Annual Energy and Heat Flows in Vented and Sealed Attics

Parametric Study: Climate Zone 2A

Mikael Salonvaara and Achilles Karagiozis, Owens Corning
William Miller, ORNL

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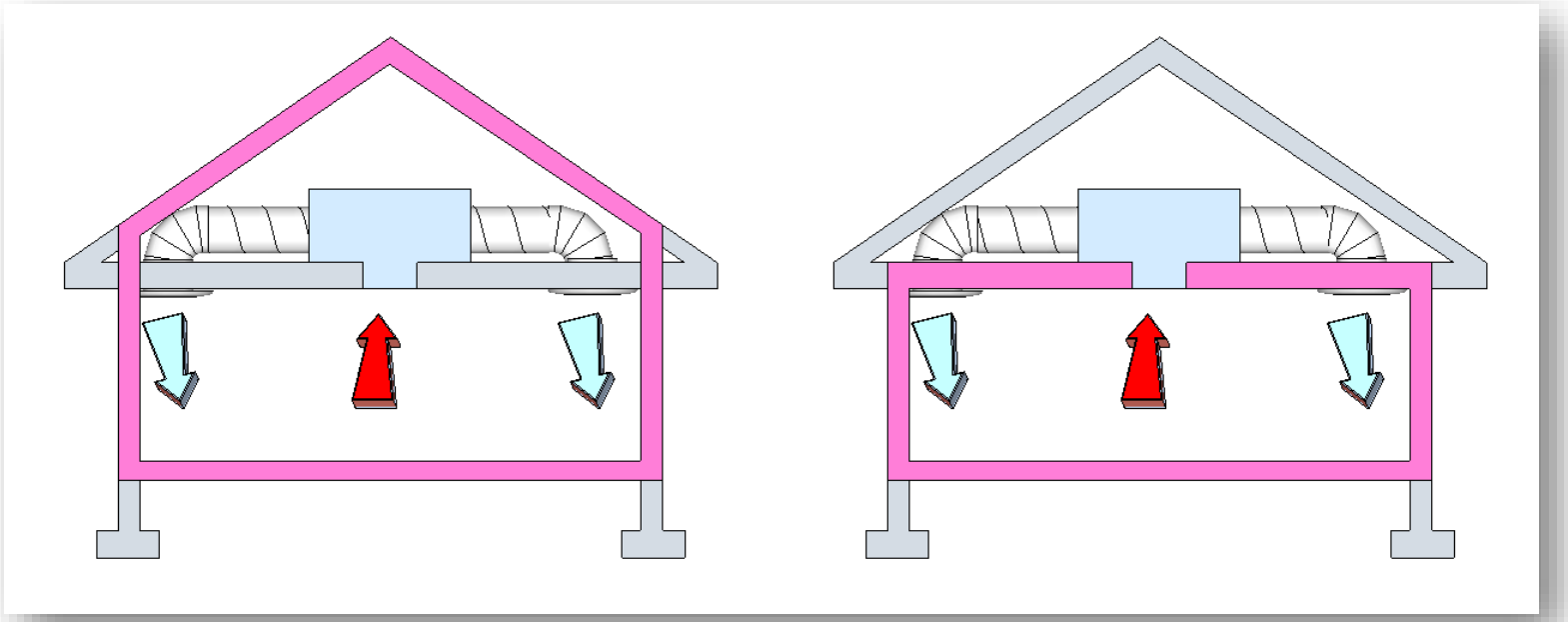
Attic Types

Sealed (Unvented) Attic ***Vented Attic***



Ducts inside thermal boundary	Ducts in unconditioned space
Attic is not living space and not conditioned	Attic is ventilated with outdoor air

Outline

- Background for the study
- New developments in unvented attics
- Goals and Approach
- Results
- Discussion and conclusions

Background

- Moisture performance of Attics was presented in Buildings XII
- Now time for energy performance
  - Attic spaces are utilized for installing ducts
  - Vented attic space is outside thermal boundary causing an energy penalty
  - Unvented attics are one way of bringing ducts into ‘conditioned space’

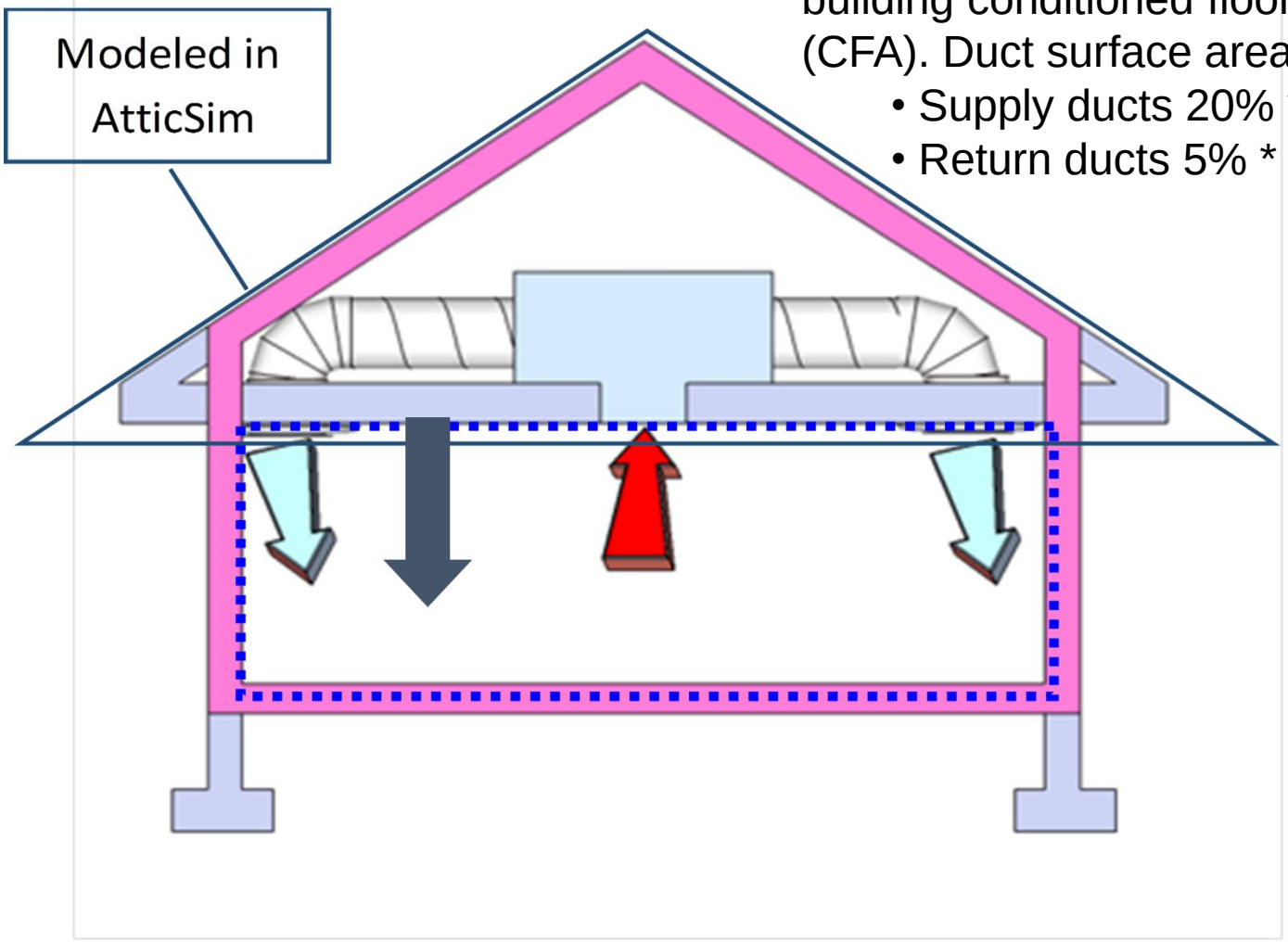
Project Goals

- The energy performance of vented and unvented (aka sealed) attics is still a question mark
  - The home energy rating tools in the past were not doing a detailed calculation giving unrealistic benefits to unvented attics
- Which features are important in vented and sealed attics?
- Results are needed for design guidance when considering different attic types in different climates

