FLORIDA SOLAR ENERGY CENTER®

Creating Energy Independence

Winter Infiltration Results from the FRTF Laboratory

Building America Stakeholders Meeting
Austin, TX
March 1-2, 2012

Philip Fairey

A Research Institute of the University of Central Florida

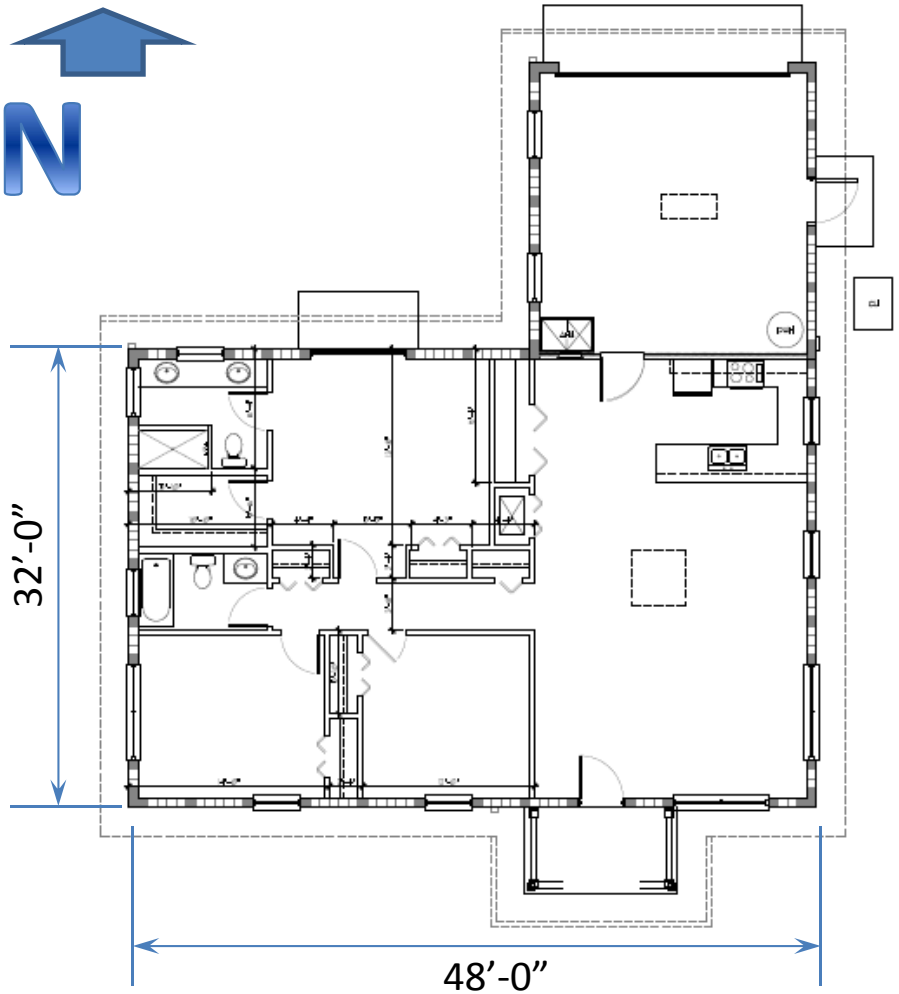
Project Objectives

Under side-by-side, in situ controlled conditions:

- Measure effectiveness of various energy retrofit improvements
- Produce high-quality empirical data set useful for home energy simulation verification.

- Two identical side-by-side 1536 ft^2, concrete block, slab-on-grade residences
- Single pane fenestration, evenly distributed
- No concrete block wall insulation
- R-19 ceiling insulation (current code minimum)
- SEER-13 w/strip heat HVAC systems

Lab Home Floor Plan

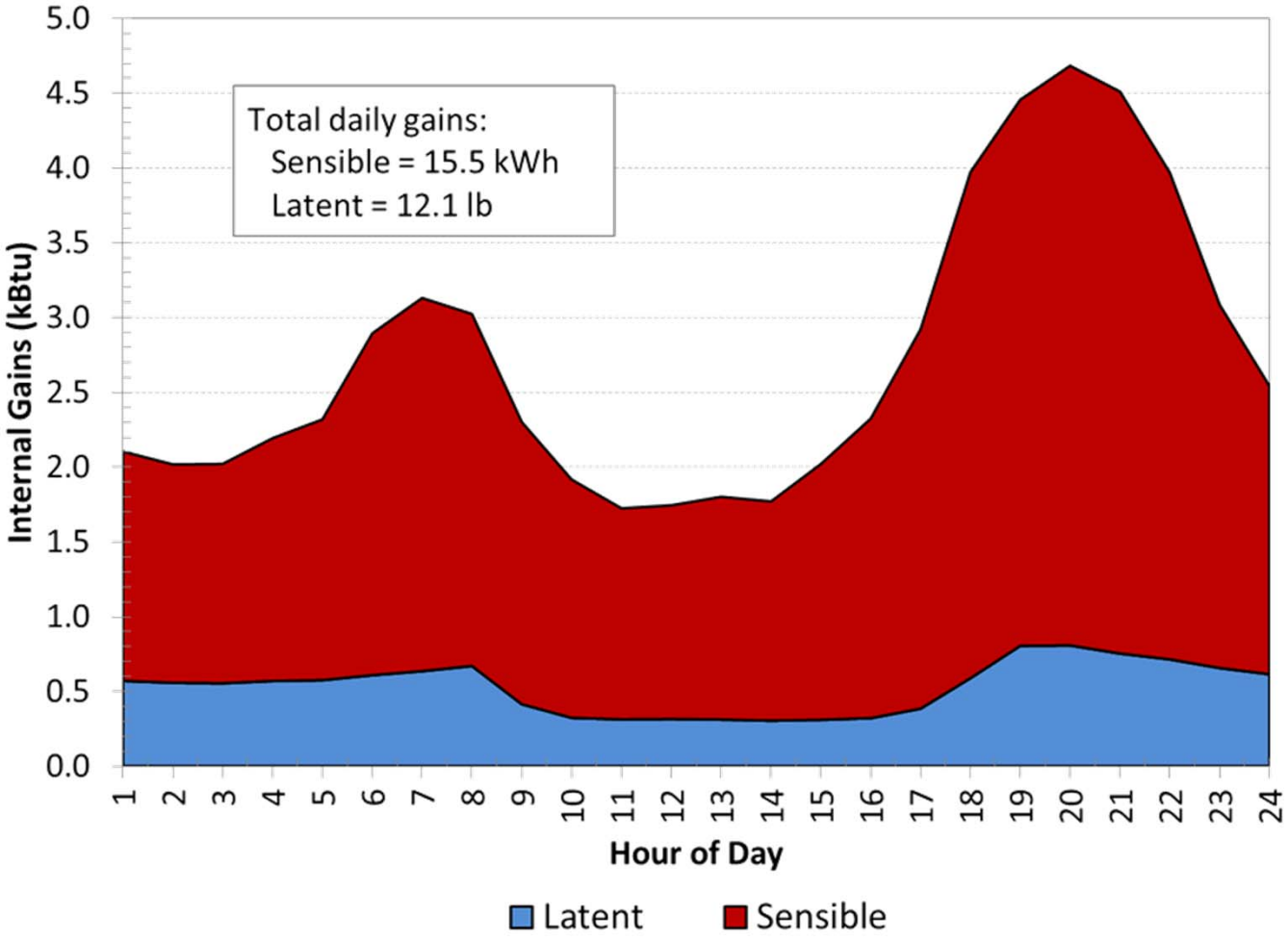


Interior walls not present in current test configuration

Occupancy Gains

- Automated (computer controlled) heat and moisture gains scheduled by time of day
- Based on RESNET lighting, appliance and miscellaneous energy usage amendment
- Imposed using BA benchmark hourly schedules with slight modifications
- Includes lighting and appliance gains and occupant gains
  - Sensible gains ≈ 15.5 kWh/day
  - Latent gains ≈ 12.1 lb H_2O/day

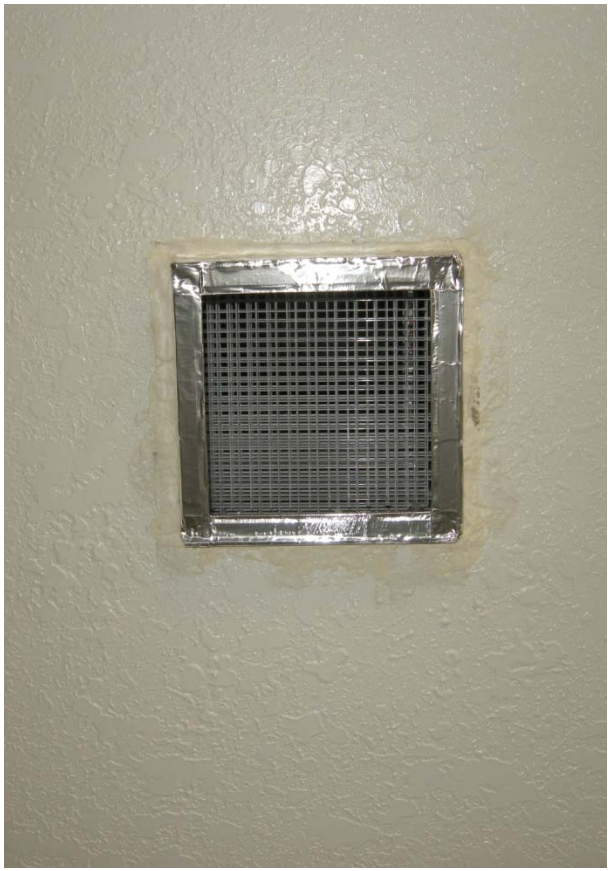
Scheduled Internal Gains



Enclosure Air Leakage Set-Up

- Both home enclosures air-tightened to achieve 2.5 ach50
- Air distribution systems in both homes tightened to achieve 20 cfm25 (Qn=0.013)
- Leaky home configured with 4 controllable ceiling leakage sites providing ~70% of leakage area needed to achieve ~9 ach50
- Remaining 30% of leakage area in leaky home achieved using metal shims at all windows.

