



PIER Research for the 2008 Residential Building Standards

UZM Residential ACM Attic/Duct Model

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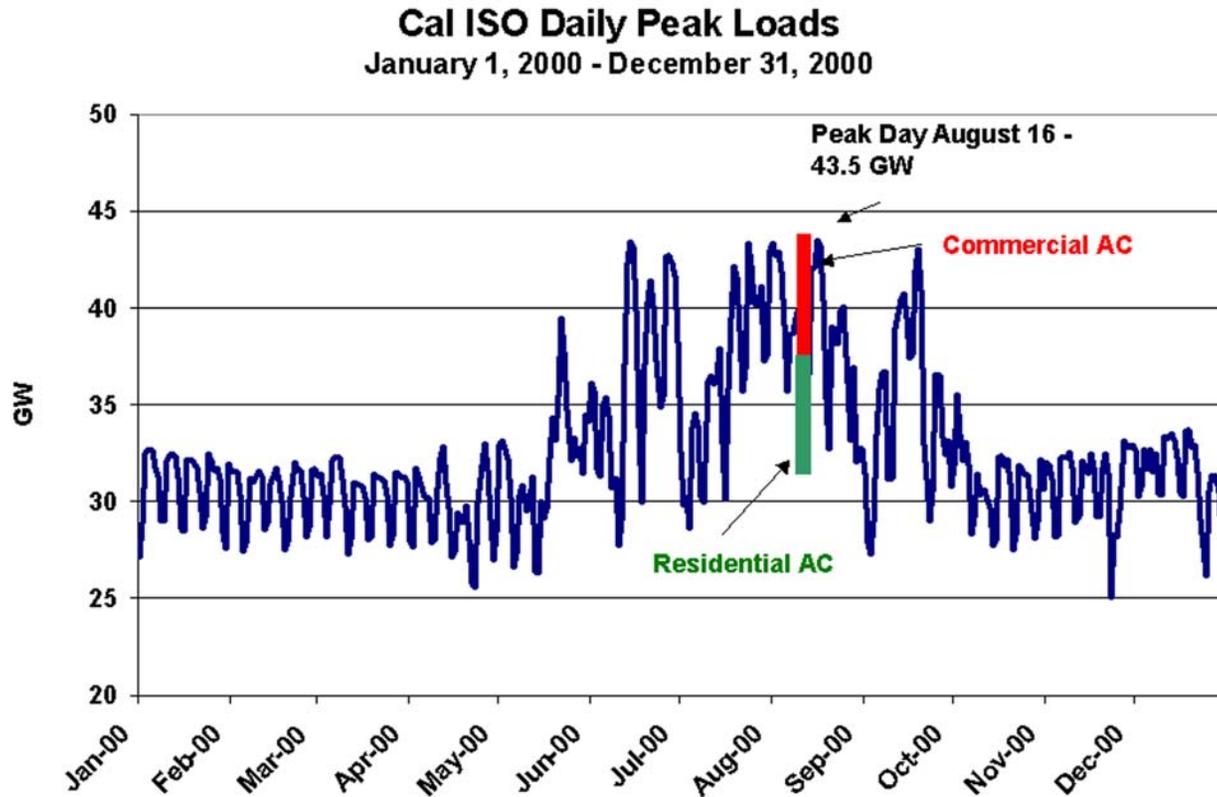
Agenda

- Background
- Approach and Status
- Experimental Data Comparison
- Attic Temperatures and Distribution Efficiencies
- Impact on Measure Savings and Compliance

Attic/Duct Model

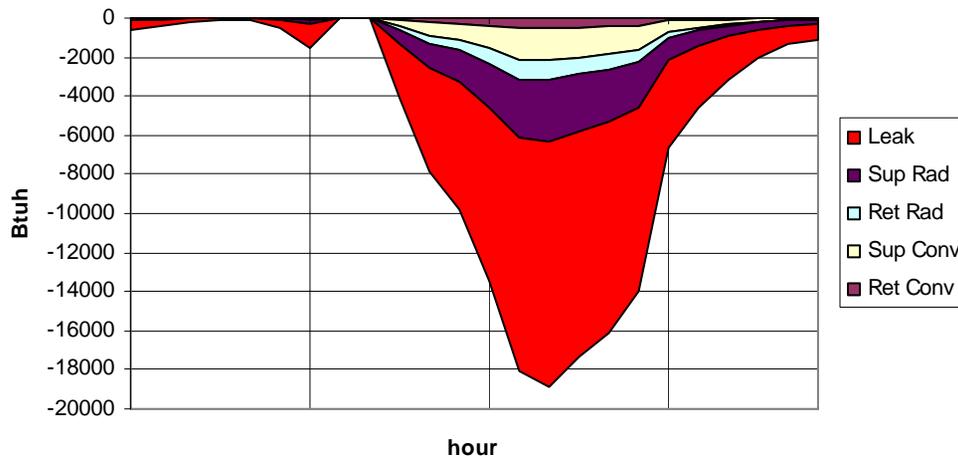
- Attics with ducts are typical in California homes
- Approximately 30% of heating and 35% of cooling energy is lost in unimproved California attics
- Peak roof/attic/duct performance is an electrical supply issue

Residential AC is a BIG Part of California's Peak Electricity Problem

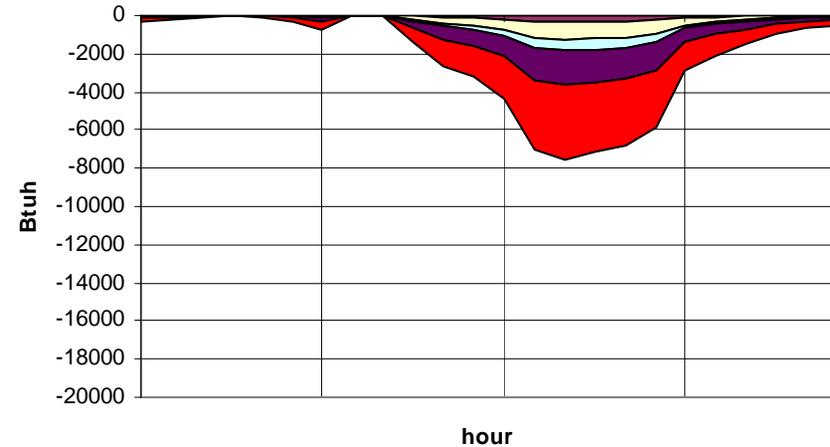


The Attic/Duct Contribution to Peak on a Palm Springs Peak Day

Zone 15 Peak Day Duct Loss
Typical Attic (dark roof, R-4 unsealed ducts)



Zone 15 Peak Day Duct Loss
2005 Stds Attic (radiant barrier, R-8 sealed ducts)



Attic/Duct Model

- California has a performance based energy code
- An accurate roof/attic/duct model that evaluates all of the relevant measures in combination is needed for standards development
- An improved roof/attic/duct calculation that treats measures equitably is needed for performance compliance

Compliance Constraints

- Include current measures and credits
- Very limited field checkable inputs
- The need to handle significant variations
 - Crawl spaces with ducts
 - Flat roofs with attics and ducts
 - Multiple air conditioning systems
 - Houses with multiple systems, multiple zones and ducts in attics, crawl spaces and indoors

Efficiency Measures Covered

- Duct sealing
- Duct insulation (including buried ducts)
- Duct location (including conditioned space)
- Roof solar absorptivity and emmissivity
- Tile roofs
- Radiant barriers
- Attic ventilation
- Attic insulation
- Sealed attics
- Insulation construction quality

Limited Inputs

- Pitch (4 in 12) or height of peak
- No other geometry or orientation
- Vent details (free area and location)
- Roof properties (solar absorptivity and infrared emmissivity, roofing type)
- Current duct system inputs only

Limitations

- Generalized attic geometry
- Simple hourly duct calculation adapted from current ACM duct model
- Regression based attic infiltration and ventilation model
- One attic space and one crawlspace per building



New Capabilities

- Improved conditioned space air infiltration calculation
- Unbalanced duct system leakage
- Forced ventilation of attic using air from conditioned space
- Radiant properties of duct surfaces
- Impact of radiant barrier at gable ends
- Impact of temperature on insulation R-value

Approach

- Learn from existing attic/duct models
- Develop proposed model in beta form
- Test and compare
- Integrate in special version of Micropas
- Support 2008 standards process
- Publish in 2008 ACM