Approach

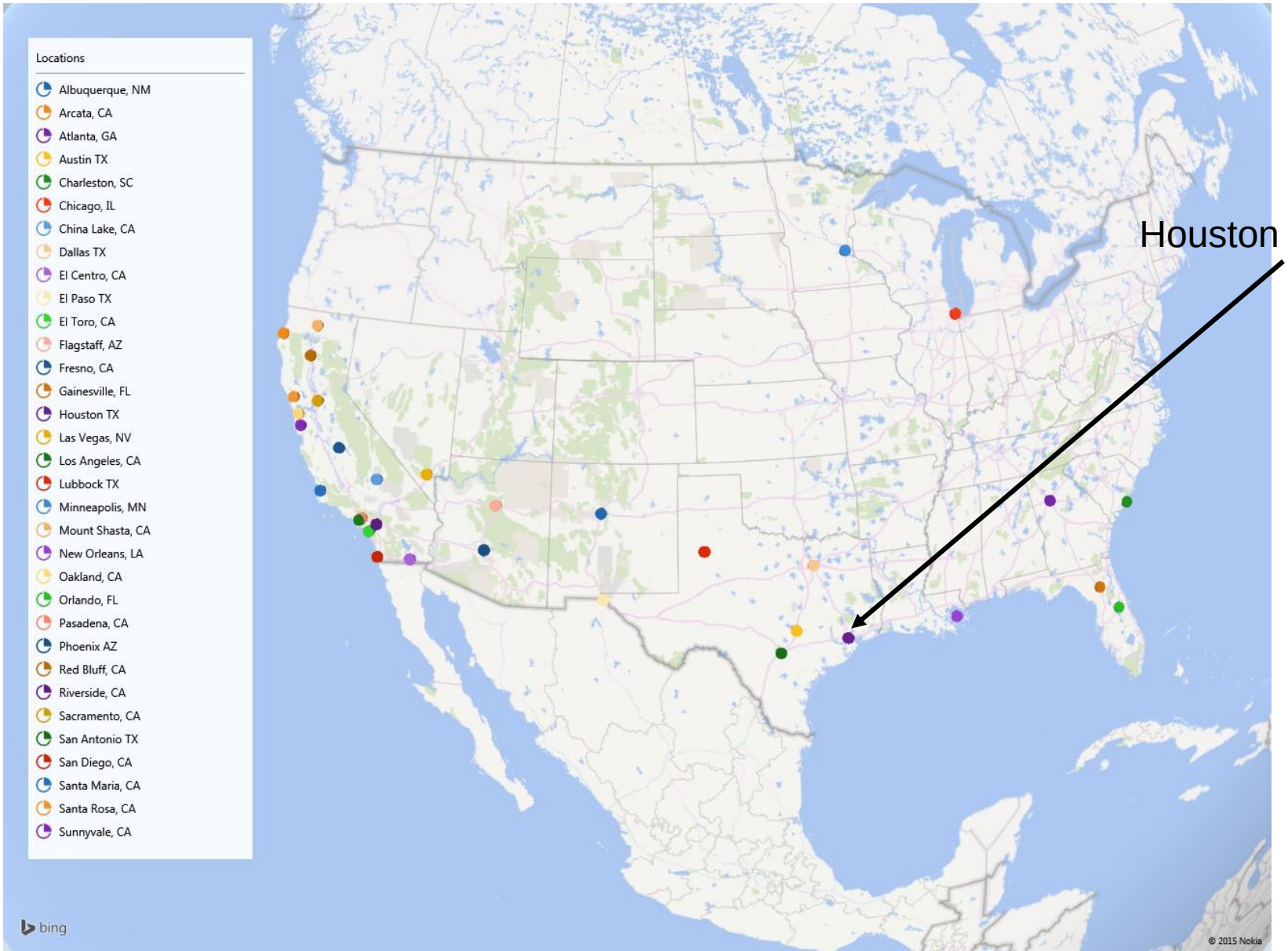
- Focus on thermal performance of shingled roofs
- Modeling tools used: EnergyPlus and AtticSim
  - Small and large attic in a one story building
  - SEER=13 cooling and HSPF=8.5 for heating
- Compare different attics to a reference case
  - Reference building pre-simulated with EnergyPlus to calculate heating/cooling On-Time on the location
  - On-Time fine tuned based on performance of the attic to deliver the same indoor conditions

Controlled Boundary



- Amount of ducts based on building conditioned floor area (CFA). Duct surface area =
  - Supply ducts 20% * CFA
  - Return ducts 5% * CFA

Locations


Locations
Albuquerque, NM
Arcata, CA
Atlanta, GA
Austin TX
Charleston, SC
Chicago, IL
China Lake, CA
Dallas TX
El Centro, CA
El Paso TX
El Toro, CA
Flagstaff, AZ
Fresno, CA
Gainesville, FL
Houston TX
Las Vegas, NV
Los Angeles, CA
Lubbock TX
Minneapolis, MN
Mount Shasta, CA
New Orleans, LA
Oakland, CA
Orlando, FL
Pasadena, CA
Phoenix AZ
Red Bluff, CA
Riverside, CA
Sacramento, CA
San Antonio TX
San Diego, CA
Santa Maria, CA
Santa Rosa, CA
Sunnyvale, CA
Houston TX
bing
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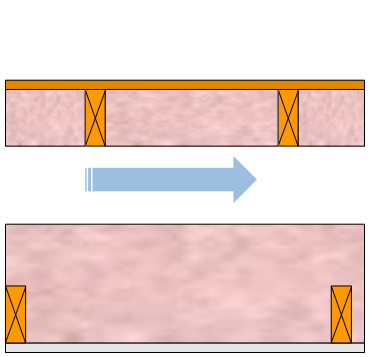
Variations of Features in Attics

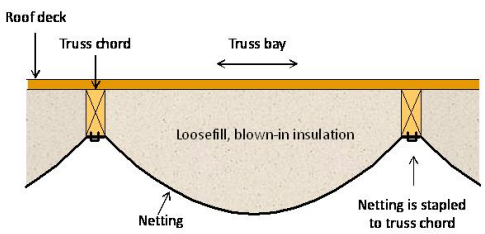
Attic Type	Vented	Sealed	Naming in Charts
Attic leakage to outside, leakage area*	1:300 1:150 1:75	1:1567 1:3000 0	As in “Vented” and “Sealed”
Solar absorptivity of shingles	0.97 0.90 0.75	0.97 0.90 0.75	0.97 0.90 0.75
Attic insulation	R-30 R-38 R-49 R-30+R-10 (deck)	R-30 boxed FG R-30 draped CFI R-22 ocSPF R-30 ocSPF	As in “Vented” and “Sealed”
Duct diameter (in)	6, 8, 10	6, 8, 10	d06, d08, d10
Duct Leakage (% of flow)**	0, 2, 4, 6, 10	0, 2, 4, 6, 10	L0, L2, L4, L6, L10
Duct R-Value* [(hr ft^2 ^{o}F)/Btu]**	R-6, R-8, R-12, R-16	R-4, R-6, R-8	R04, R06, R08, R12, R16

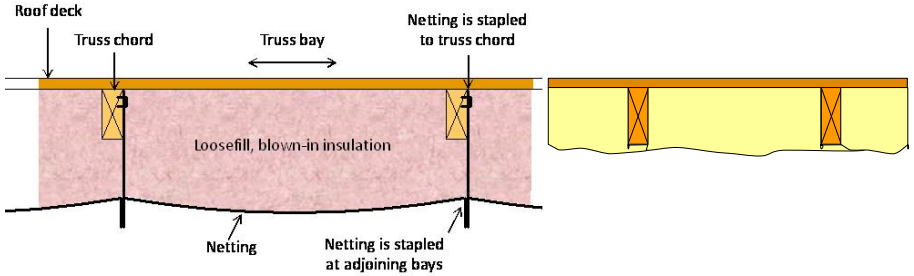
- Additional features simulated: Size, slope and orientation
- Total of apprx. 250 000 simulations