Ceiling Infiltration Sites



Ceiling-side port

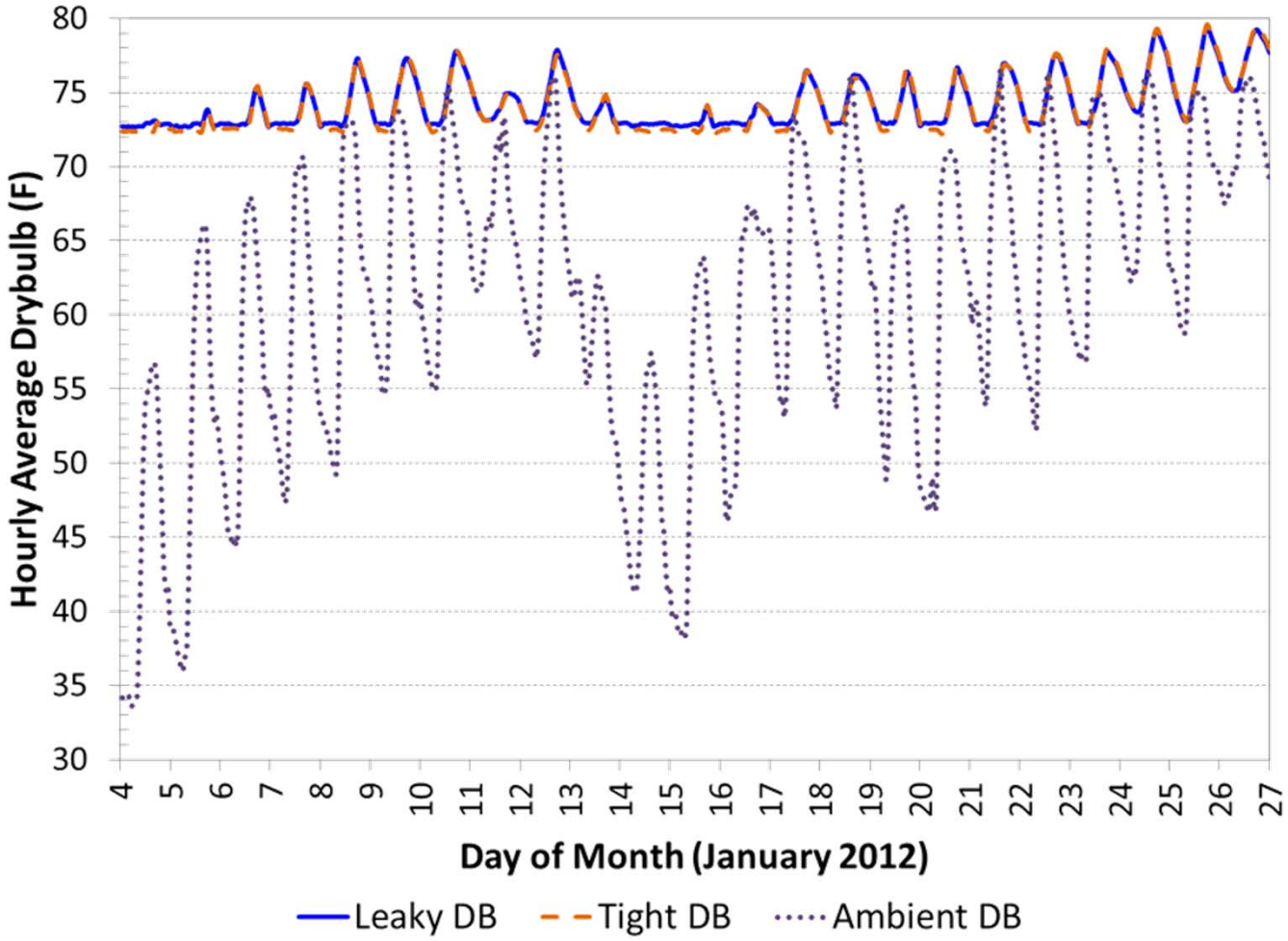
Attic-side port

Enclosure Leakage Test Results

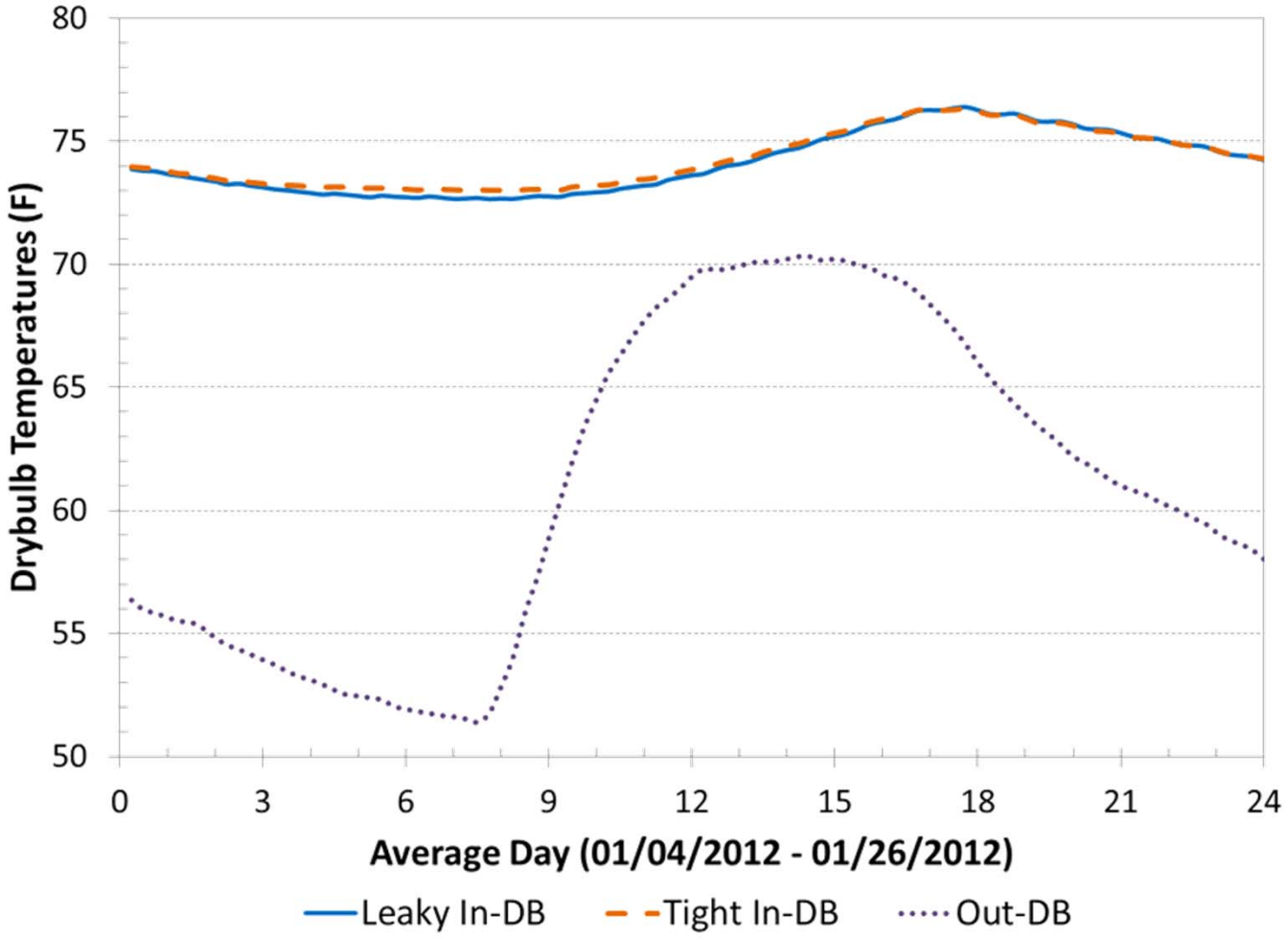
Leakage Parameter:	Leaky Home	Tight Home
cfm50	1926	520
ach50	9.17	2.48
C	182.3	36.0
n	0.603	0.683
R-sq	0.99805	0.99983
ELA (in^2)	118.9	26.3
SLA	0.000538	0.000119