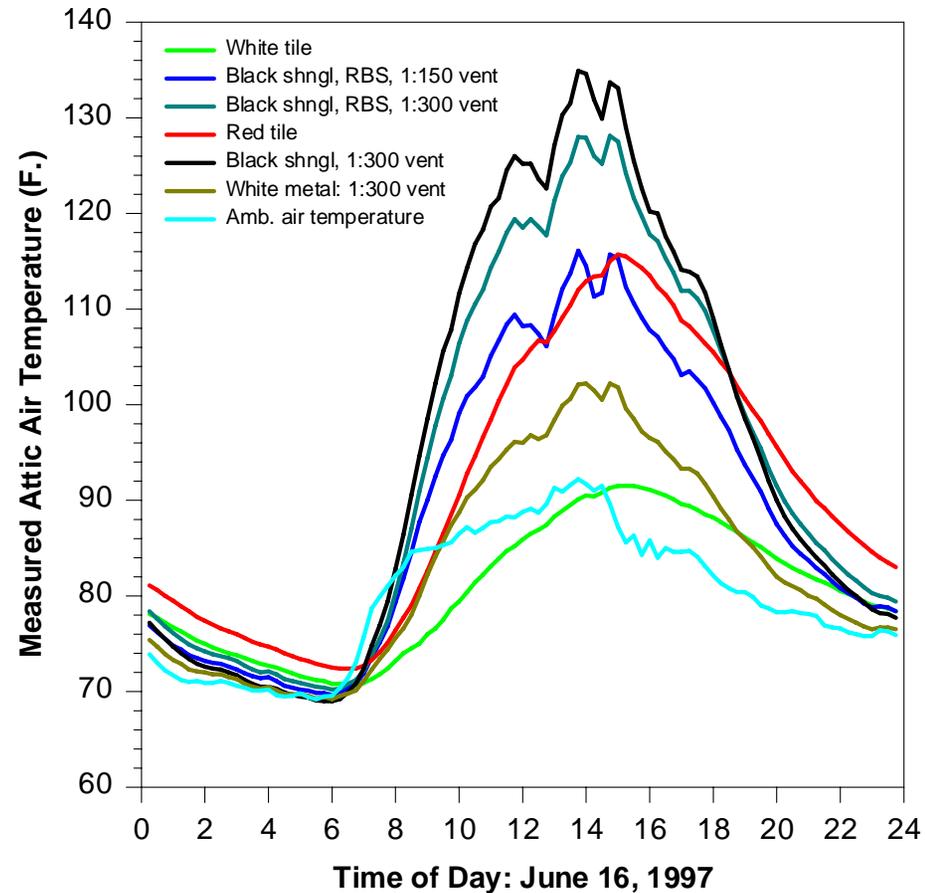
Status

- UZM model complete
- Documentation draft complete
- Stand-alone UZM tested against data
- Micropas integration complete
- Distribution efficiency comparison complete
- Compliance comparison complete

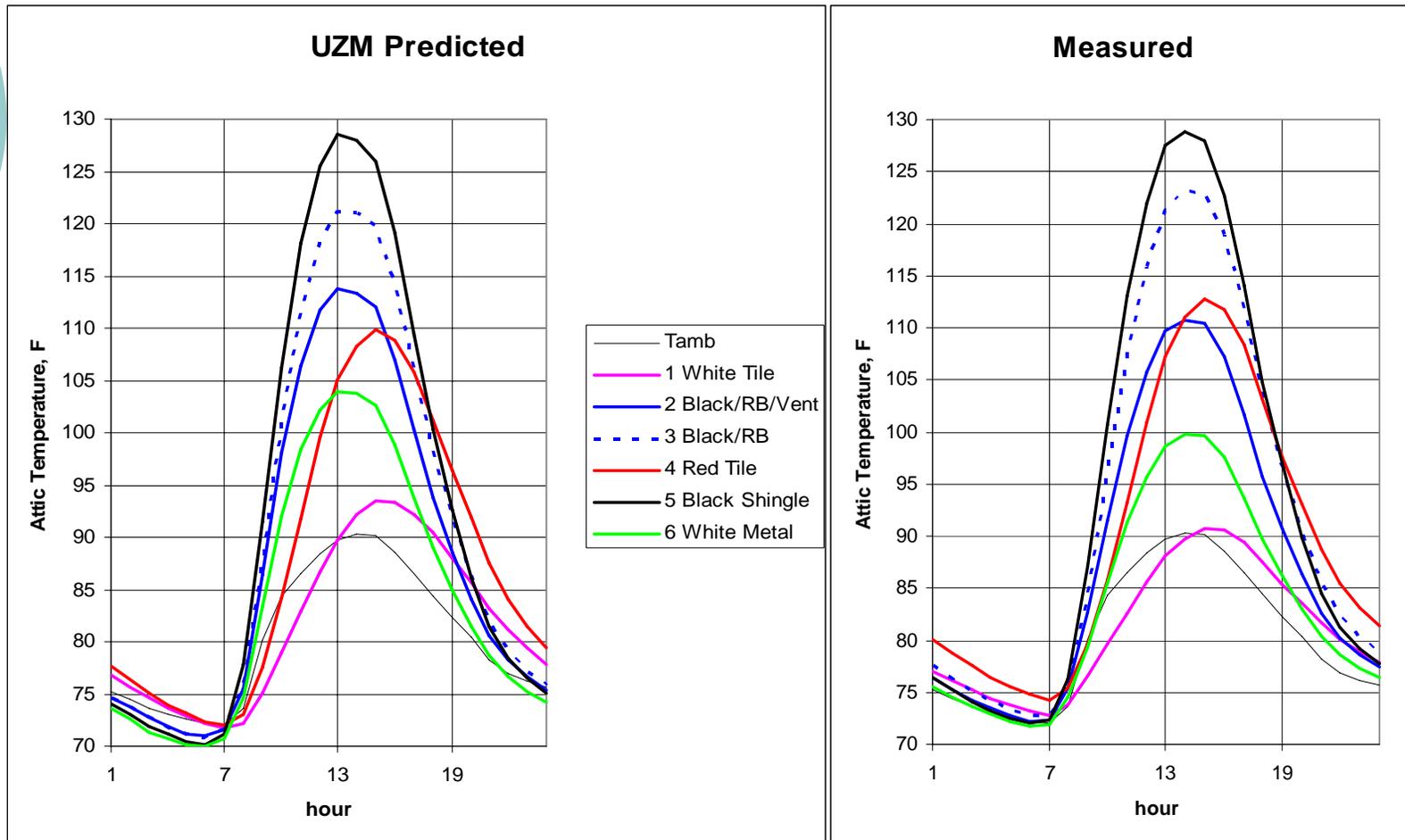
Experimental Data Comparison

- Florida Solar Energy Center Flexible Roof Facility
 - Compare attic temperature predictions with data
 - 6 different roof types side by side
 - Summer average and peak
- California Production House
 - Cardinal Glass experimental house in Roseville
 - 1 year unoccupied and instrumented running ACM occupancy
 - Tile roof, sealed attic ducts, enhanced ventilation

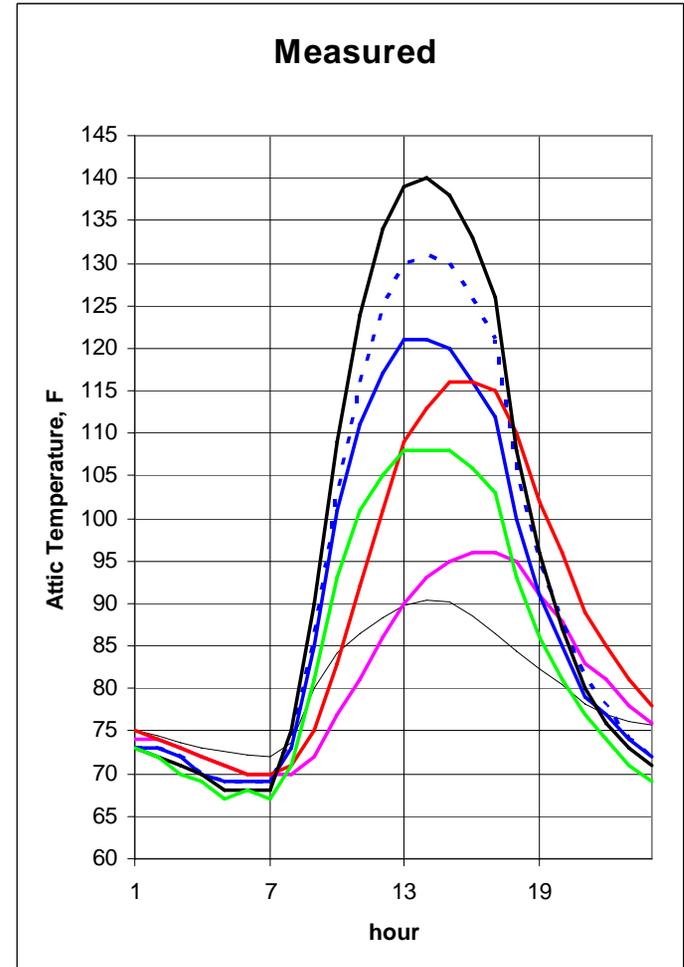
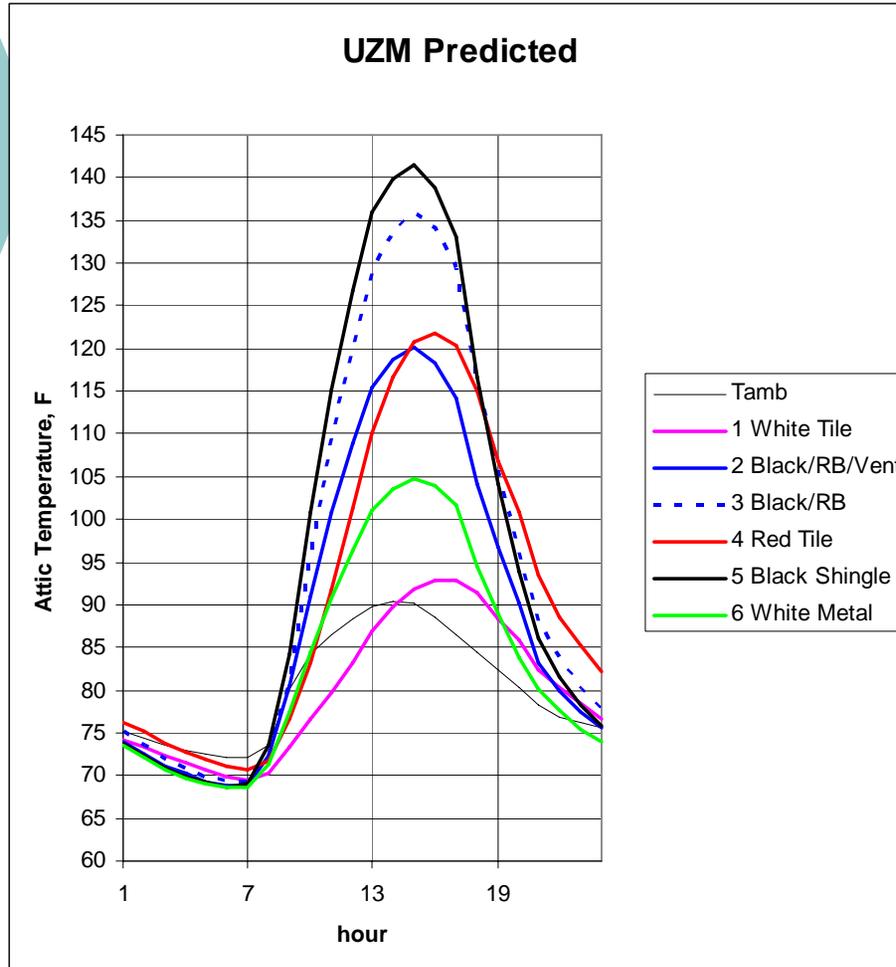
Flexible Roof Facility