Attic Insulation Scenarios

Insulation types and configurations in addition to traditional vented attic







Vented
R10ci or R13 cavity
R30

Sealed
Draped CFI

Sealed
Boxed Fiberglass

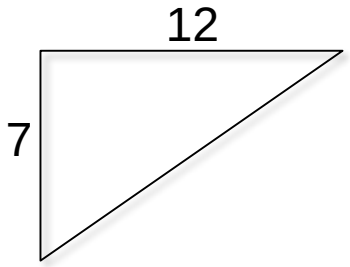
Sealed
ocSPF

Results

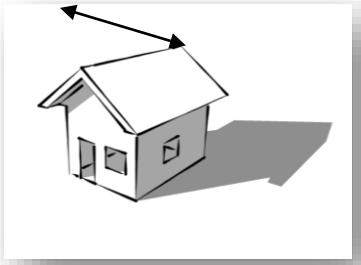
Parametric evaluation of the small attic in Houston TX

1. Roof slope and orientation
2. Insulation level: Ceiling, roof deck
3. Attic ventilation
4. Roof solar absorptivity
5. Duct size
6. Duct R-value
7. Duct leakage

Slope and Orientation

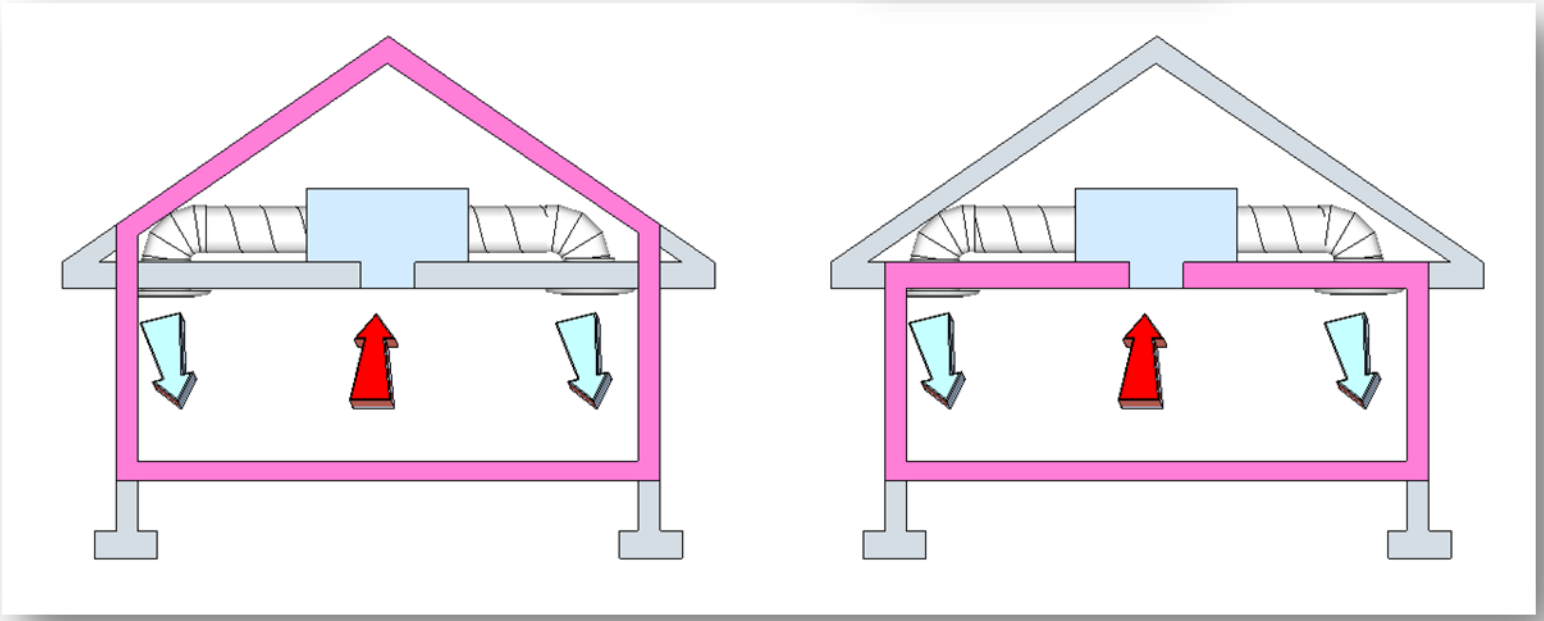


5:12
7:12
9:12



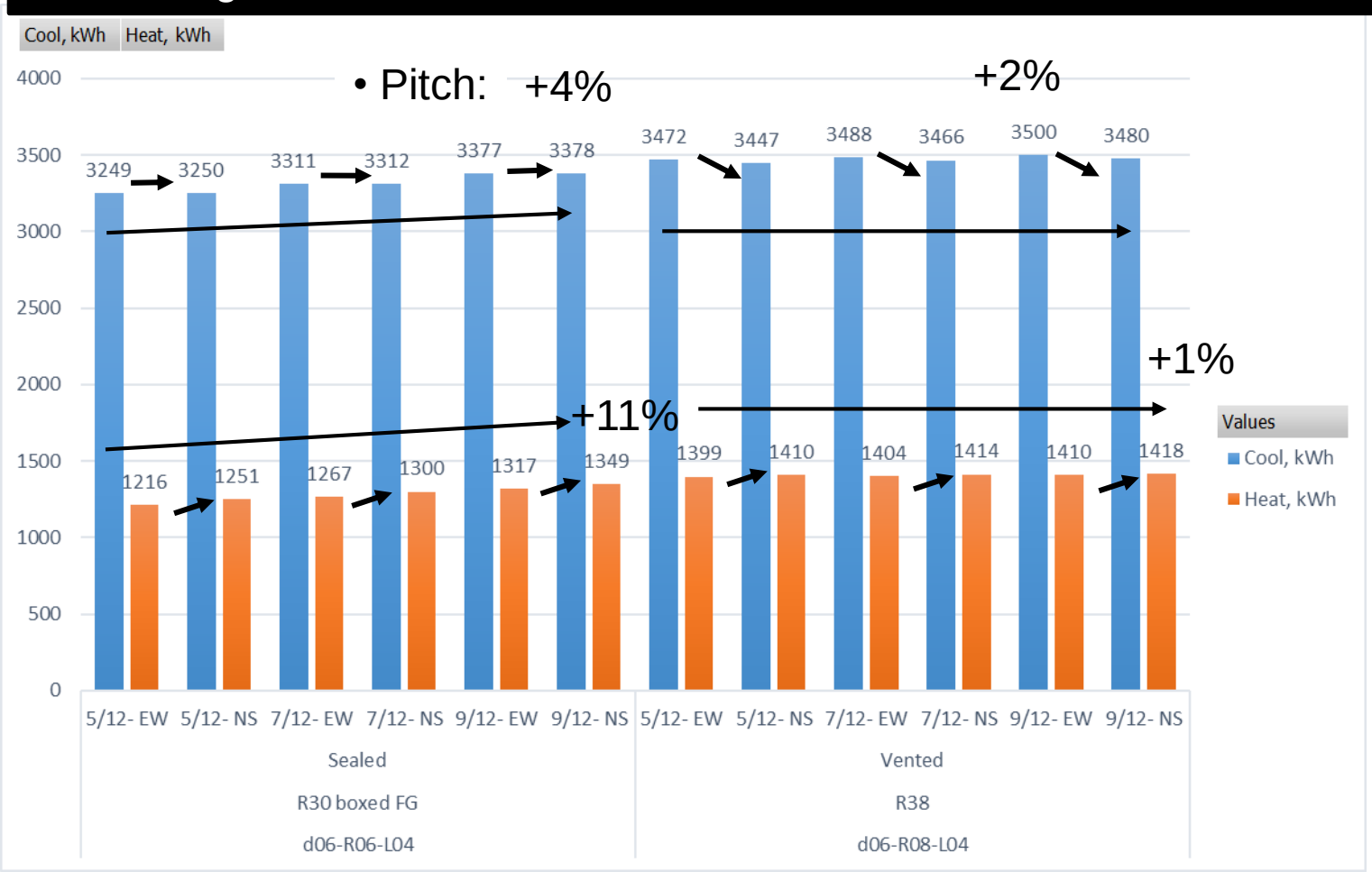
Slope orientations:

East – West
North – South



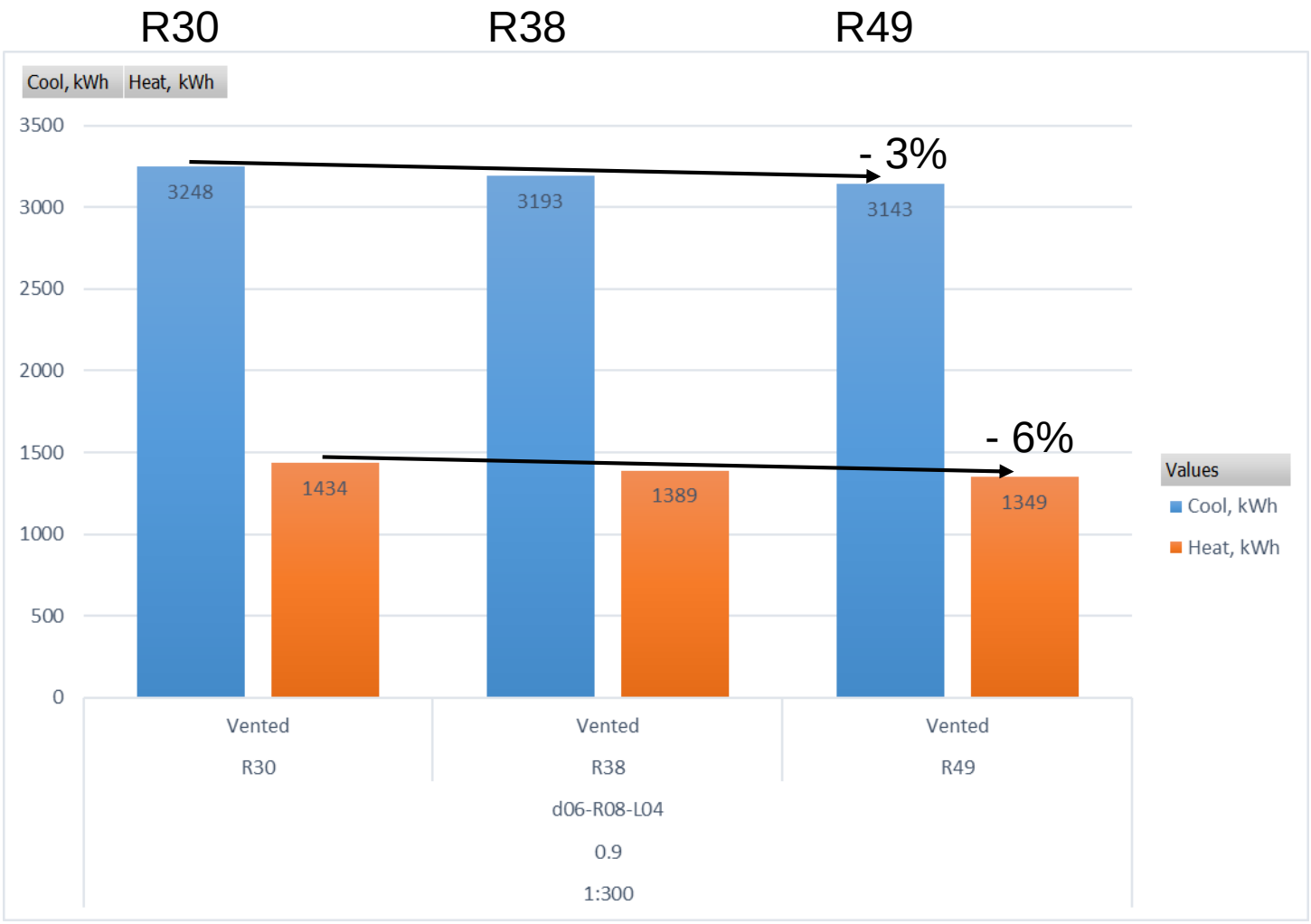
Slope and Orientation

- Slope orientation: North-South > East-West (exception Sealed heating)
- Pitch: Higher > Lower