$$\text{Airflow (cfm)} = C * \Delta P^n$$

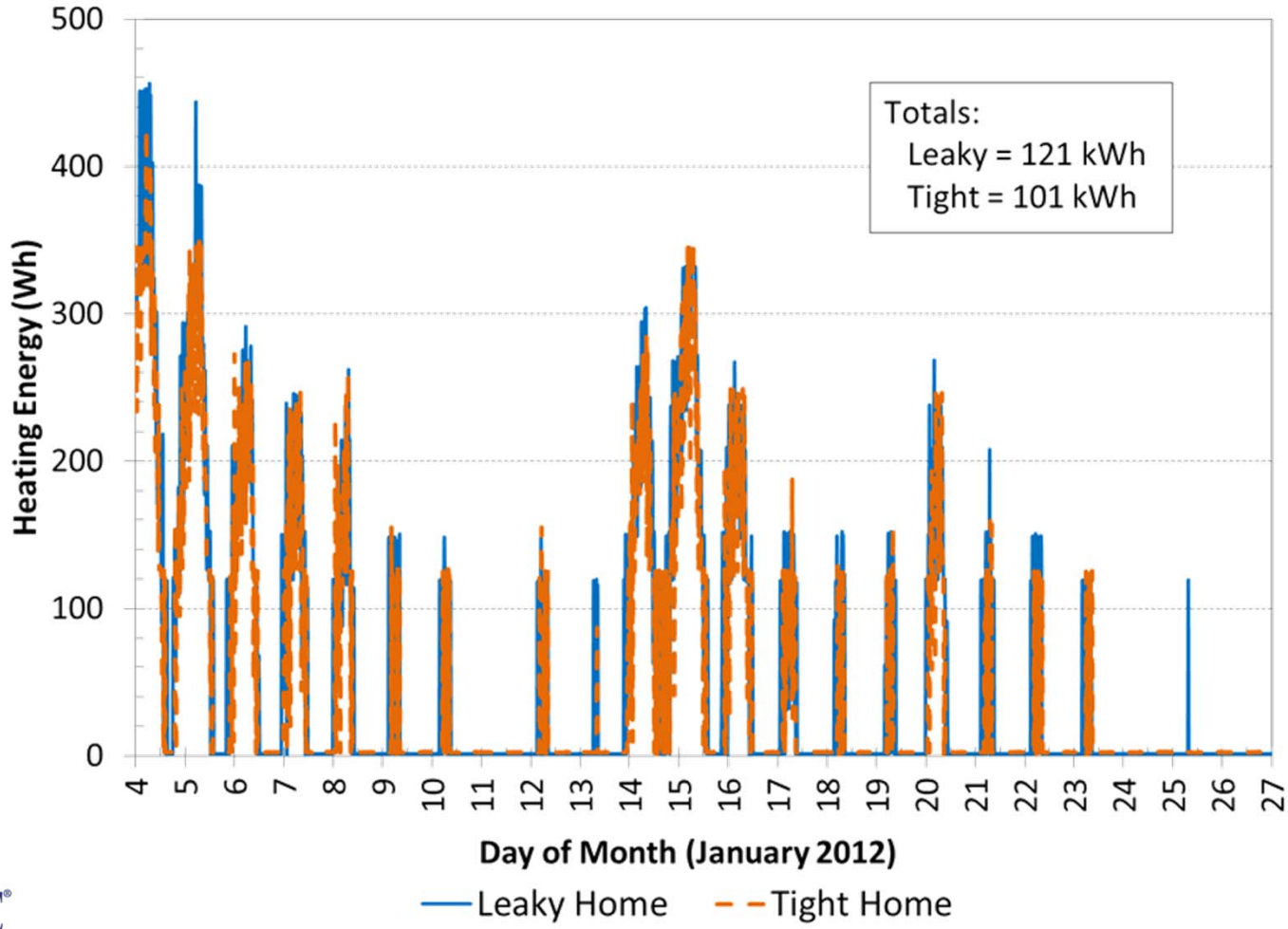
January Temperature Data



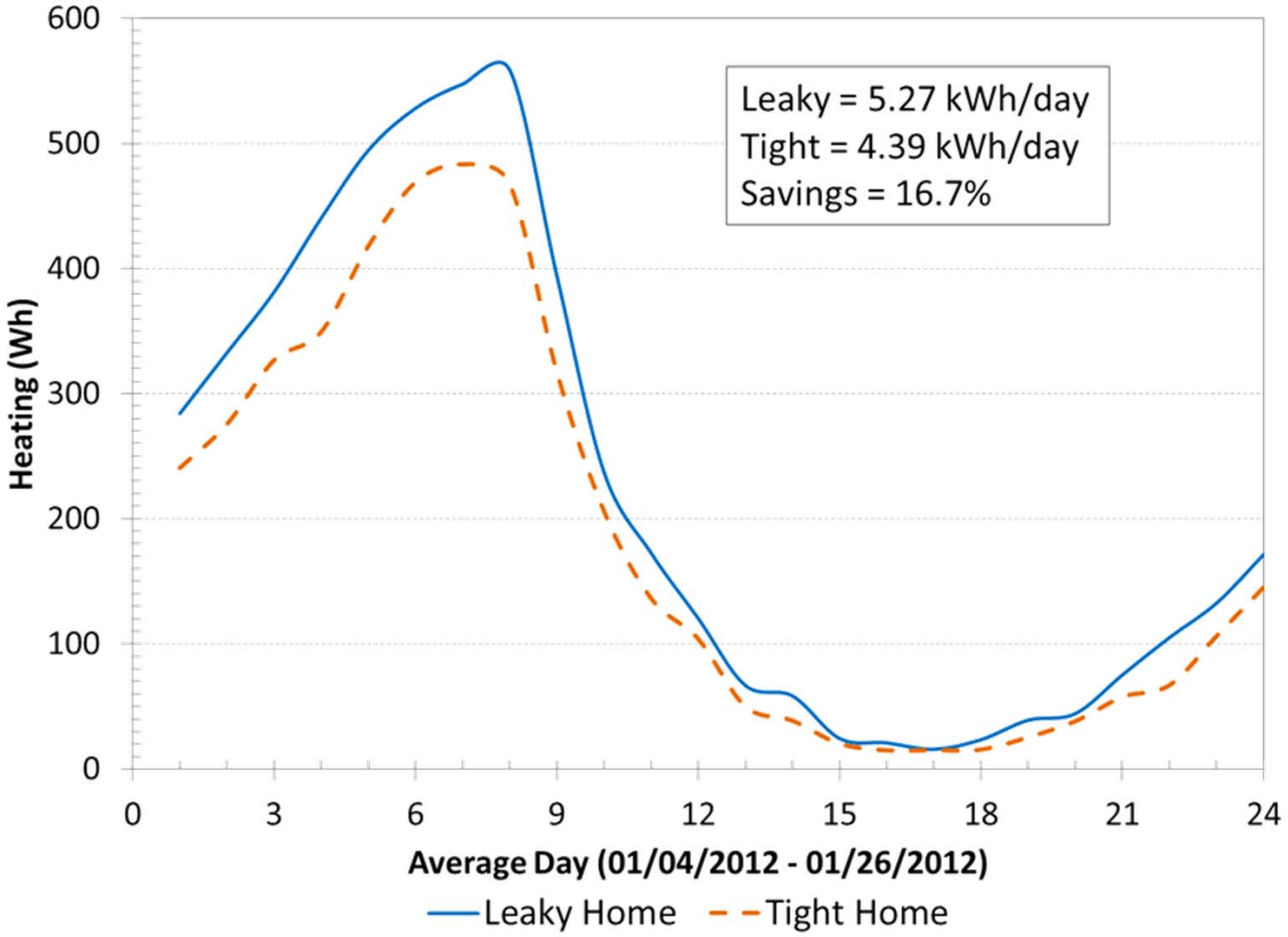
Average Day During Tests



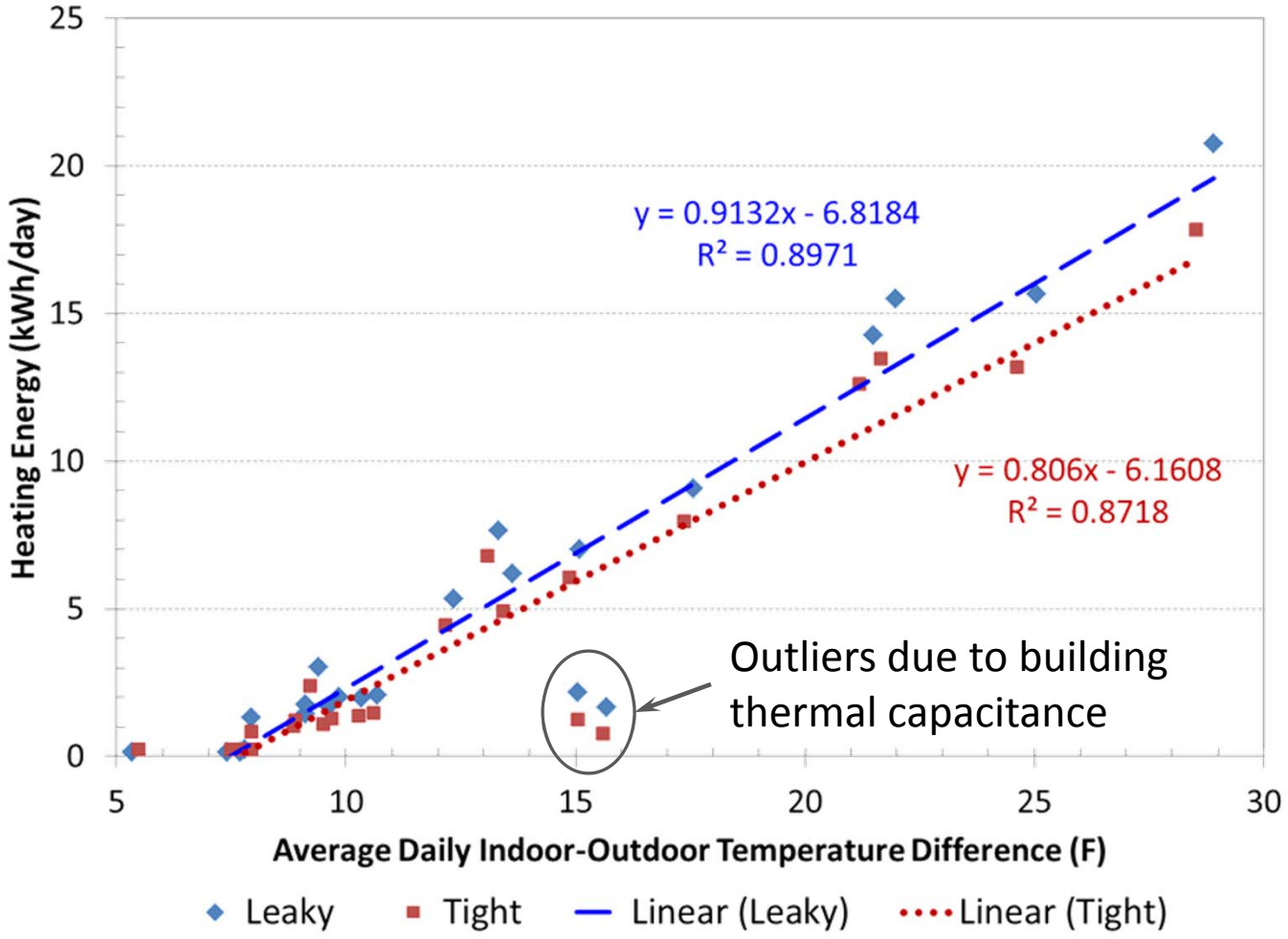
January Heating Data



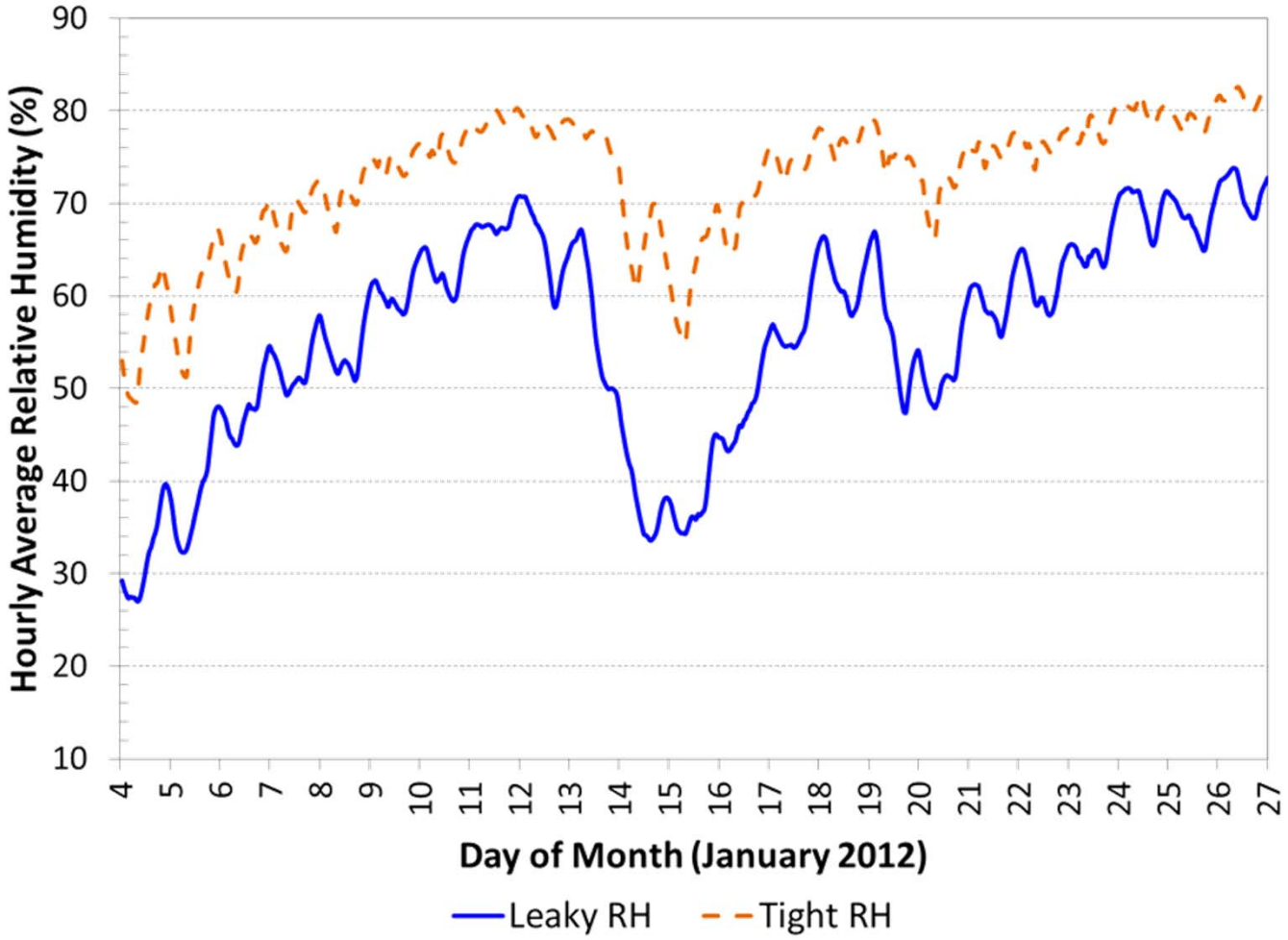
Average Day Heating Energy



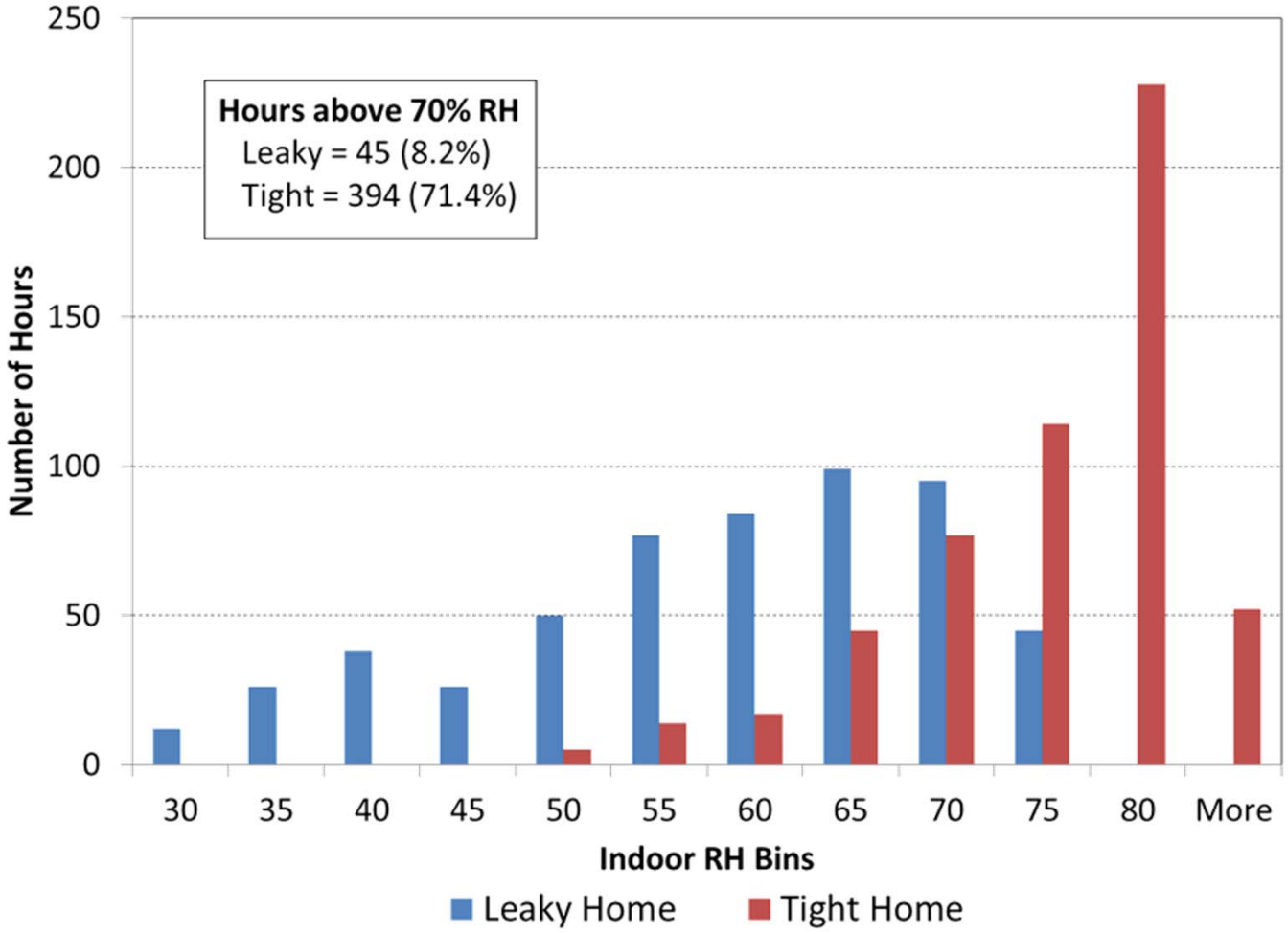
Heating Energy Characterization



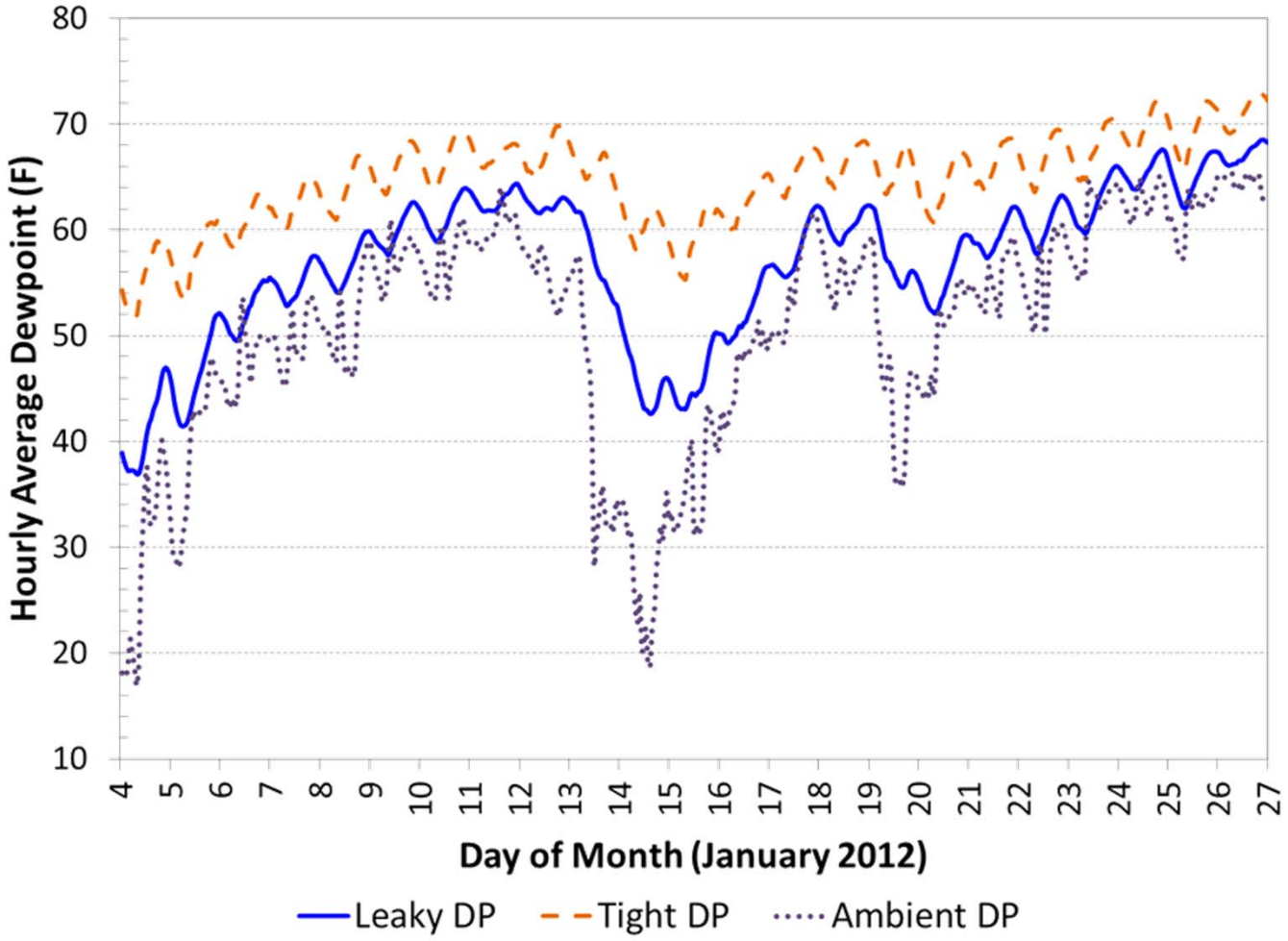
