Verification Protocols for Rating Software Programs

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New Verification Activities

- Development of new “rule sets” for IECC compliance and tax credit purposes
  - Revision of Standard Reference Design auto-generation test
- Development of additional test suites for IECC performance compliance and tax credits:
  - Duct heat transfer and air leakage
  - Thermostat setup/setback
  - Natural ventilation & heating/cooling seasons
  - Insulated concrete form construction
  - PV system performance
  - Solar hot water system performance

Tax Credit "Rule Set"

- Numerous "specificity gaps" in Chapter 4, IECC 2003, including:
  - Envelope component types, solar absorptance and far-infrared emittance
  - Sunroom treatment
  - Envelope air exchange rates
  - Mechanical ventilation
  - Natural ventilation to offset cooling
  - Structural mass
  - Electric heating systems
  - Thermal distribution systems

Window Area

- Window areas for multifamily homes and homes with conditioned basements are ill-specified by IECC 2003:
  - "Strict" interpretation (18% CFA) results in excessive Standard Design window area for homes with conditioned basements
  - Proposed conditioned basement window area specification is same as RICC, where window area is discounted by 50% of underground wall area
  - Proposed multi-family window area specification is same as HERS standard, where window area is discounted by common wall area.

Window Area Specification

$$\mathbf{A_F = 0.18 \times A_{FL} \times F_A \times F}$$

where:

A_F = Total fenestration area

A_{FL} = Total floor area of conditioned space

F_A = (Above grade thermal boundary gross wall area)/(above grade boundary wall area + 0.5 x below grade boundary wall area)

F = (Above grade thermal boundary wall area)/(above grade thermal boundary wall area + common wall area) or 0.56, whichever is greater.

Air Exchange Rate

- Envelope air exchange rates for homes with conditioned basements are ill-specified by IECC 2003:
  - "Strict" interpretation results in excessive air exchange for homes with conditioned basements
  - Proposal is to modify basement air exchange rate based on the ratio of below-grade to total basement wall area.

Air Exchange Rate Specification

$SLA_{\mathbf{bsmt}}$ = $SLA_{\mathbf{std}}$*[(above-grade basement wall area) / (total basement wall area)]

$SLA_{\mathbf{a\text{-}g}}$ = $SLA_{\mathbf{std}}$ (where 'a-g' indicates above-grade)

$SLA_{\mathbf{overall}}$ = [($CFA_{\mathbf{bsmt}}$* $SLA_{\mathbf{bsmt}}$) + ($CFA_{\mathbf{a\text{-}g}}$* $SLA_{\mathbf{a\text{-}g}}$)] / [$CFA_{\mathbf{total}}$]

Calculation may be by zone, applying $SLA_{\mathbf{bsmt}}$ to the basement zone and $SLA_{\mathbf{std}}$ to the above-grade zones of the home and treating the energy balances separately for each zone or by applying $SLA_{\mathbf{overall}}$ to the combined spaces in the home as a single zone

Existing Test Protocols: Status

- **BESTEST, Tier 1** – in current RESNET standards
- **HVAC tests** – developed and under test
- **Reference Home auto-generation** – partially developed but being expanded to include:
  - IECC "rule sets" for RICC code compliance and and tax credit purposes
  - One-story & two story "standard" homes
  - Slab-on-grade, crawlspace and basement

New Test Protocols: Priorities

- Air distribution system tests
- Thermostat setback/setup tests
- Natural ventilation tests
- Insulated concrete form tests
- Passive solar and thermal mass tests (BESTEST, Tier 2)
- PV systems performance tests
- Solar hot water systems tests

Air Distribution System Tests

- **Purpose:** Air distribution system heat transfer and air leakage significantly impact heating and cooling energy use
- **Strategy:** Test software with duct inside and outside of conditioned space, with and without distribution system leakage
  - Vary duct location between inside, attics, crawlspaces and basements
  - Vary duct insulation levels
  - Vary distribution system air leakage

Air Distribution System Tests

- **Criteria:** Require % change in heating and cooling to be within bounds based on ASHRAE Standard 152, “Standard Method of Test for Air Distribution System Efficiency” ± some % yet to be determined.

Thermostat Setback/Setup Tests

- **Purpose:** Thermostat setting has a significant impact on cooling and heating energy use and software must accurately predicts these impacts
- **Strategy:** Test software with and without programmable thermostat applied
  - Test in heating dominated climate (Madison), cooling dominated climate (Miami) and benign climate (San Diego)
  - Require percentage change in heating and cooling energy use to be within specified bounds.

Thermostat Setback/Setup Tests

Example Results:

Change in Energy Use With Respect to No Setback/Setup Case

Climate Location	Cooling Energy Change (%)	Heating Energy Change (%)
Madison, WI	-9.6%	-5.3%
Miami, FL	-10.8%	-22.7%
San Diego, CA	-15.7%	-26.6%

Natural Ventilation Tests

- **Purpose:** Cooling energy use can be significantly over-predicted if natural ventilation is not correctly applied
- **Strategy:** Test software with and without natural ventilation applied
  - Test in heating dominated climate (Madison), cooling dominated climate (Miami) and benign climate (San Diego)
  - Require percentage change in heating and cooling energy use to be within specified bounds.