UZM matches the relationship between roof type and July average attic temperatures for 6 different roof systems

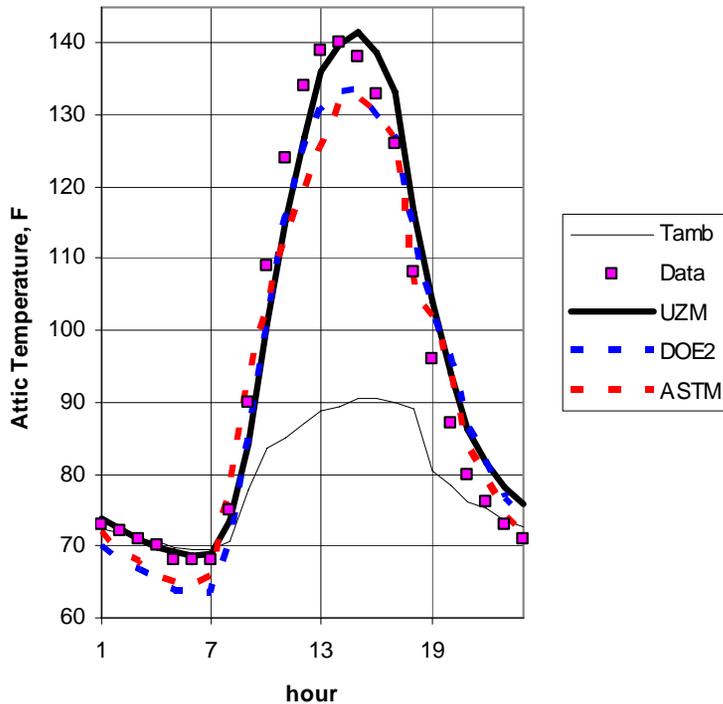


UZM matches the measured peak day attic temperature impacts of the 6 different roof systems

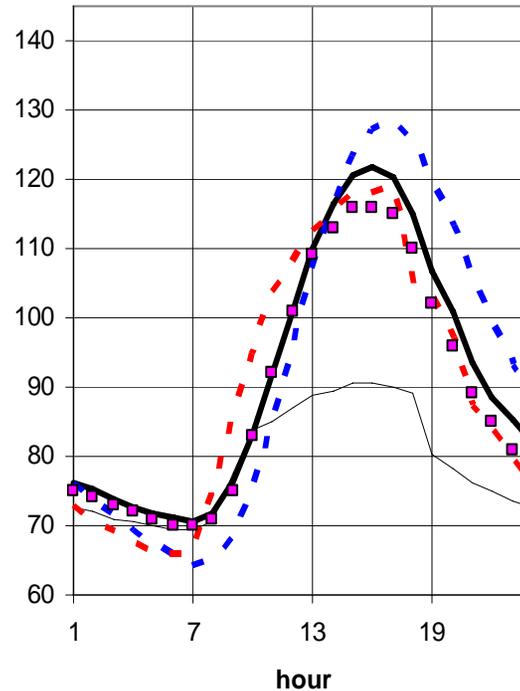


UZM matches the measured data on peak day temperatures as well as EnergyGaugeUSA or ASTM C-1340