But . . . It's Still the Humidity!



January Indoor RH Histogram

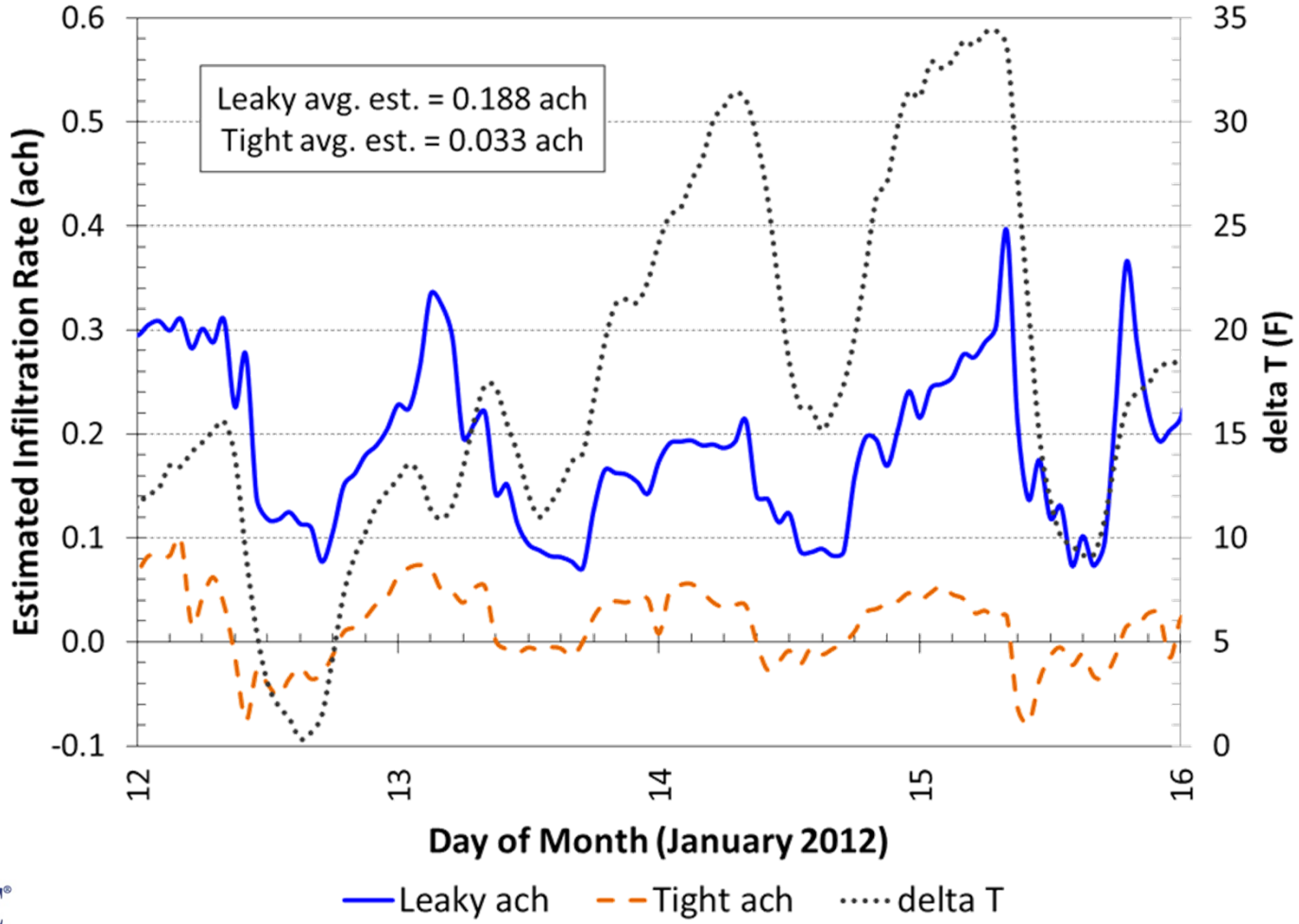


Why Leaky is Dryer



Estimated Infiltration Rates

(Moisture storage and condensation not included)



General Findings

- Moisture control is a critical issue
  - More than 70% of hours exceeded 70% RH in tight home
  - Only 8% of hours exceeded 70% RH in leaky home
  - Significant condensation on single-pane windows and glass doors in tight home led to local mold growth during tests
- Mild weather resulted in humidity control issues in both lab homes
  - Outdoor dewpoint temperatures sometimes to high for effective indoor RH control in leaky home
  - Tight construction exacerbates mild weather humidity issues
  - Enthalpy controlled ventilation systems should be evaluated in light of humidity control results.