Natural Ventilation Tests

Example Results:

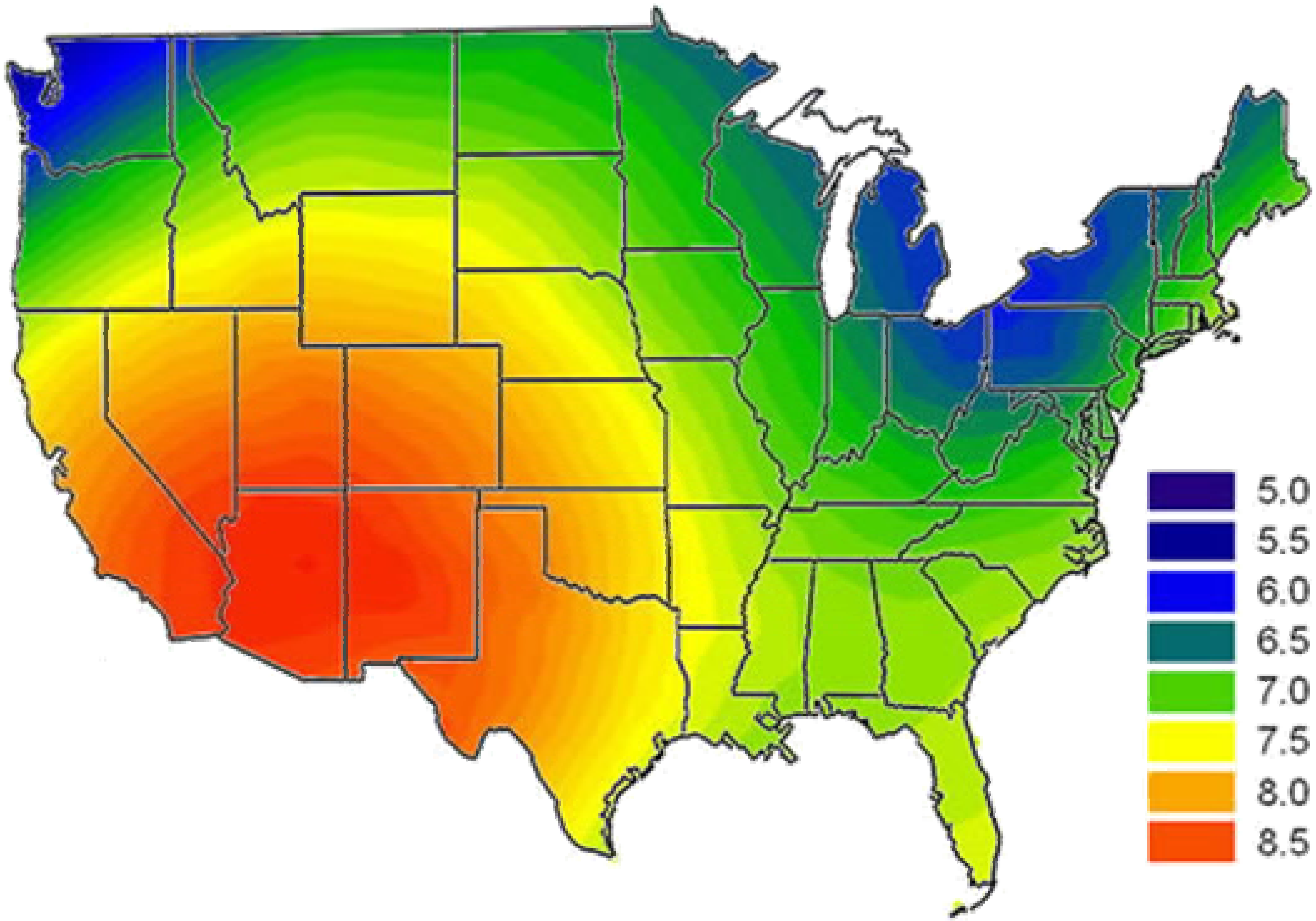
Change in Energy Use With Respect to Unvented Building Case

Climate Location	Cooling Energy Change (%)	Heating Energy Change (%)
Madison, WI	-30.0%	+3.7%
Miami, FL	+2.8%	+36.2%
San Diego, CA	-53.3%	+57.8%

PV System Performance Tests

- **Purpose:** In addition to orientation, tilt and rated panel and inverter performance, annual PV system performance is also significantly dependant on solar availability and array temperature.
- **Strategy:** Test software with and without a specified PV system
  - Test in a hot dry, sunny climate (Phoenix), a cool marine climate (San Francisco) and a hot, humid climate (Miami)
  - Require PV energy production to be within specified bounds yet to be determined.

Example: PV Performance



Average daily kWh delivered for 2 kWp residential PV array

Solar Hot Water Tests

- **Purpose:** Solar hot water system energy factors (EF) are based on national “average” conditions that can not predict specific performance. For example:
  - Inlet water temperature is set to 50 ^{o}F
  - Hot water supply temperature is 140 ^{o}F
  - Hot water draw is set at 64 gallons per day
- Actual conditions may vary significantly from the above EF assumptions.

Solar Hot Water Tests

- **Strategy:** Test software using 3 different specified solar hot water systems (integrated collector storage, open loop flat plate and closed loop flat plate) using the following variations:
  – 3 climate types: hot, dry (Phoenix); hot, humid (Miami) and cold (Madison)
  – 2 water use levels: 2-bedroom (50 gpd) and 4-bedroom (70 gpd)

Solar Hot Water Tests

- Use HERS standard and local climate data inputs:
  - Daily hot water use (30 + 10*N_{br})
  - Hot water supply temperature = 120 ^{o}F
  - Inlet mains water temperature (NREL equation)
  - Hot water draw profile (ASHRAE standard)
- **Criteria:** Require % change in hot water energy use to be within bounds based on Solar Rating & Certification Corporation (SRCC) standard TRNSYS models ± percentage yet to be determined.