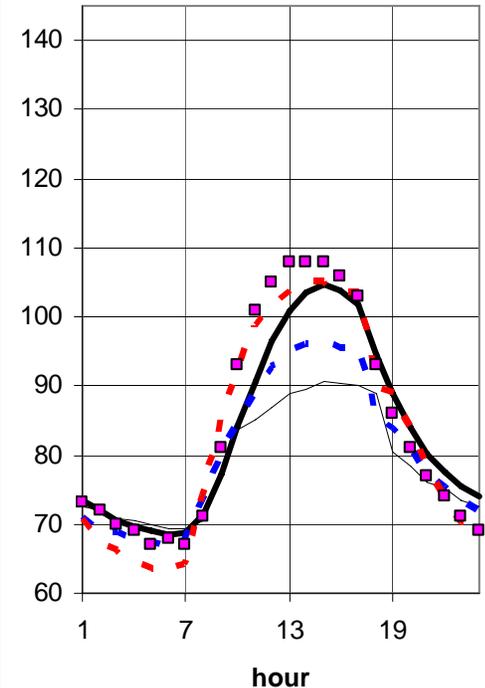
Black Shingle Roof



Red Tile Roof



White Metal Roof

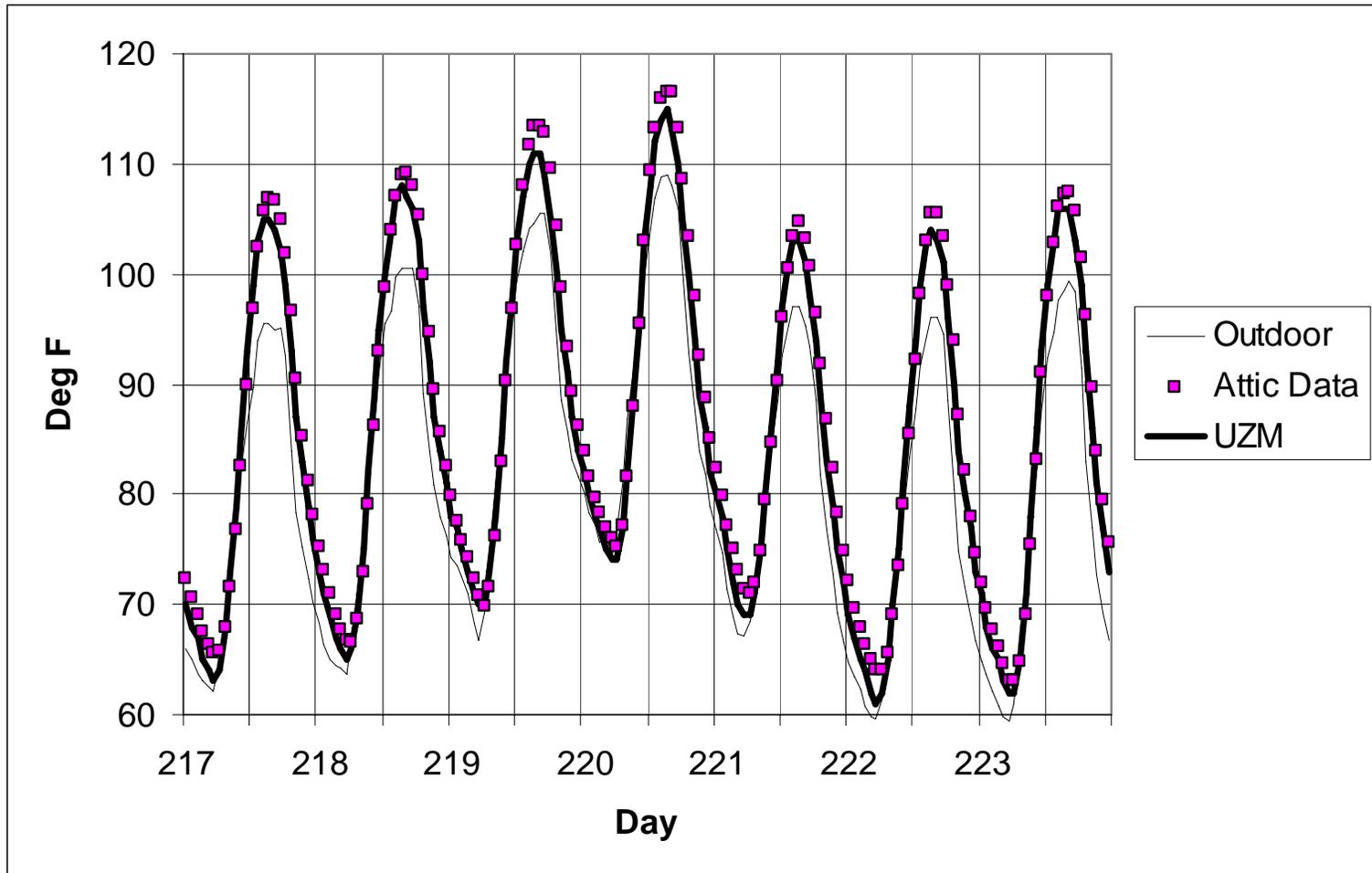


California Data Comparison

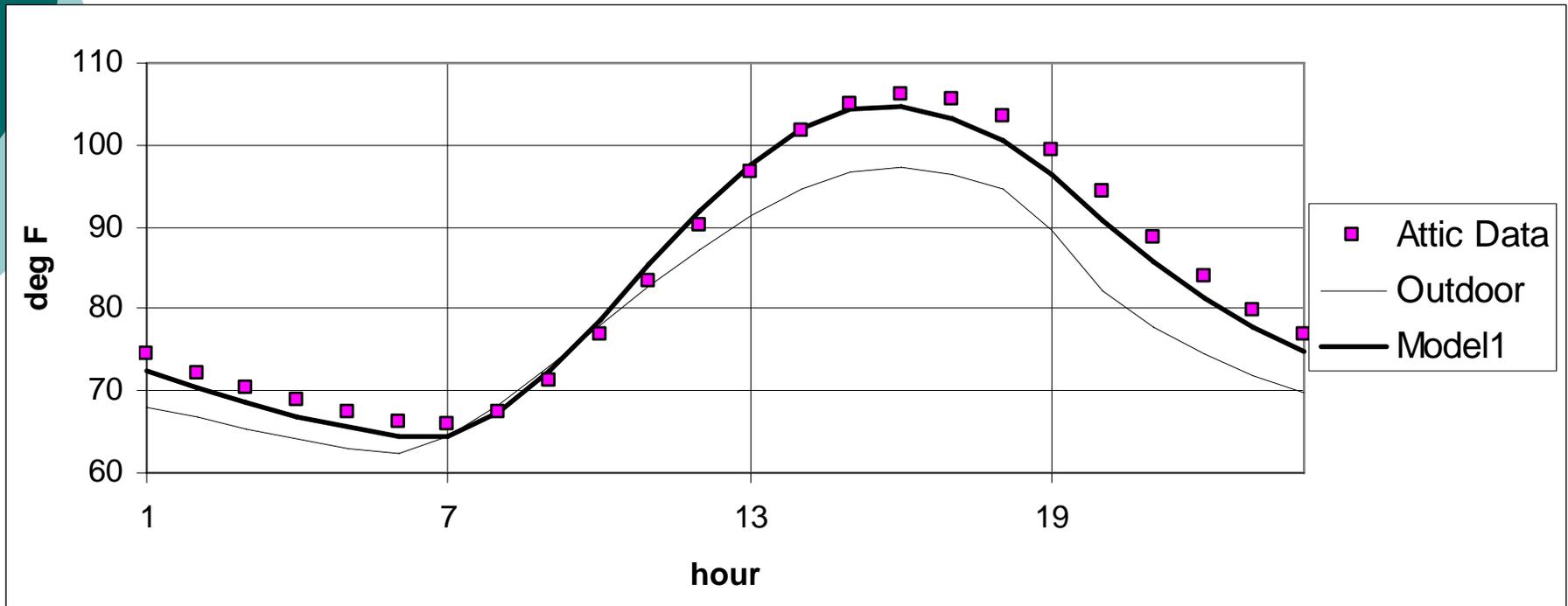


- One year of measured attic temperature data for Cardinal Glass research house in Roseville
- Unoccupied, instrumented, ACM occupancy
- Tile roof with high/low ventilation, sealed ducts in attic, ceiling construction defects, all modeled using proposed approach

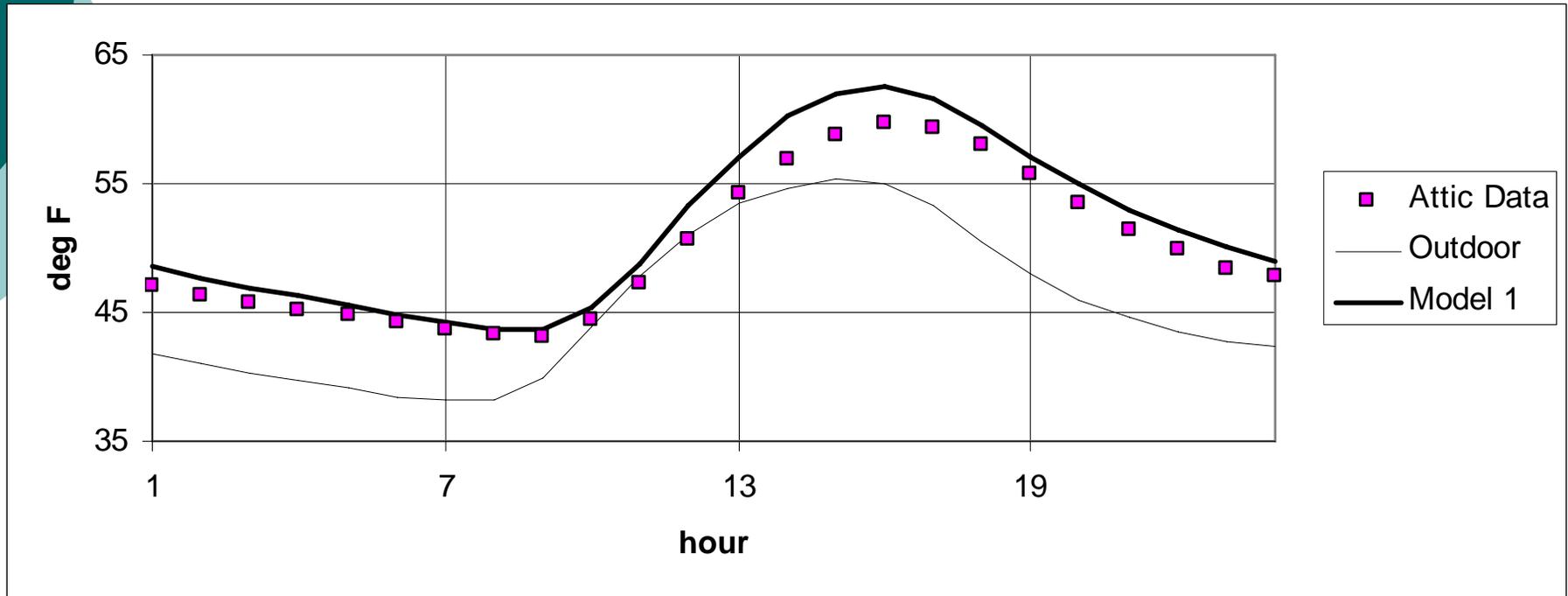
UZM matches attic temperature pattern for week including highest attic temperature of the year