Window Condensation

Condensation on all windows of tight building

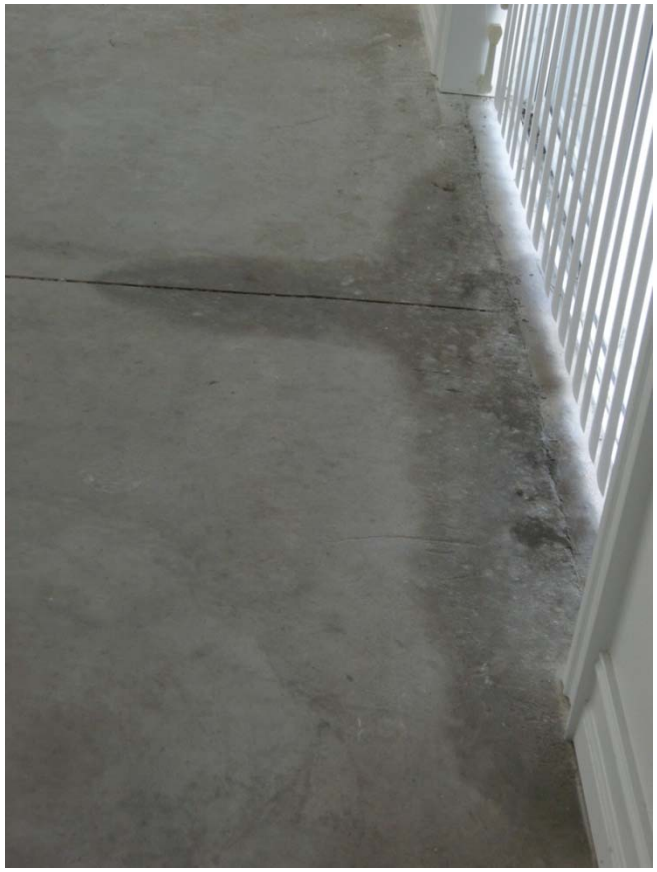
No condensation on windows of leaky building

Window Condensation

Much less condensation on screened portion

Window Condensation

Tight Home Glass Door Conditions



Water on floor from door condensation

Mold on drywall at bottom of door

Tight Home Window Mold

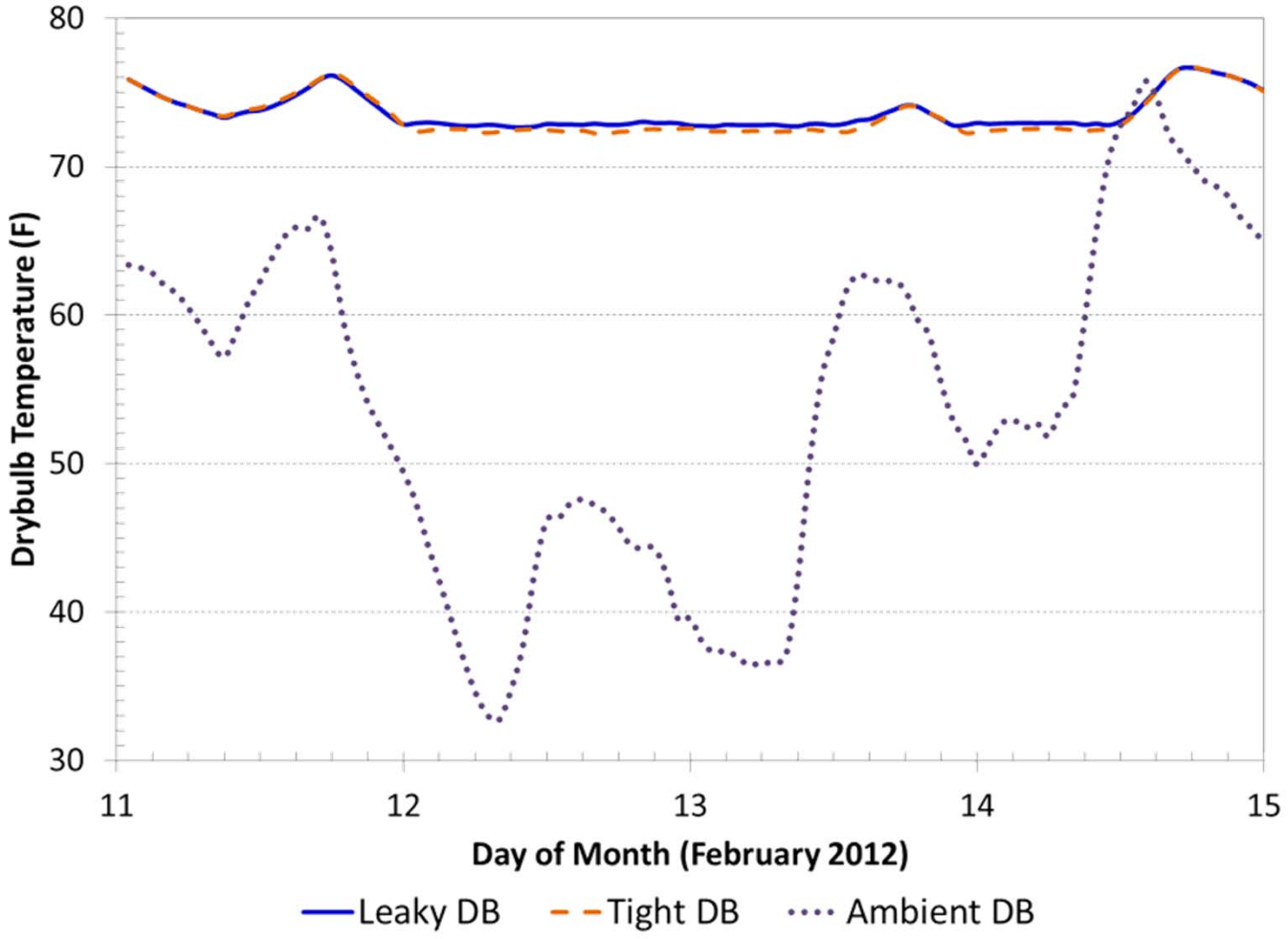
Some Caveats

- Lab homes have little moisture capacitance
  - No interior walls
  - No carpeting and no furnishings
- Lab homes operation is atypical
  - No exterior door openings
  - No kitchen or bathroom ventilation fan operation
- Could internal moisture generation schedule be the largest source of humidity control problem?

