procedure

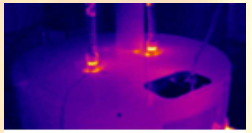
- Attempt to measure quantity of “hot” water available

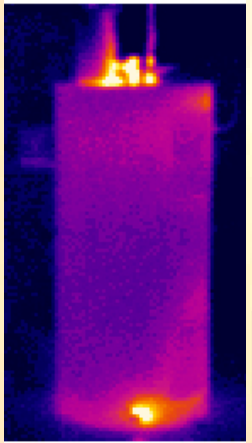
1990 24-hour “Simulated Use” Test Introduced

- 64.3 gallons removed in six equal hourly draws
- Inclusion of tankless water heaters
- Inclusion of heat pump water heaters

1998 Changes to “Simulated Use” Test Procedure

- Revision of First Hour Rating
- New rating for tankless water heaters
- Amended definition of heat pump water heaters





Residential Water Heaters

Unresolved Issues

Tankless Water Heaters:

Evidence suggests that tankless water heaters are incorrectly rated by current test procedure because of their efficiency degradations as the number of draws increases.

Heat Pump Water Heaters:

Heat pump water heater performance is strongly dependent upon ambient temperature, water temperature, and draw patterns. Does the current procedure give an accurate representation of the energy consumption of heat pump water heaters?

Repeatability:

Recent studies have uncovered vague areas in the current test procedure that lead to a lack of repeatable results.

Test Conditions:

The current test conditions that specify, among other items, that stored water temperature be 135 F and the total draw volume be 64.3 gallons per day may not replicate real-world use. Should these and other values be adjusted to provide a more accurate estimate of energy consumption?

Residential Refrigerators and Freezers

Test Procedure History

1977 First DOE Test Method for Residential Refrigerators

- Unacceptably burdensome for manufacturers

1979 Association of Home Appliance Manufacturer (AHAM) publishes less burdensome test method, HRF-1-1979, and petitions DOE to adopt this method

- Overall, rating procedure is reasonably accurate for estimating field use performance
- Units rated under static conditions
- Tested in elevated ambient temperature to account for usage
- Only primary storage function is tested (ice maker, water dispenser, other features not tested)

1982 DOE adopts HRF-1 as the official test method

- Test program for refrigerators have resulted in energy reductions of 60% from 1980 – 2005*

No significant changes in the past 25 years

*** Data Provided by AHAM**

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Residential Refrigerators and Freezers
Unresolved Issues

HRF-1 Prescribes Static Test Conditions:

- Modern appliances use sensors and controls to adjust performance for dynamic operating conditions (*Example ambient humidity sensors influence "anti-sweat heaters")*
  - Fair and reasonable credit during test
- Some manufacturers use sensors and controls to detect test conditions and switch operation to low energy "test mode"
  - Exploiting test procedure to achieve unrealistically favorable energy rating

Globalization:

- Manufacturers operating in multiple markets must perform energy tests for each market due to differences in rating methods (AHAM,IEC,JIS,AUS/NZ, etc.)
- NIST personnel active in multinational effort to develop new globally acceptable rating procedure that minimizes test burden for international trade and safeguards integrity

Residential Dishwashers

Test Procedure History

1977 First Test Procedure Released

- Direct measure of machine energy consumption
- Calculation of energy consumption for supply water heating
- Results used to estimate annual energy consumption

1987 Cold Water Supply Test Introduced

- 50 degree F inlet water temperature
- Requirement to heat to 120 degree F in wash cycle

2001 Consumer Usage Data Adjusted

- Revision of compact and standard dishwasher definitions to capacity (place setting) basis
- Reduction in estimated annual operating use to 264 cycles per year (impacts estimated annual operating cost)
- Need for soil based testing established

2003 Method for Adaptive Control Models, Stand-by Power Introduced

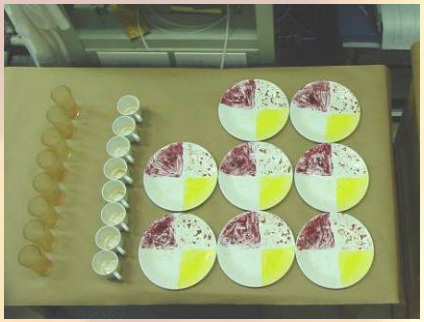
- First soil-based test introduced (light, medium, and heavy loading)
- Inclusion of stand-by power consumption in the estimated annual operating cost for all dishwashers (not in energy factor)
- Reduction in estimated annual operating use to 215 cycles per year

Residential Dishwashers

Unresolved Issues

Stand-by power:

Stand-by power is not included in the energy factor calculation. Stakeholders were resistant to include standby power on label.