UZM matches August average attic temperature



UZM matches January average measured attic temperature



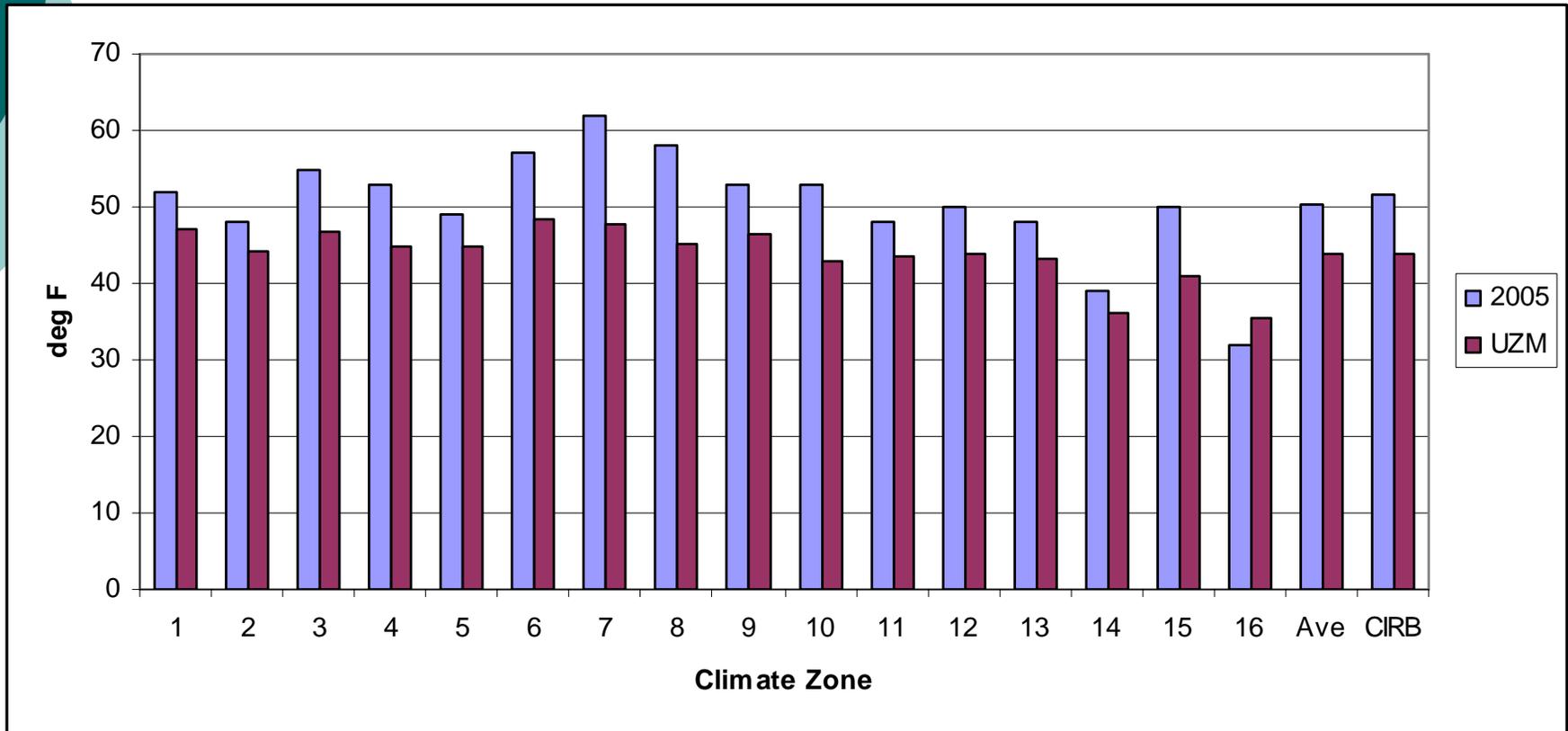
○ .



Comparison of 2005 ACM and UZM

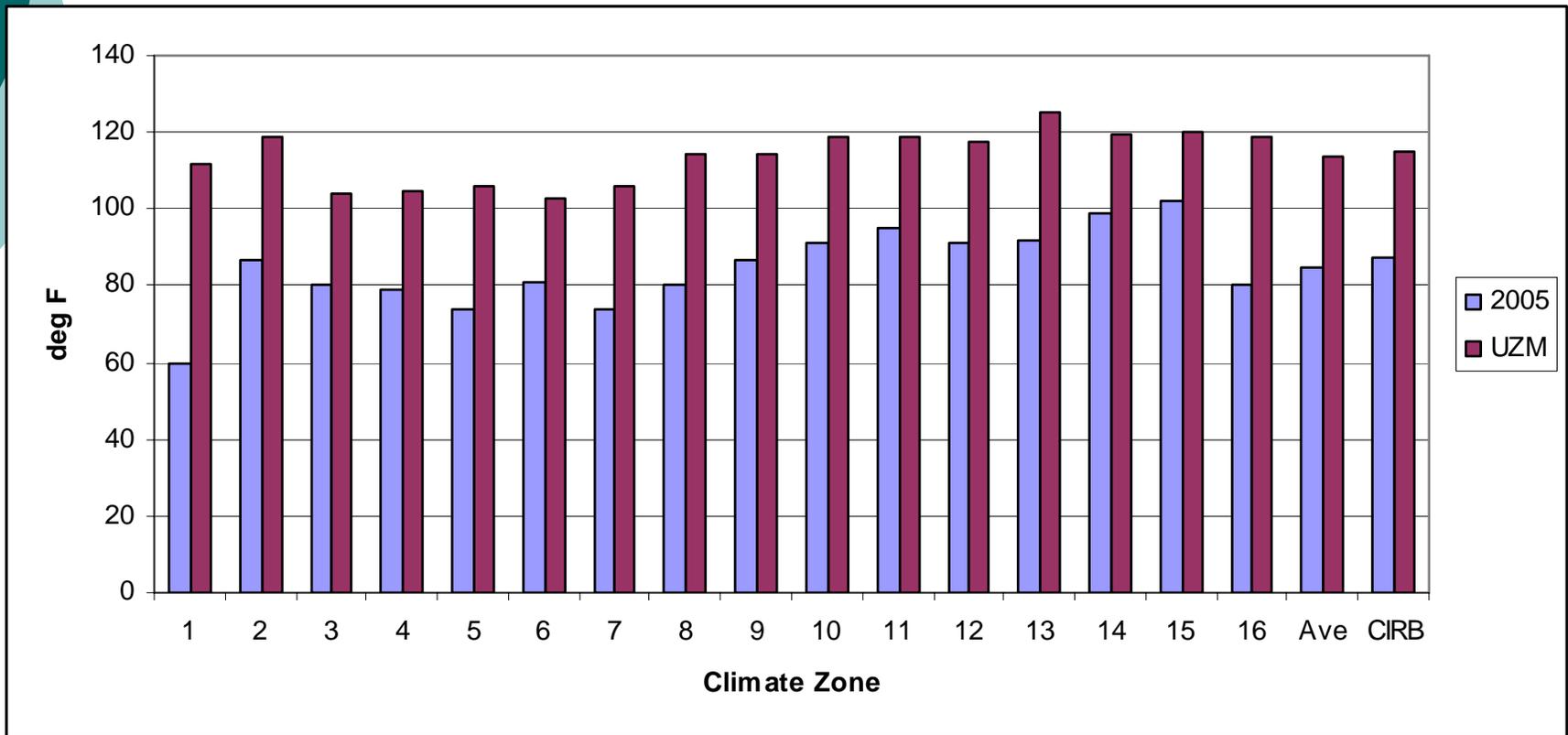
- Attic Temperatures
- Distribution Efficiencies
- Compliance Impact