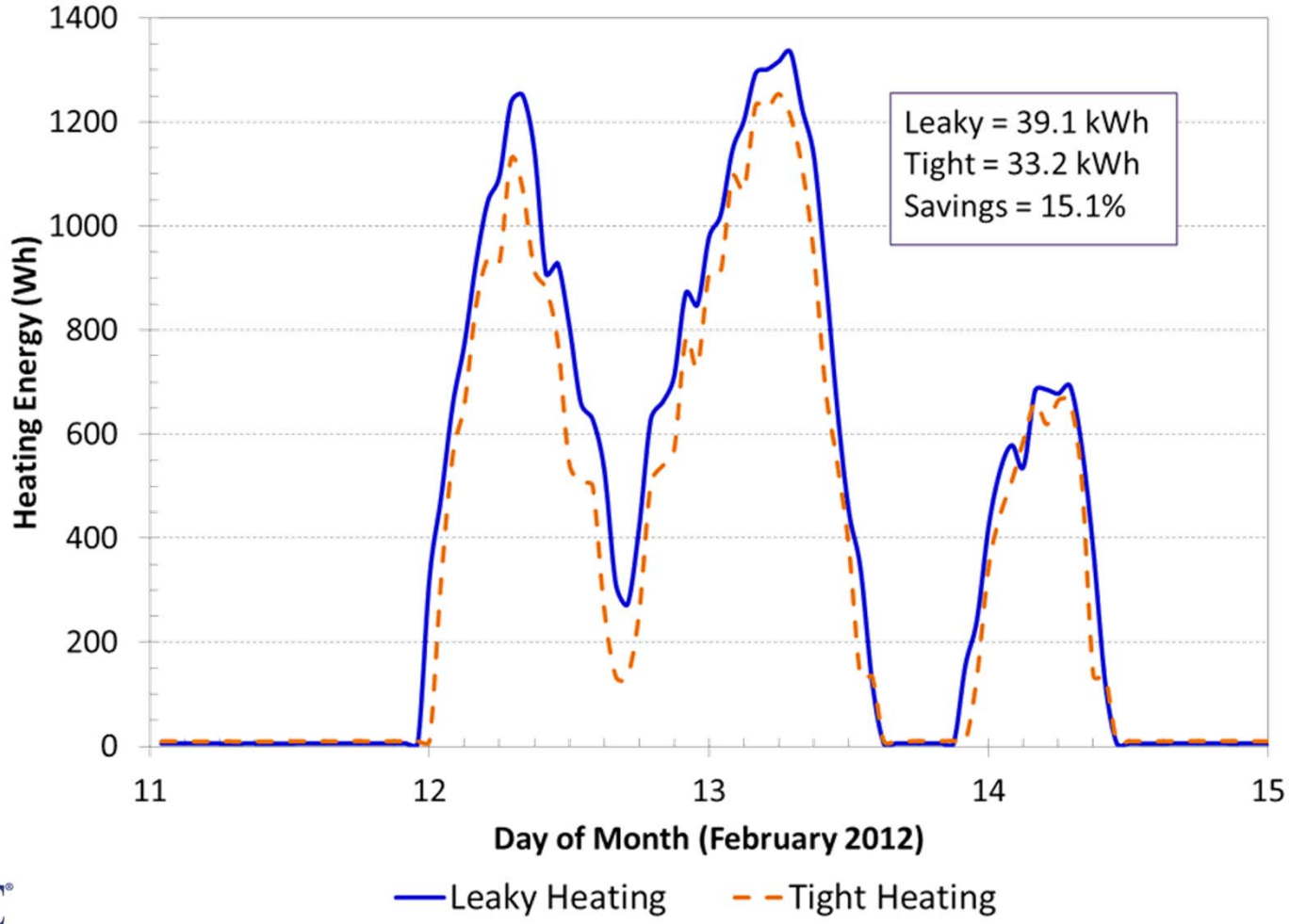
Immediate Follow-up Tests

- Immediately following the January test period
  - Lab homes were dried out by eliminating internal moisture generation and air conditioning as much as possible
  - Internal moisture generation was cut in half from 12.10 lb/day to 6.05 lb/day
- On February 8th, the heating systems in both lab homes were reactivated
- Cold snap on February 11-14 allowed additional measurements under the revised internal moisture generation schedule.