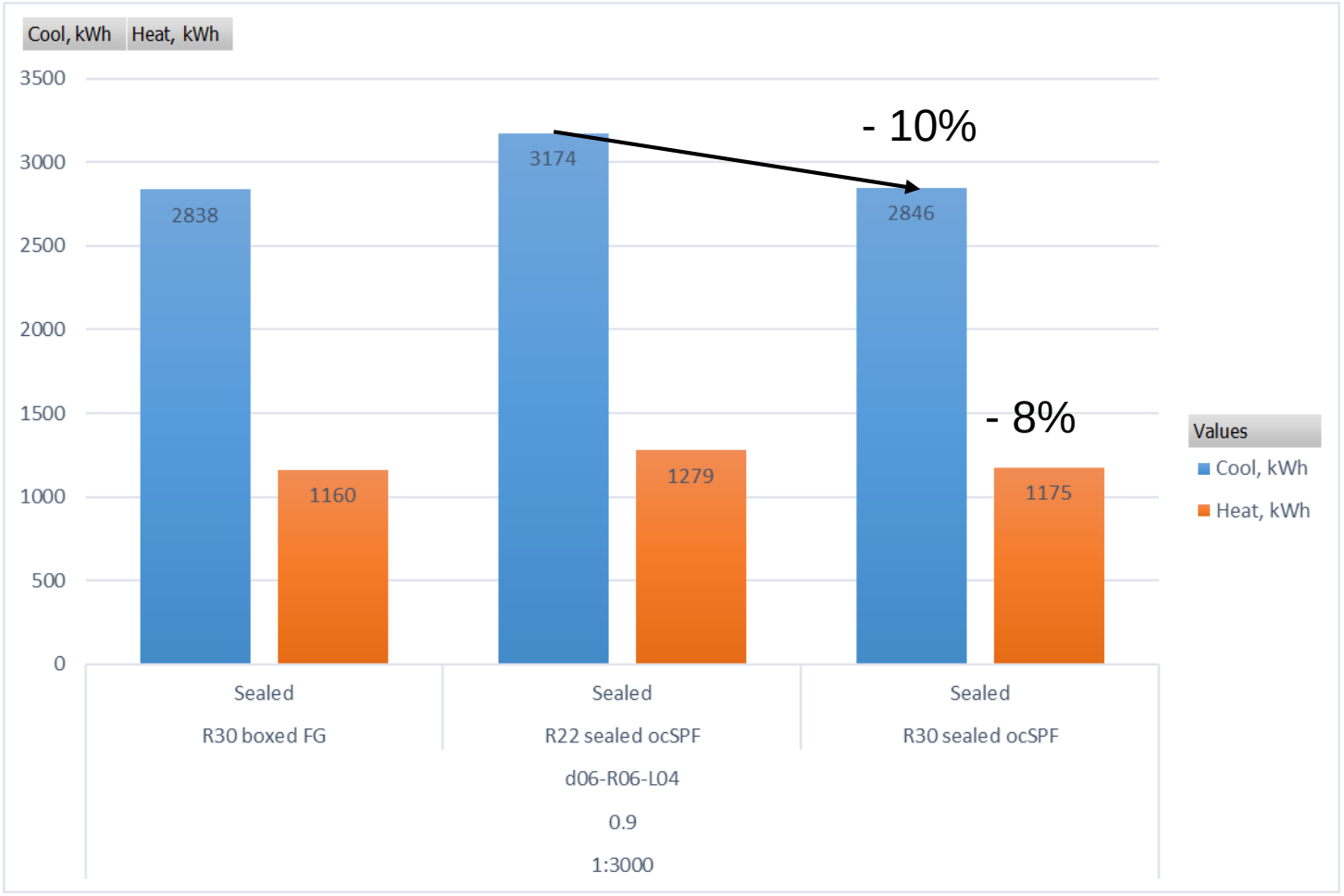
- San Antonio TX

Ceiling Insulation



Roof Deck Insulation

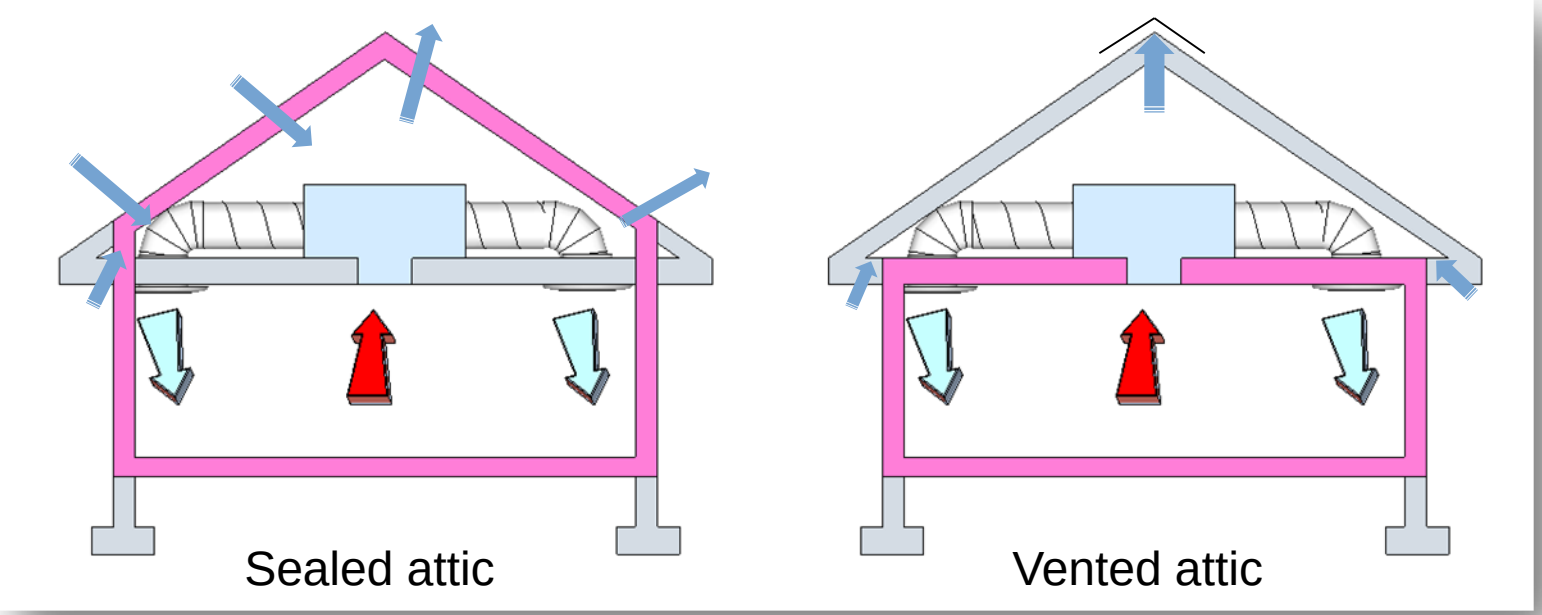
R30 boxed FG R22 ocSPF R30 ccSPF



Attic Vent Area

Leakage

0
1:3000
1:1567



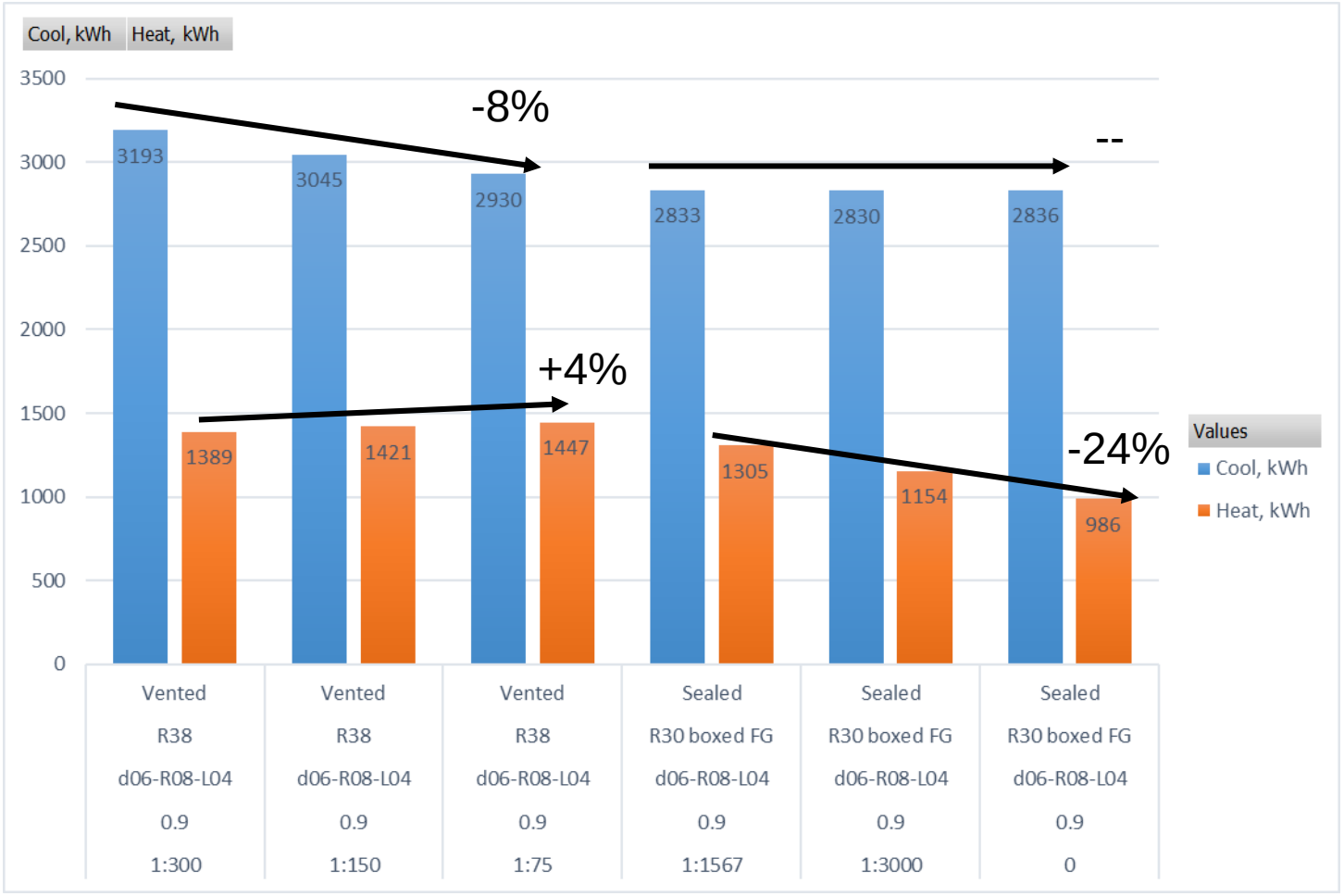
Vent area

1:75
1:150
1:300

Attic Vent Area

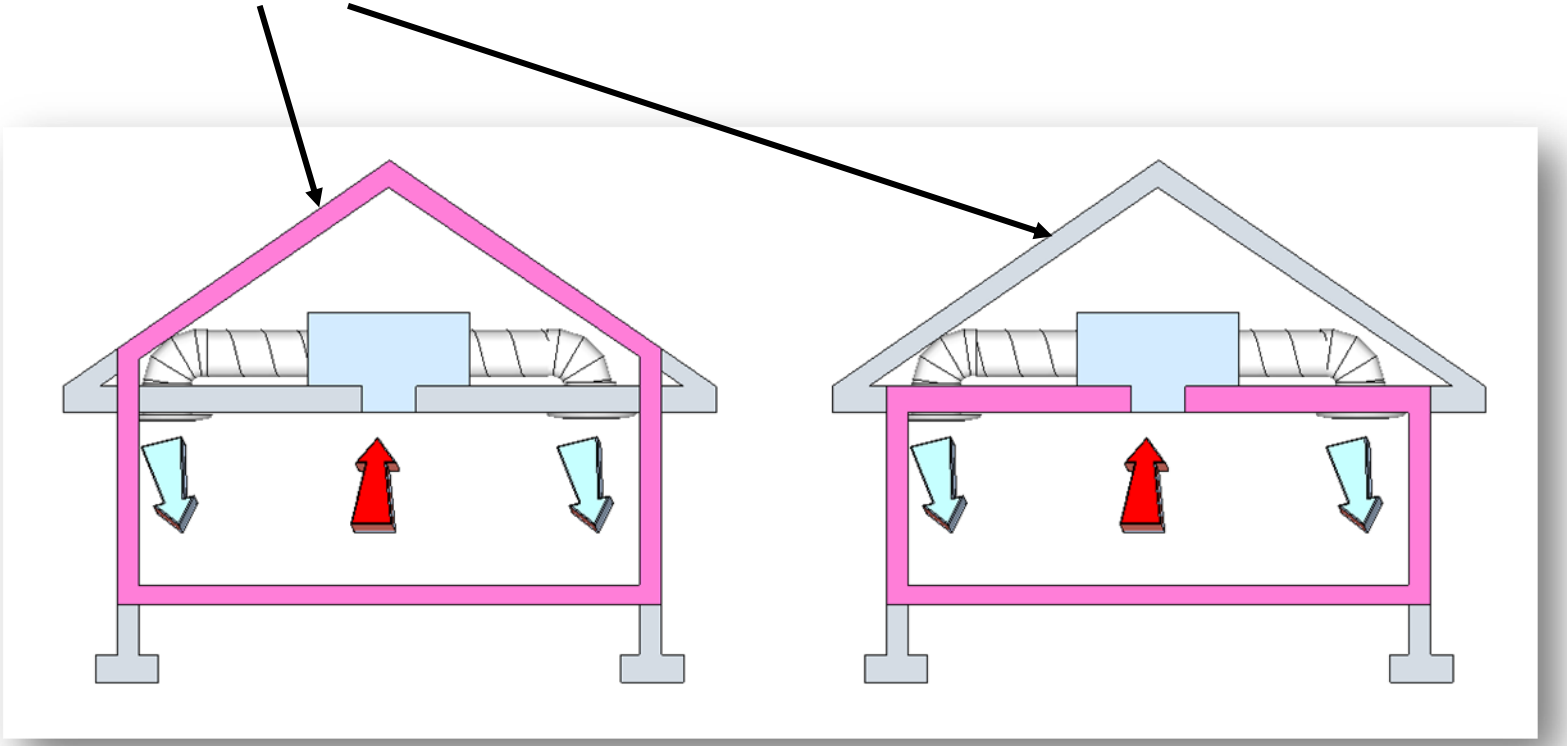
→ Vented attic More venting better