Attic temperatures for Heating



○ Base case dark shingle roof

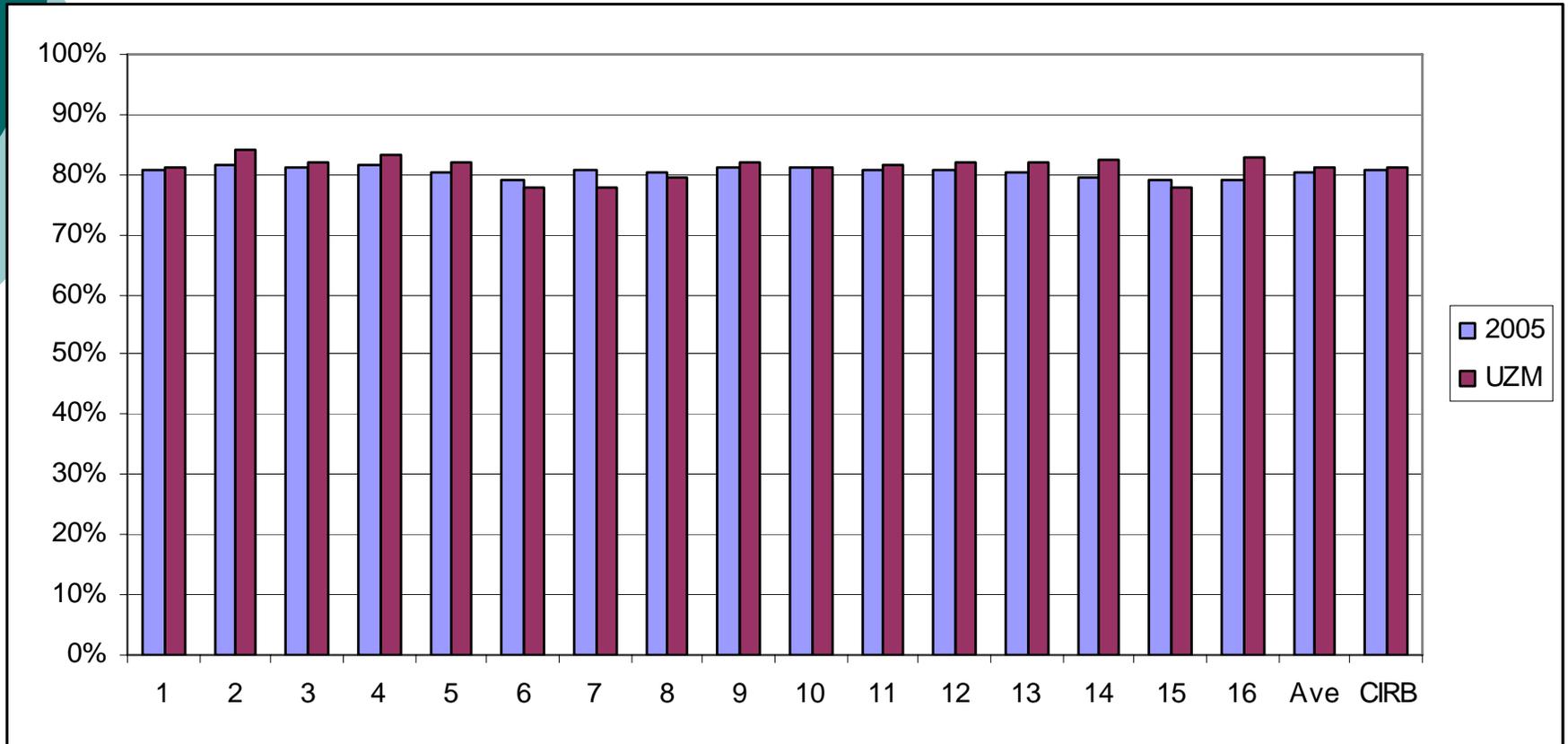
Attic temperatures for Cooling



Base case dark shingle roof

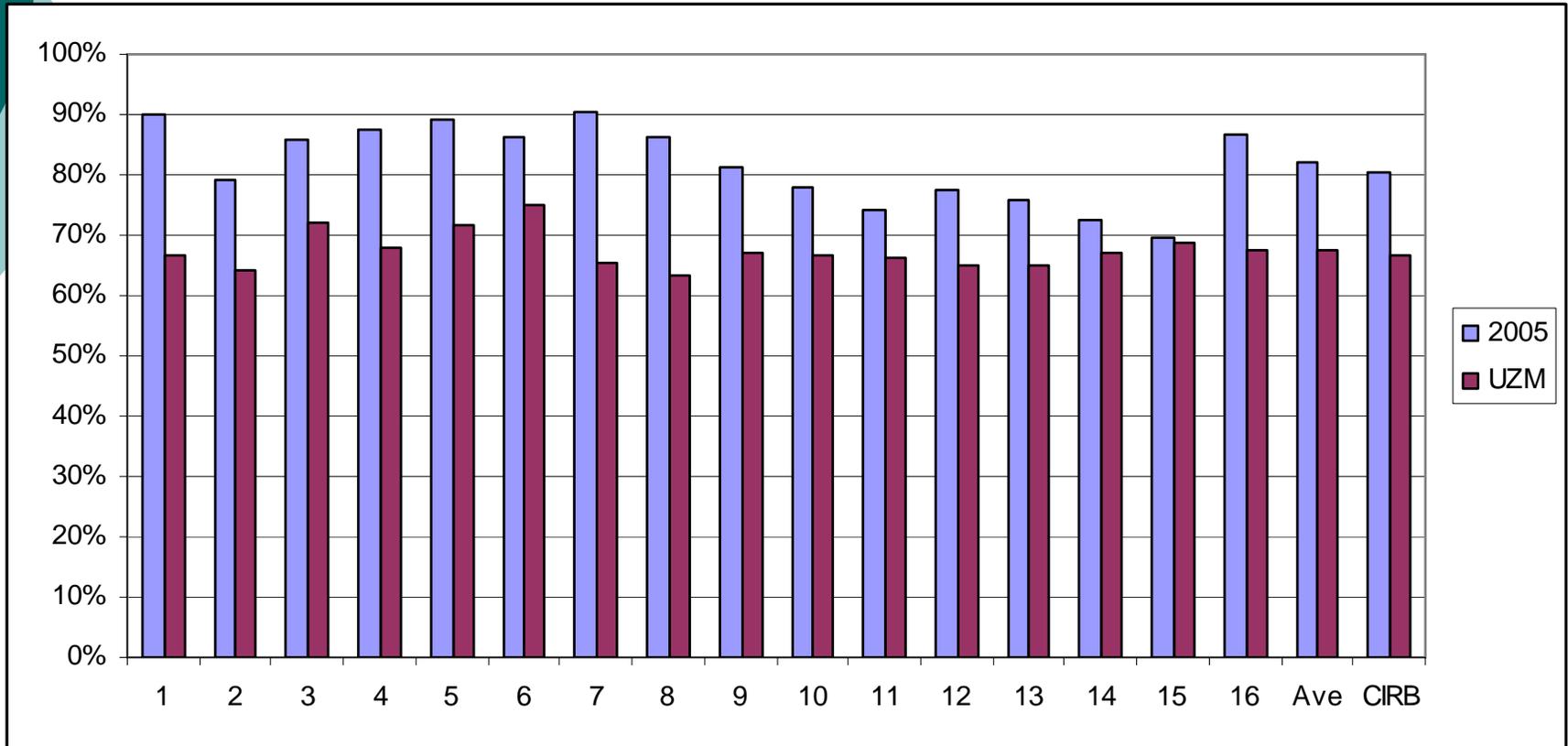
Wilcox - PIER Research for the 2008
Residential Building Standards

Seasonal Heating Efficiency



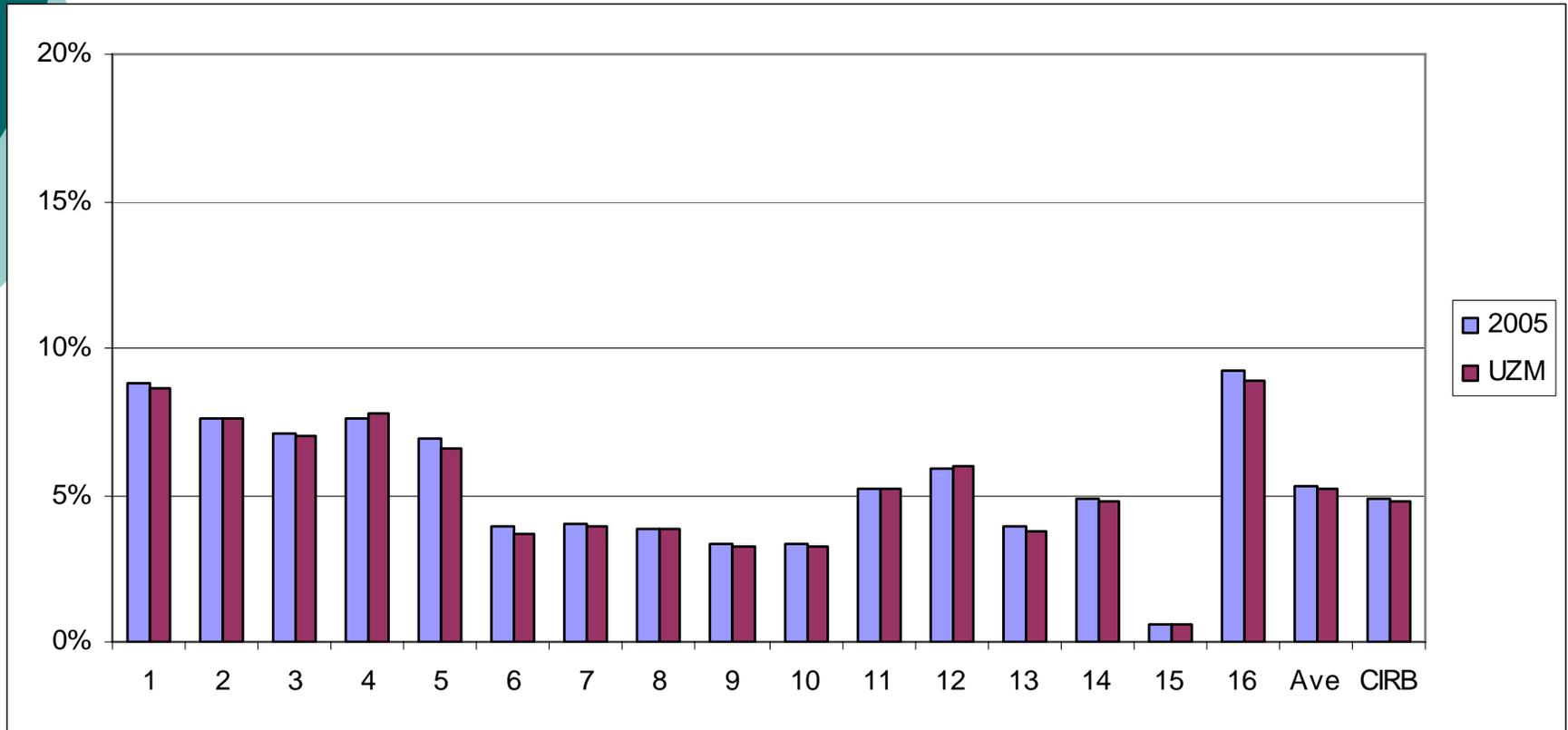
○ Base case dark shingle roof, sealed ducts