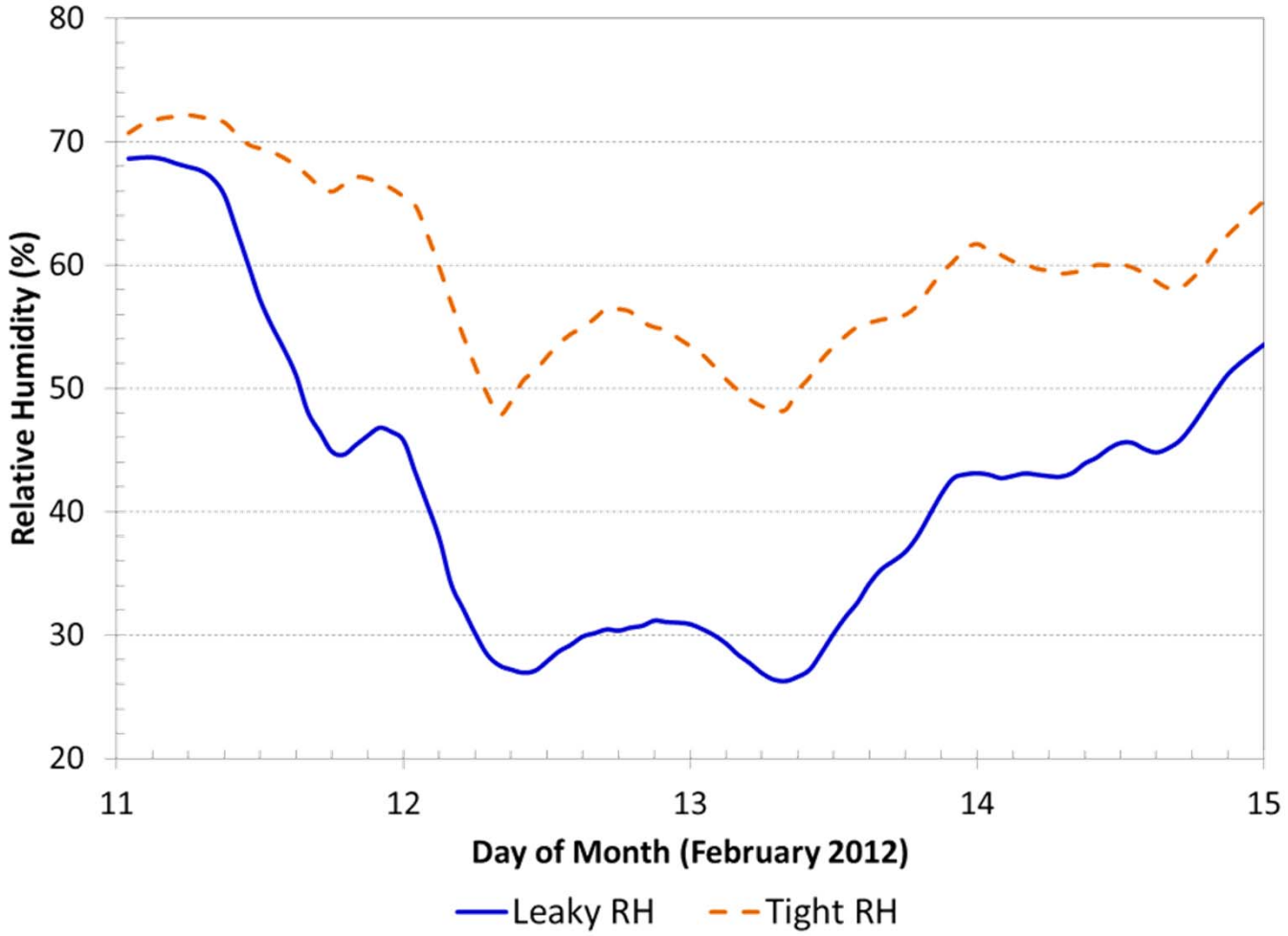
February Drybulb Temperatures



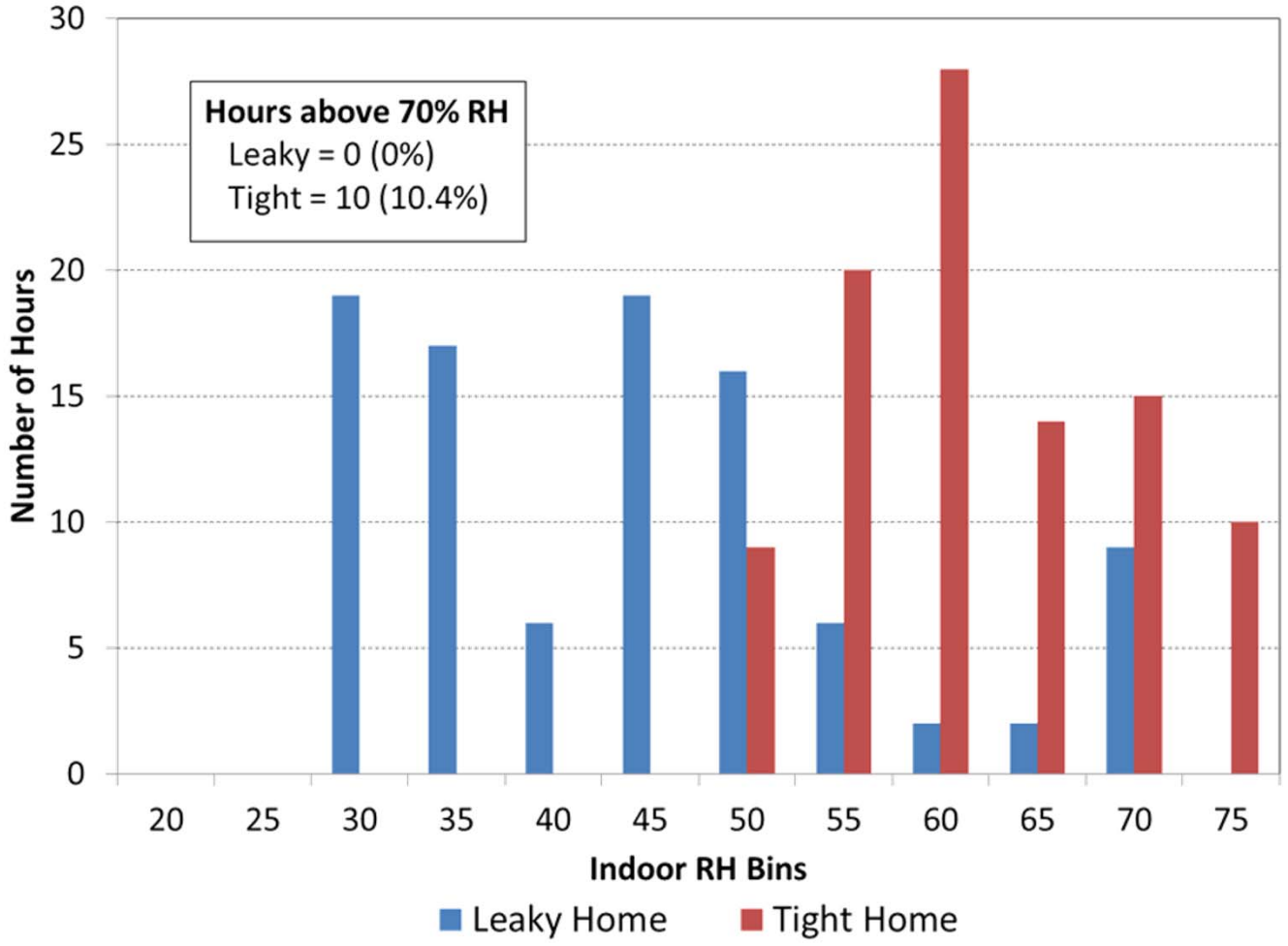
February Heating Energy



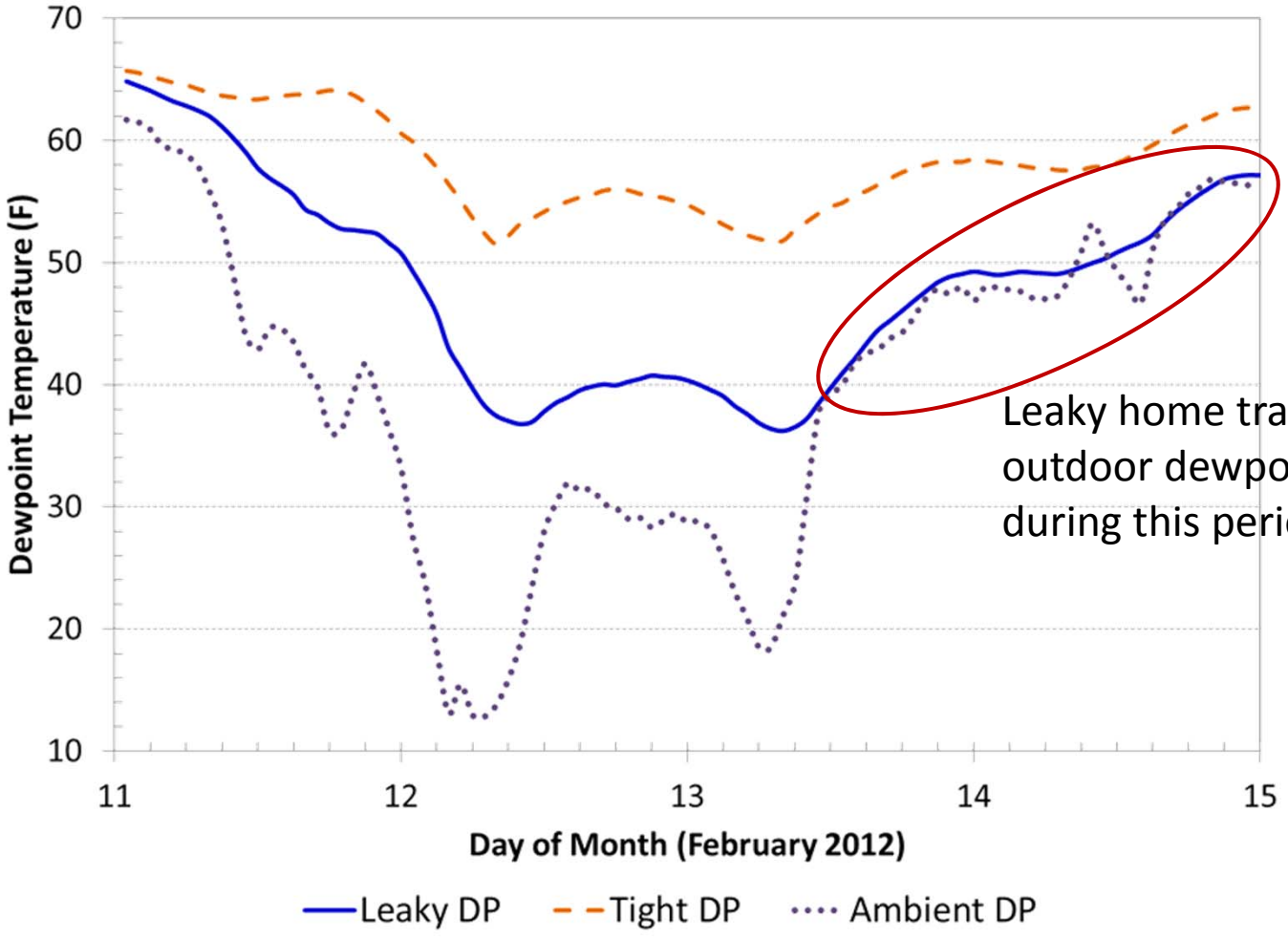
February Indoor Relative Humidities



February Indoor RH Histogram



February Dewpoint Temperatures



Re-Test Implications

- Halving internal moisture generation results in significant difference in percentage of hours exceeding 70% RH
- Indoor RH during cold period is 25% greater in tight home compared with leaky home
- On February 14th indoor dewpoint in leaky home is virtually identical to outdoor dewpoint
- Additional outdoor ventilation air is needed to better control indoor humidity in tight homes.

FLORIDA SOLAR ENERGY CENTER®

Creating Energy Independence

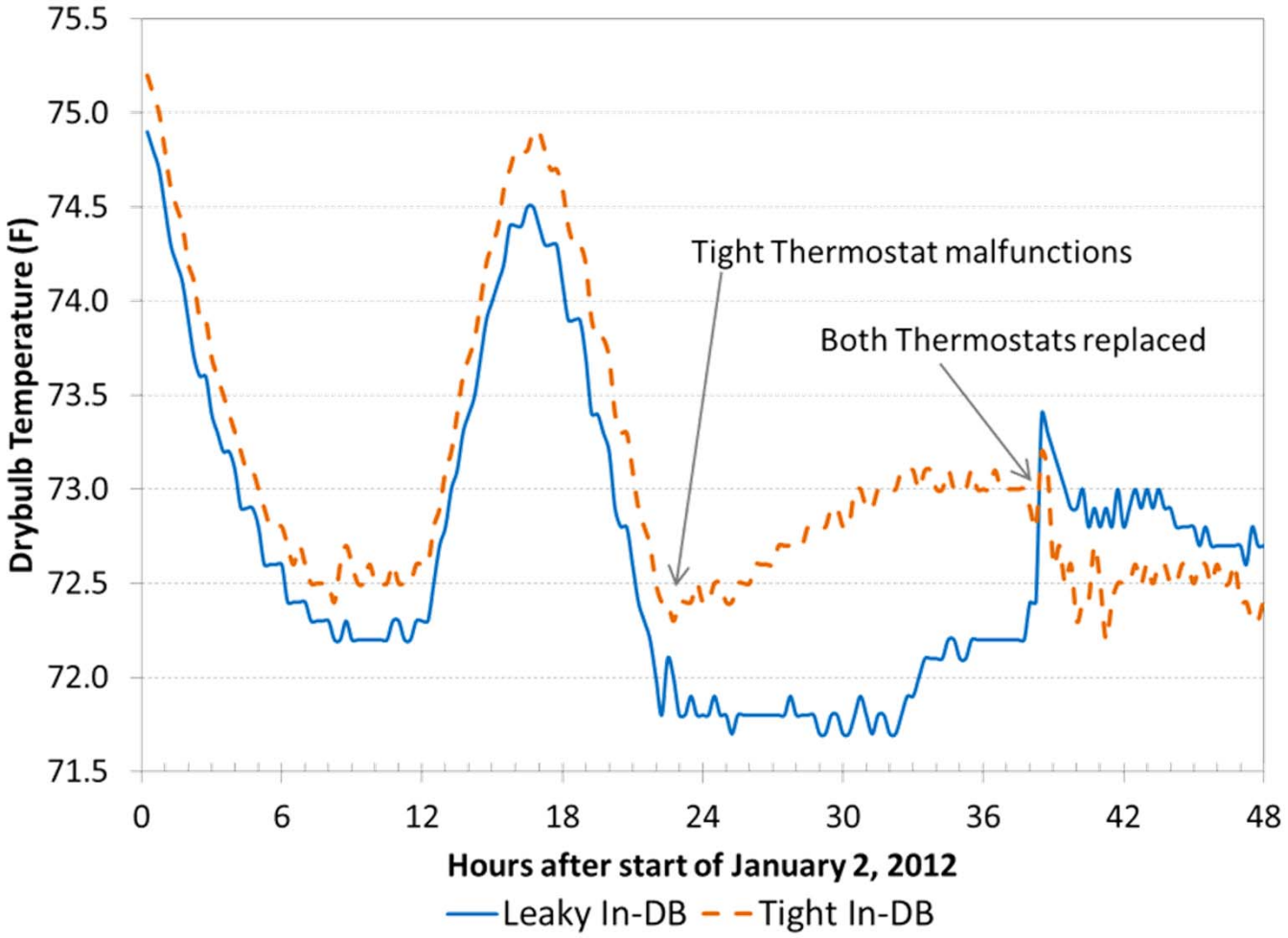
Questions?

FLORIDA SOLAR ENERGY CENTER®

Creating Energy Independence

Extra Slides

Just Before the Cold Snap!



Null Tests – No HVAC