Repeatability:

Soil loading has significant impact on energy factor/annual energy consumption
Specified soil loads should be reviewed
Repeatability of current test procedure needs to be verified

Special features:

Features that impact energy consumption are being introduced
Existing test procedure may not capture impact

Test Conditions:

The current test conditions for soil-sensing models specify a 3-level weighted average with soil levels intended to replicate real-world use. Should these and other values be adjusted to provide a more accurate estimate of energy consumption?

Central Air Conditioners and Heat Pumps

Test Procedure History

1980 Original Test Procedure

- Covered single-speed and two-capacity ducted units
  - Steady-state and “Frosting” tests used to generate performance “maps”
  - Cyclic tests used to capture degradation due to unit cycling
- Included algorithms for estimating seasonal performance (SEER and HPSF) and converting to seasonal energy consumption and operating cost

1988 First Revision/Expansion of Test Procedure

- Add coverage for variable-speed (one-to-one) units, non-ducted mini-splits, and a credit for demand defrost heat pumps

1992/1993 NAECA Minimum Standards Became Effective

- Noted because 2005 and 2007 test procedure revisions limited to updates that did not change the SEER & HSPF of an existing unit

2005 & 2007 Second and Third Test Procedure Revisions

- Add coverage for niche products: multi-splits (1st pass, northern heat pumps
- Address new equipment features: constant CFM blowers, heat comfort controllers
- Address issues tied to sampling tested combinations and to rating untested combinations

Central Air Conditioners and Heat Pumps

Unresolved Issues – Near Term

Multi-Split Air Conditioners and Heat Pumps

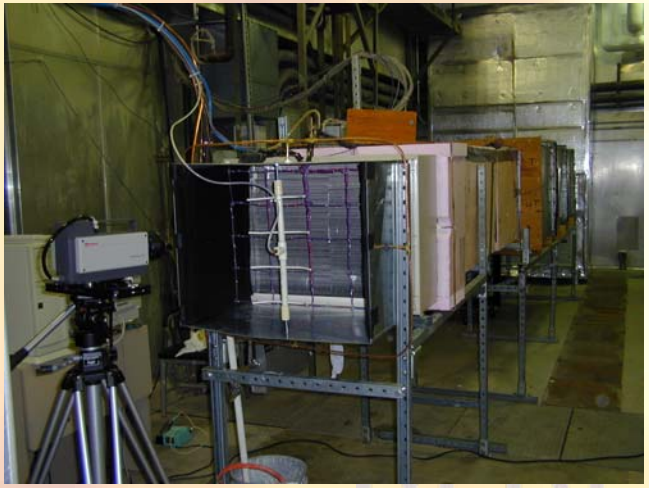
Improve upon the current approach for testing and rating the highest sales volume combination (2nd pass). Also, develop a method for predicting the performance of the multitude of untested combinations.

Guidance for Consumers Having a Heat Pump and a Gas Furnace

Develop a user-friendly computer program that can be used to evaluate the economics of such a system and the best way to operate it (i.e., when to switch the heat pump off) for a specific installation: account for the individual equipment efficiencies and capacities, the unique building load, local weather data, and the specific utility rates.

Lab and Field Testing

Determine if relative ratings under laboratory conditions translate to field conditions.



Central Air Conditioners and Heat Pumps

Unresolved Issues – Long Term

Are SEER, HSPF, and Cyclic Testing "The Future"?

Evidence of growing need for instantaneous efficiency at peak load and CO_2 contribution.
Cost-benefit of laboratory cyclic testing is perceived as diminishing.

Utility Interactive/Responsive Controls

Account for controls that help the consumer minimize the cost of operation in an electric utility rate structure that more directly passes on the utility's real-time price of power.