Sealed attic Tighter better

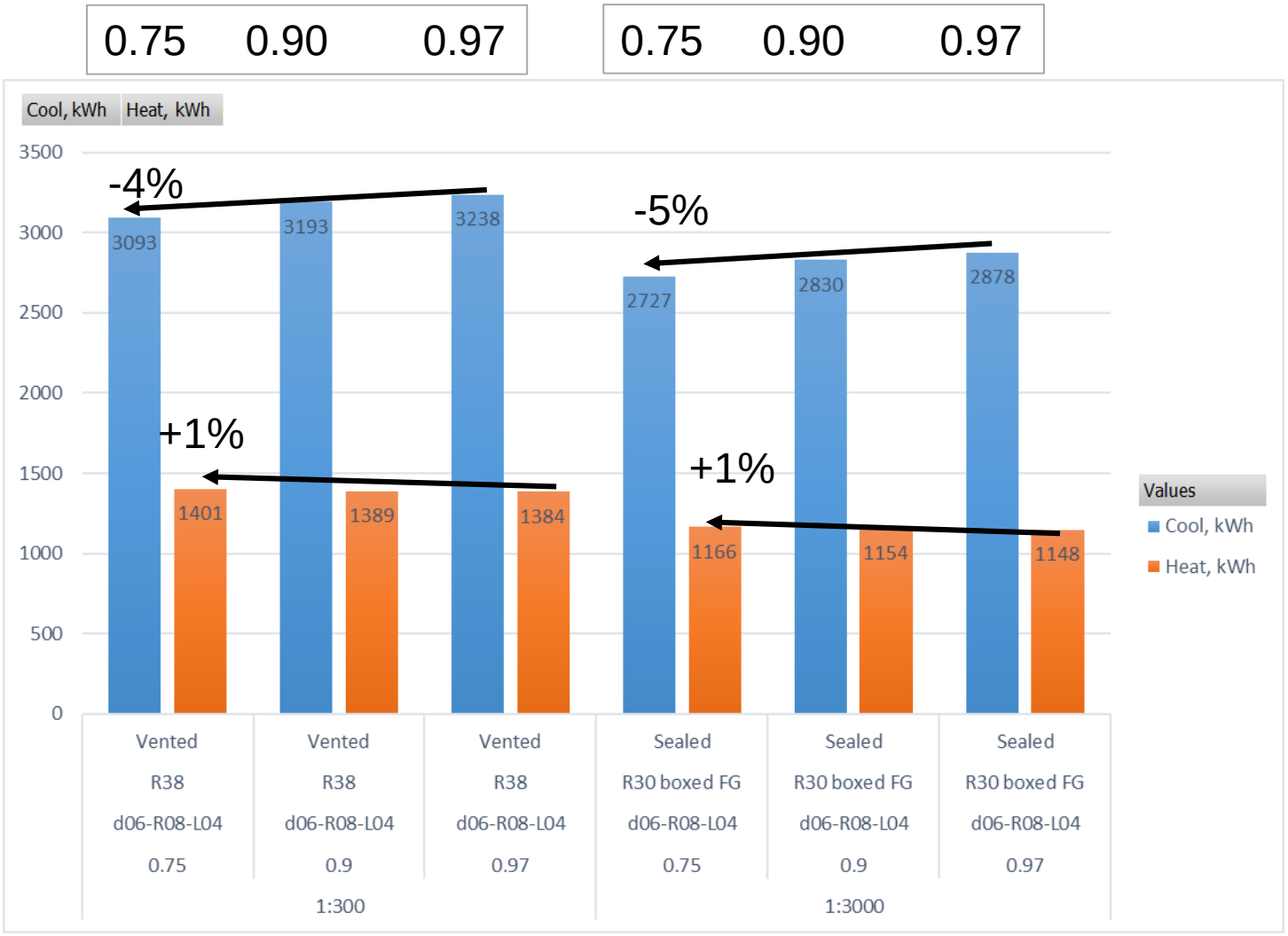


Roof Solar Absorptivity

Solar absorptivity of shingles: 0.75, 0.9 or 0.97



Roof Solar Absorptivity



Vented

Sealed

Duct Size (Compact Ducts)

Compact design vs standard …or “spider” web

FIGURE 1: Standard Air Distribution System

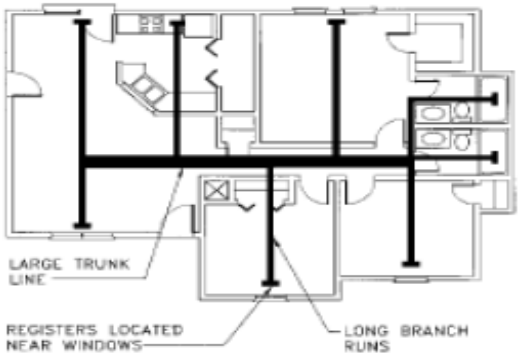
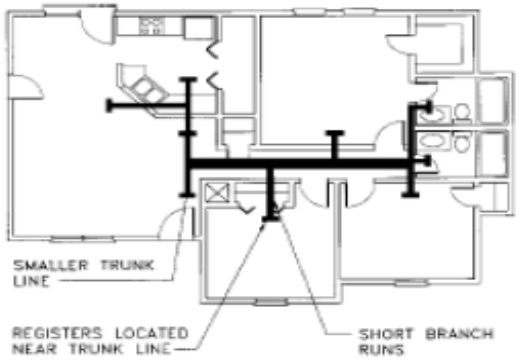