Seasonal Cooling Efficiency



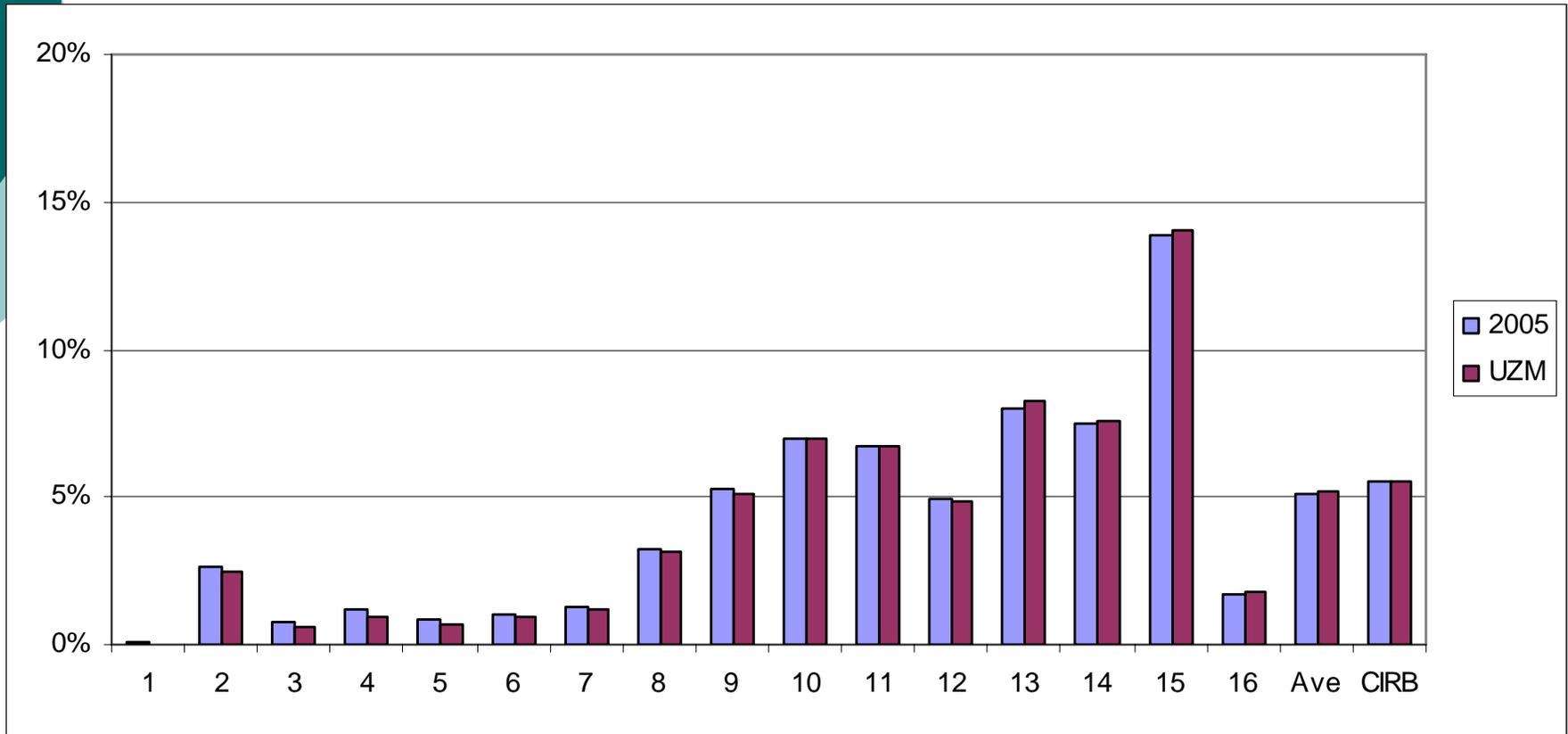
○ Base case dark shingle roof, unsealed ducts

TDV Savings 92% AFUE Furnace



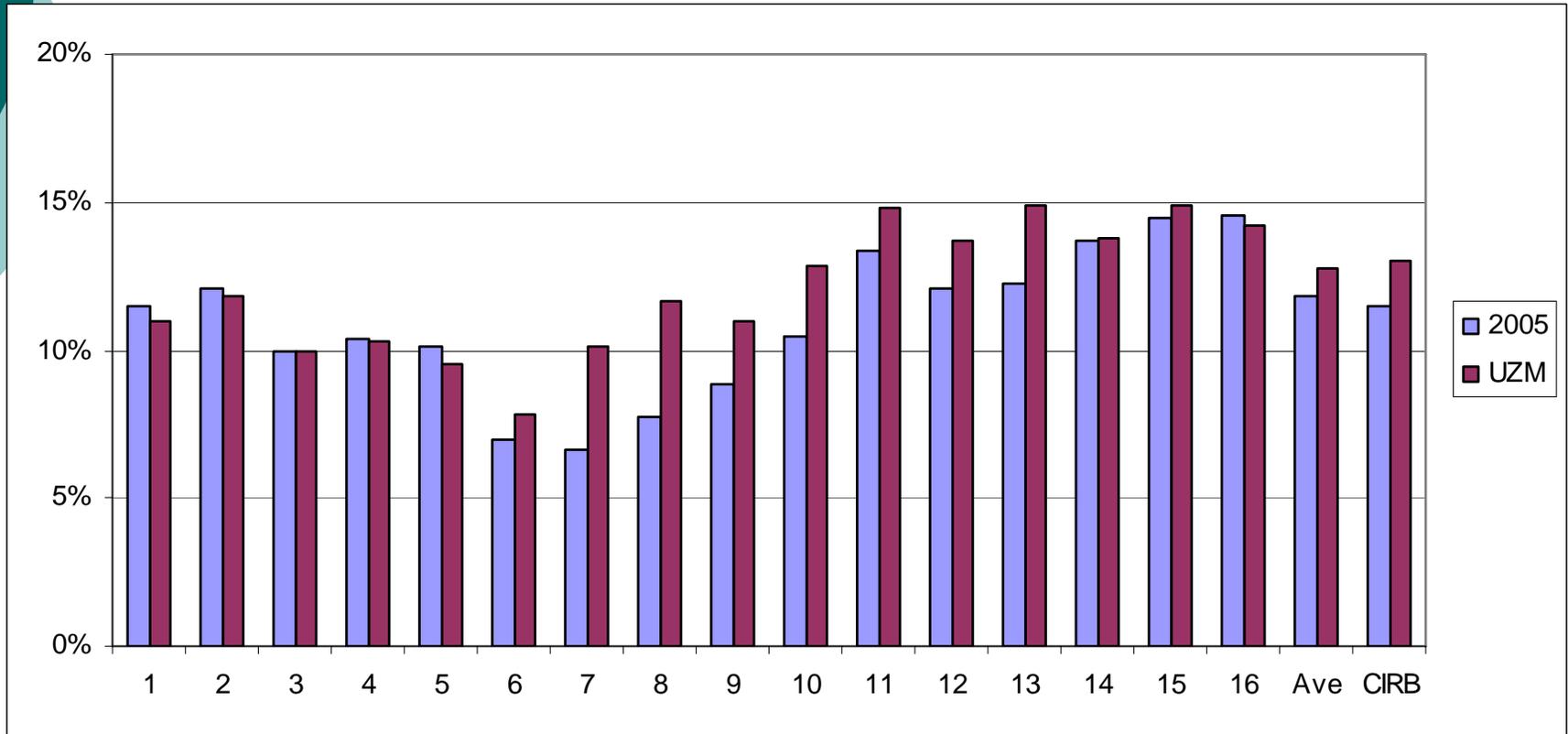
Base case dark shingle roof, prescriptive requirements in each zone

TDV Savings 14 SEER / 12 EER



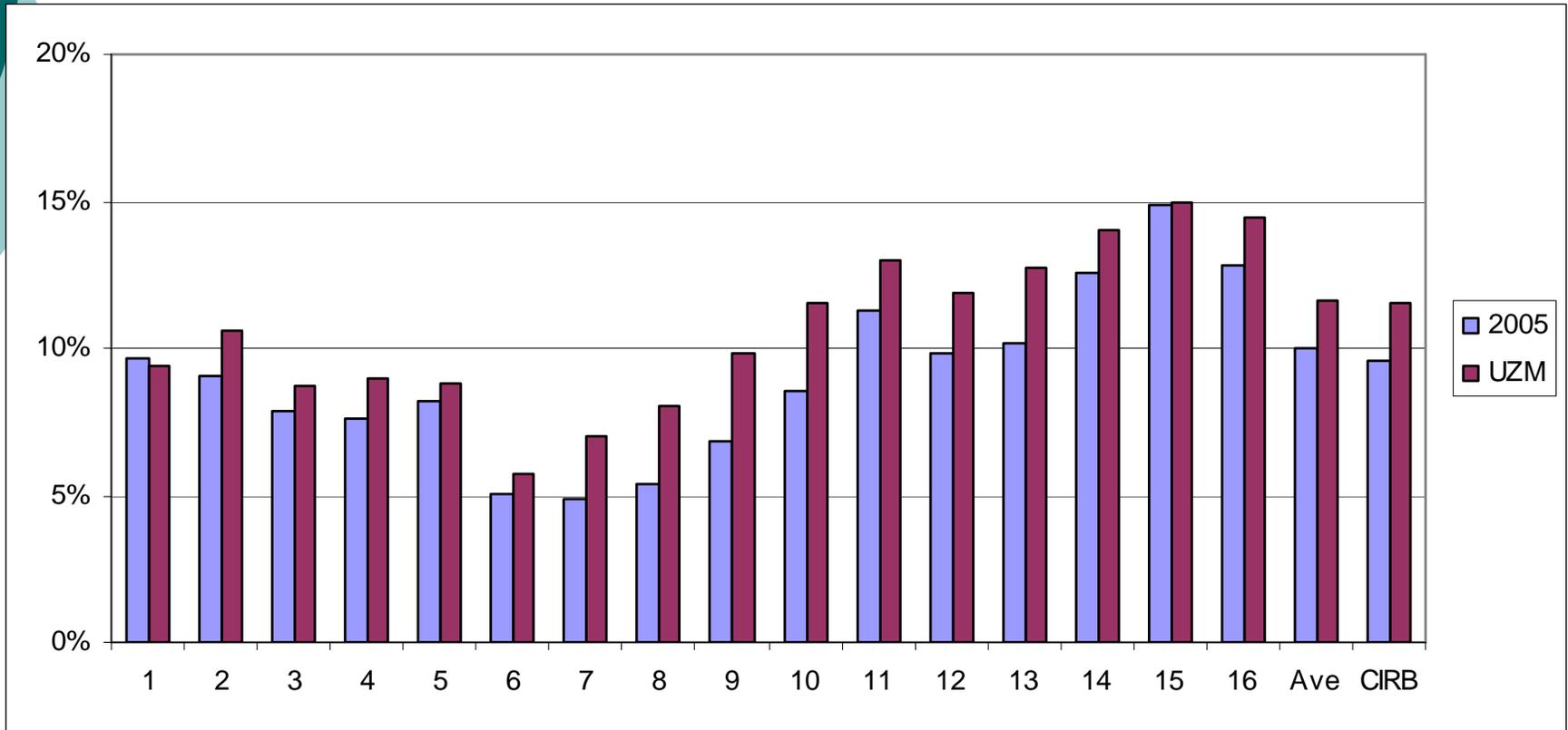
Base case dark shingle roof, prescriptive requirements in each zone