Test Conditions

Indoor-side inlet air conditions, minimum external static pressure that must be achieved by the indoor blower, the histogram of the hourly outdoor temperatures occurring during the cooling and heating seasons, and the equations that define typical building loads are among several key testing and calculation parameters that are subject to complaints as being atypical of most field installations.

Humidity Control

In certain locations of the US now and as progress continues toward net zero energy buildings, the latent building load – not the sensible load – dominates. Look for ways to explicitly credit equipment that excels at maintaining the indoor humidity at a comfortable level.

International Standardization

Convert to using SI units and work towards convergence with evolving ISO Standards.

Source or Site Energy?
Depends on Your Perspective

Homeowner/Building Owner

- Majority base purchasing decision on appliance/equipment's initial cost, features, and operating cost
- Minority (but increasing) are concerned with overall energy implications and environmental emissions

Energy Advocate/Environmentalists

- Concerned with reducing the Nation's overall energy consumption, and reducing emissions associated with fossil fuel energy generation
- Use of source energy encourages utilities to improve central power plant efficiencies and decrease transmission and distribution (T&D) losses

Gas/Oil Supplier*

- Feels that source energy should be used for all appliances regardless of primary energy source
- Presents impact of operating appliance/equipment in terms of required fuel

Electricity Provider*

- Feels that the objective of the appliance standards is to benefit the consumer
- Consumer has no control over central power plant efficiencies or T&D losses

*Based on comments published in Federal Register January 20, 1995 (Page 4347) received by DOE in response to proposed revision to existing energy factor and proposed new energy efficiency descriptor published in Federal Register – August 23, 1993, 58 FR 44538

Source or Site Energy?

A Simple Example – Residential Water Heater

Residential Water Heaters

- 50 Gallon
- Identical Loads
  - 64.3 gallons
  - 58 F inlet
  - 135 F outlet
- Assumed Energy Costs
  - $.0841 per kWh
  - $0.91 per therm

	Electric	Gas
Efficiency Factor (Site)	0.95	0.63
Efficiency Factor (Source)	0.31	0.59
Site Energy Consumed -	15.86 MMBtu (4648.3 kWh)	23.93 MMBtu (239.3 therm)
Source Energy Required to Supply Site	48.21MMBtu	25.46 MMBtu
Cost to Consumer	$390.92	$217.69
CO_2 Emissions (EPA emission calculator)	3.6 Metric Tons	1.2 Metric Tons

Assumptions :Electric - Power Plant Efficiency 35%, T&D Losses 6%, Natural Gas – T&D Losses 6%

Use of Source or Site Energy?

How do we proceed so we can all succeed?

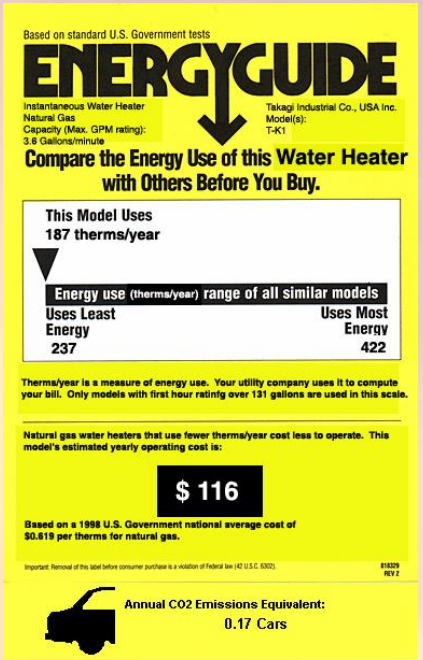
Add a CO_2 Indicator to Energy Label

- Using EPA's Equivalency Calculator it is possible to convert source emissions into various equivalent units

  http://www.epa.gov/solar/energy-resources/calculator.html

- Does not confuse purchaser with fuel source, means of generation, T&D losses, etc.

- Provides environmental impact info that a growing number of consumers desire
- Equivalent units easier to grasp than CO_2 metric tons
- Choices include –
  - Passenger vehicles per year(11,856 miles at 19.7 mpg)
  - Equivalent miles driven
  - Acres of pine or fir forests storing carbon
  - Etc.



For this gas water heater the CO_2 emissions associated with its annual use is equivalent to ".17 cars" or 2,016 vehicle miles driven