FIGURE 2: High-Efficiency Air Distribution System



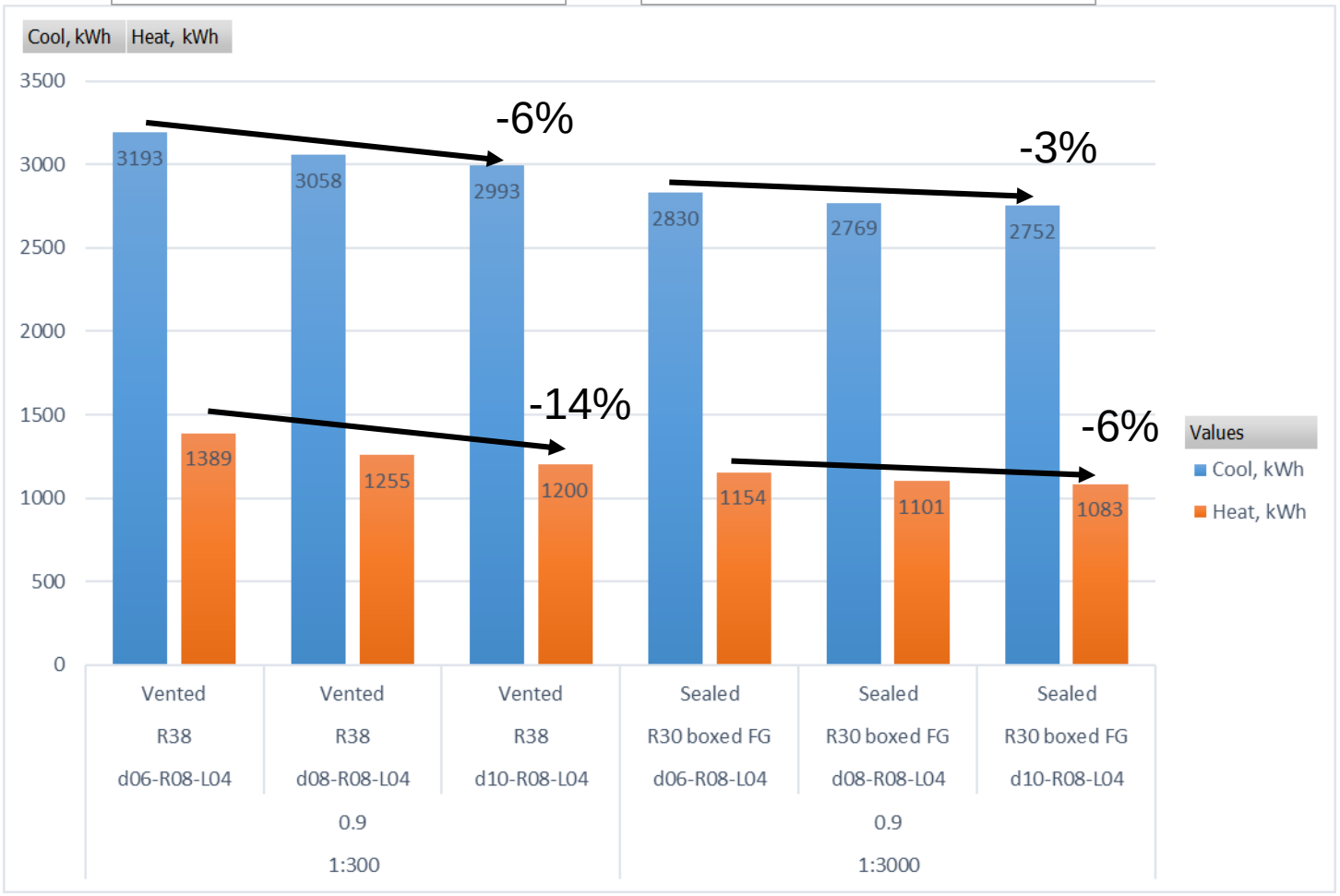
Duct length -50%

- Compact ducts: Larger main trunk, short branches

Ref: www.ductinside.org

Duct Size (Compact Ducts)

Duct diameter | 6” 8” 10” | 6” 8” 10”



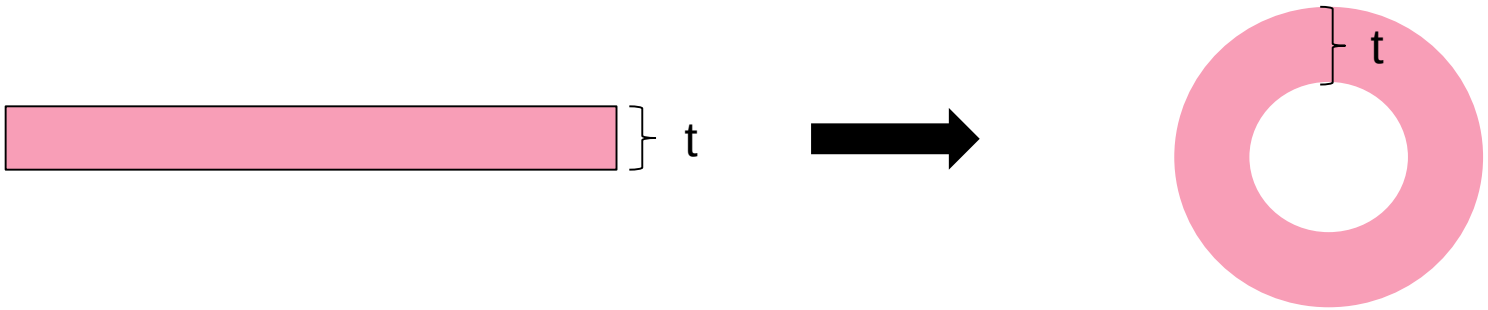
Vented Sealed

Duct R-value

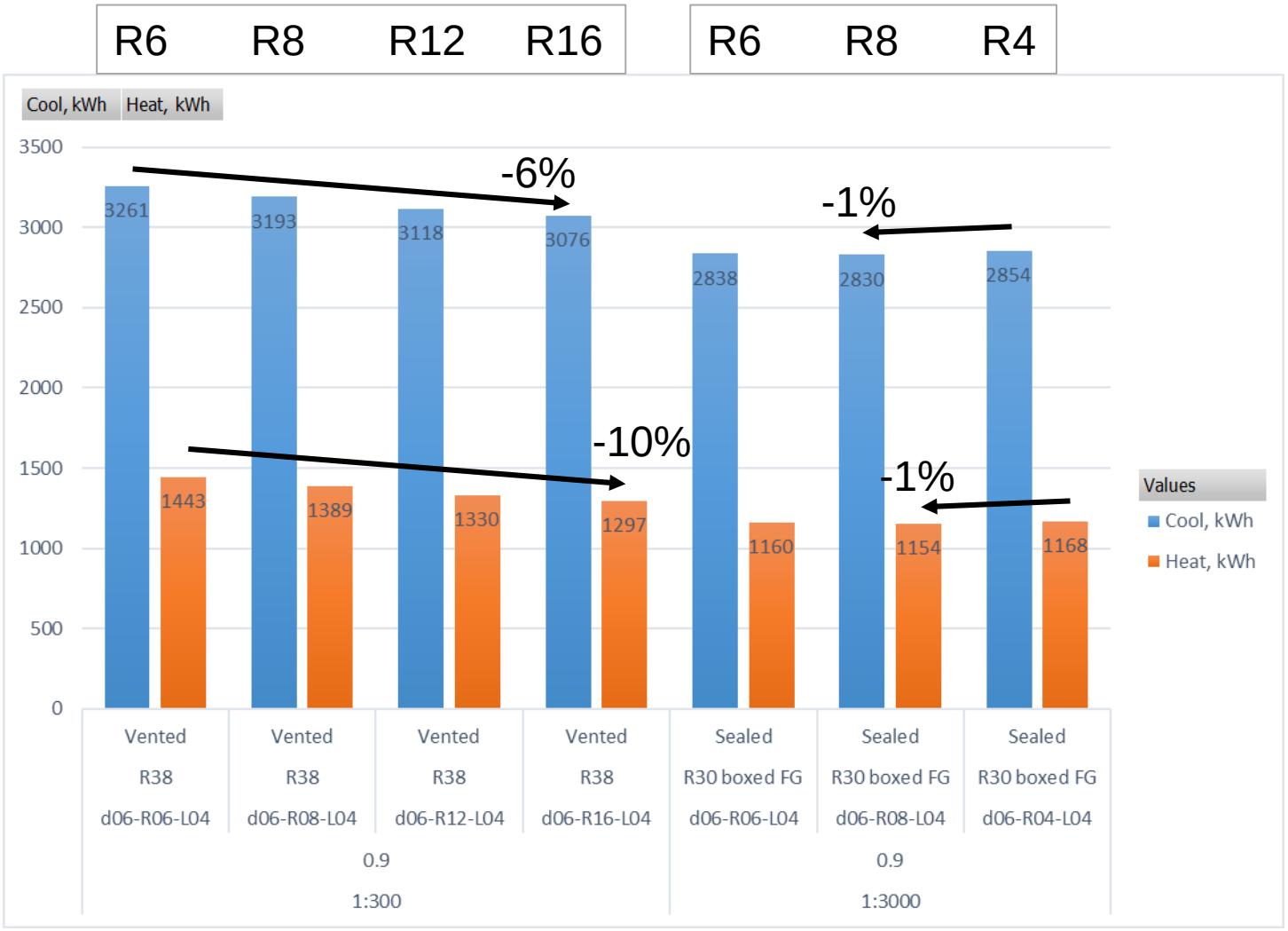
Nominal duct R-value is R-value for the flat insulation thickness.