TDV Savings Ducts in Conditioned Space



Base case dark shingle roof, prescriptive requirements in each zone

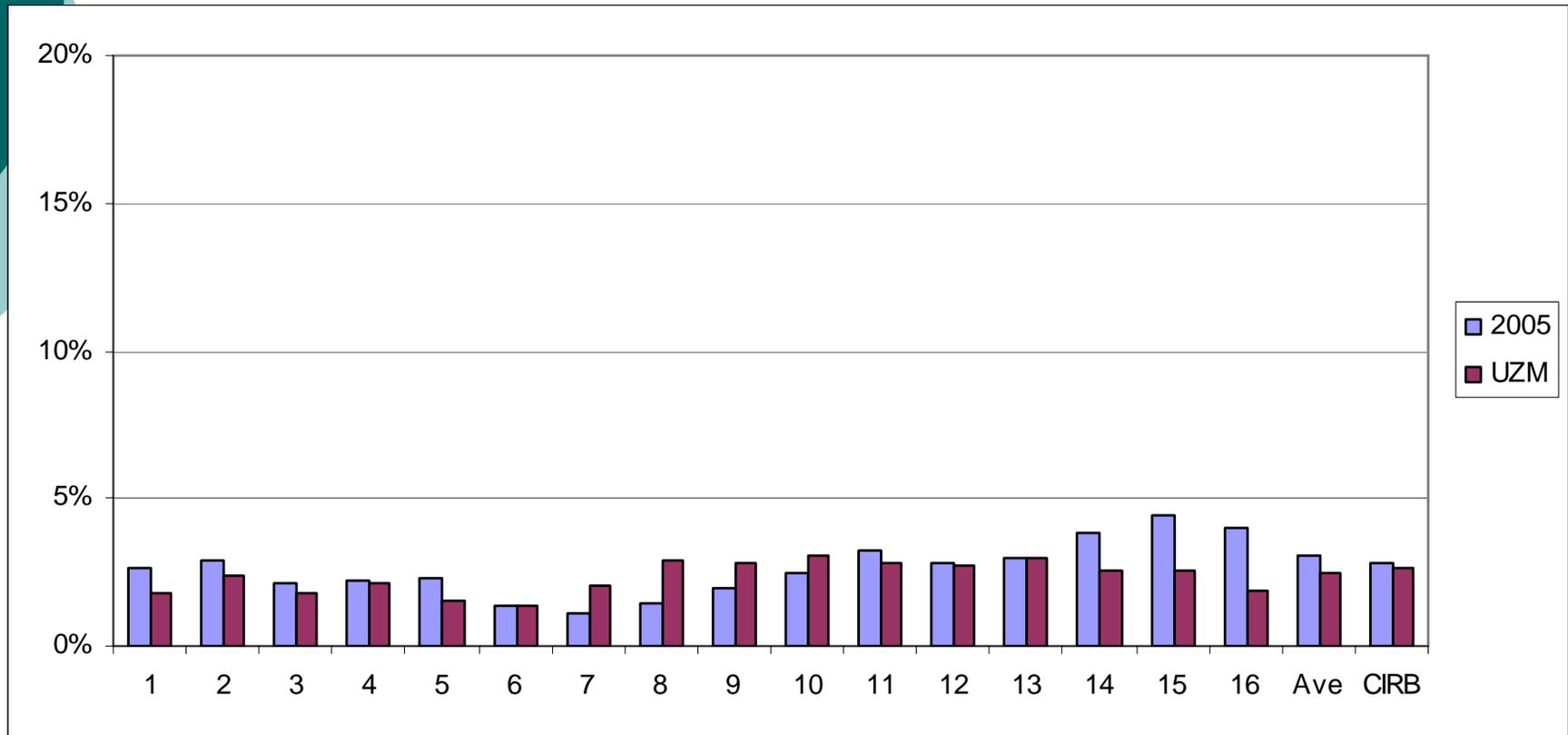
TDV Increase No duct sealing



Base case dark shingle roof, prescriptive requirements in each zone

TDV Savings

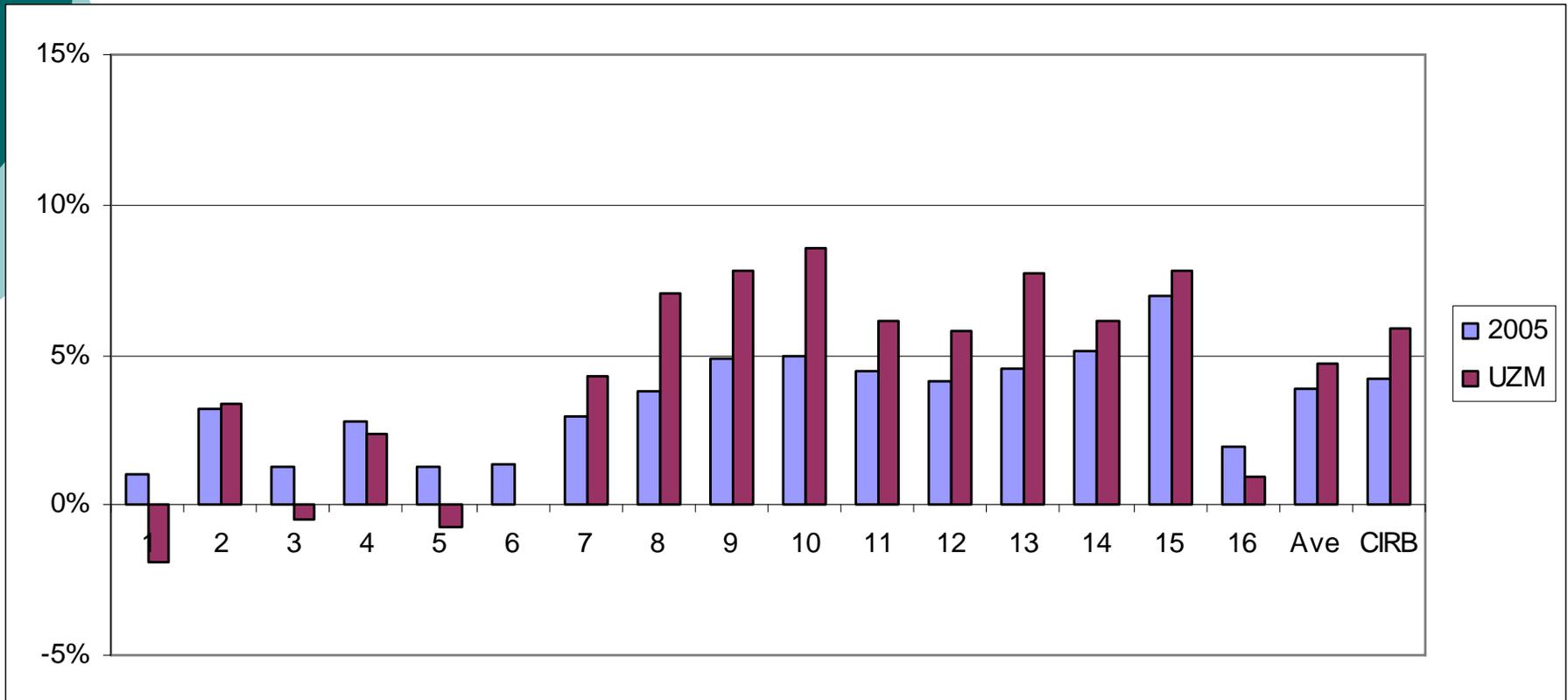
R4.2 Duct insulation Increased to R8



Base case dark shingle roof, unsealed ducts

TDV Savings

Radiant Barrier + Increased Attic Vent



Base case dark shingle roof, unsealed R4.2 ducts, R-30 ceiling

Conclusions

- UZM provides attic temperatures consistent with experimental data
- UZM distribution efficiencies are reasonable
- UZM compliance changes are reasonable for standard efficiency measures