The effective R-value per surface area will be different depending on the surface (inner or outer diameter of the insulation)

AtticSim calculates the effective R-value based on thermal conductivity and configuration

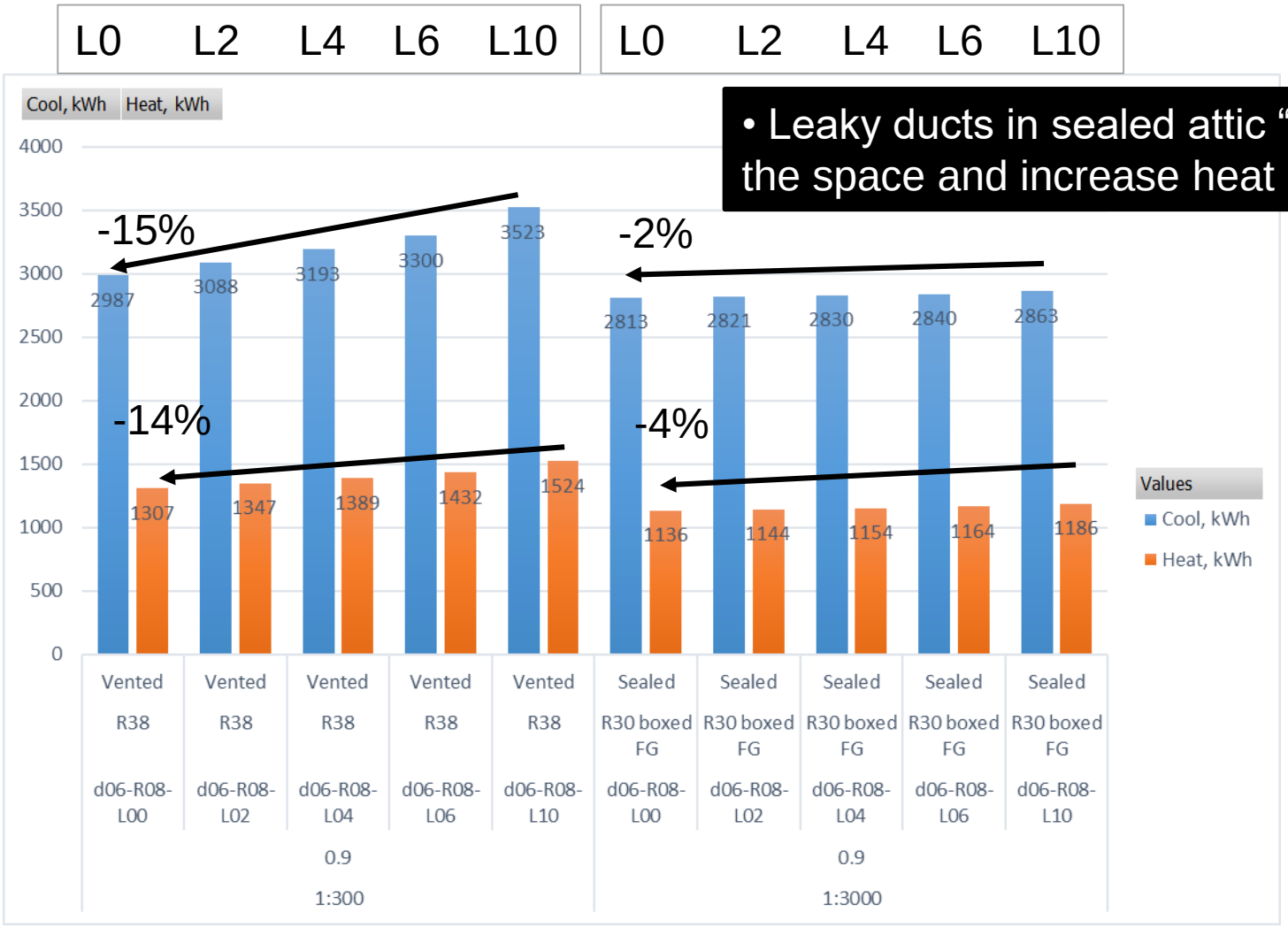


Effect of duct R-value

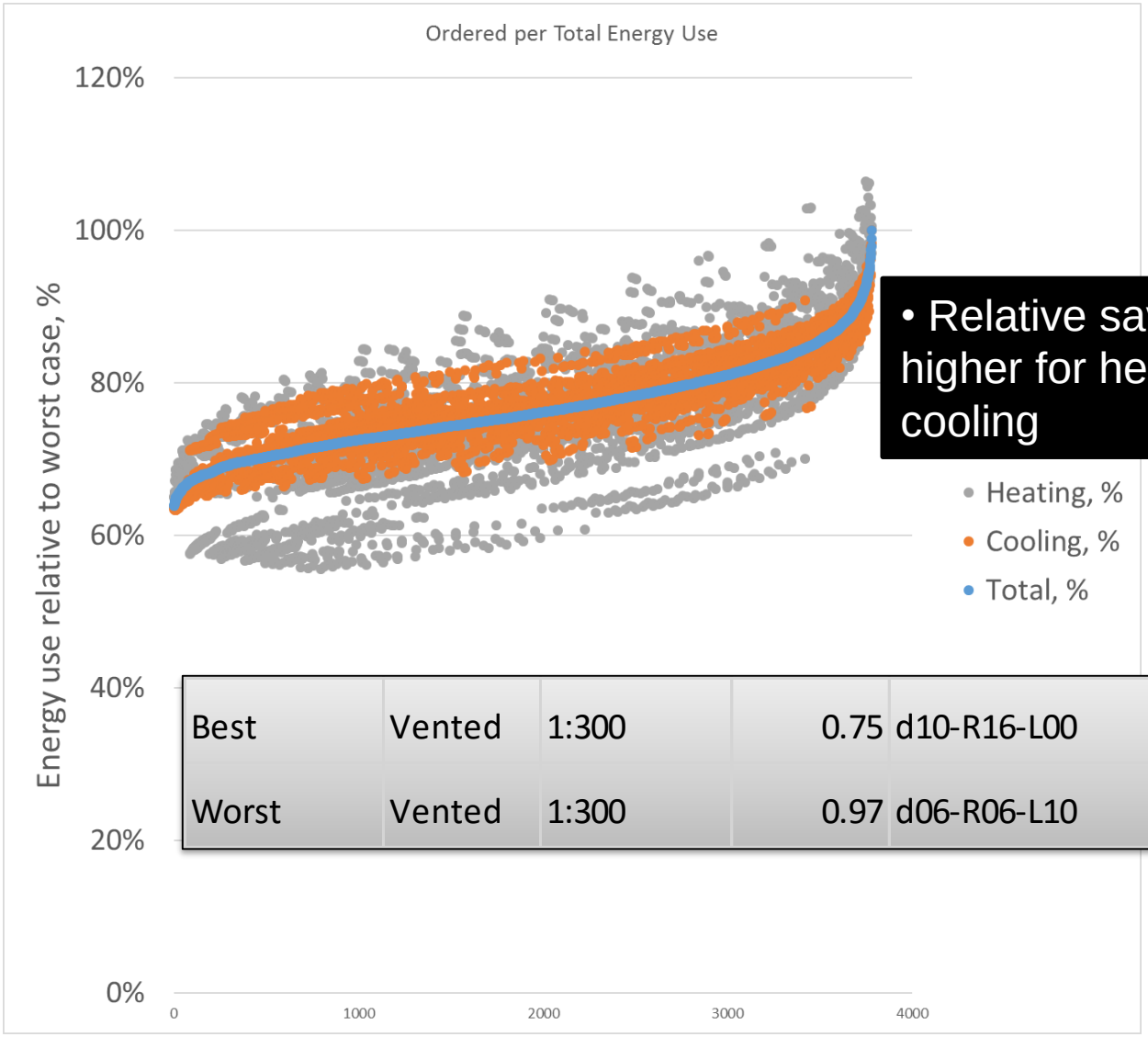


Vented Sealed

Effect of duct leakage



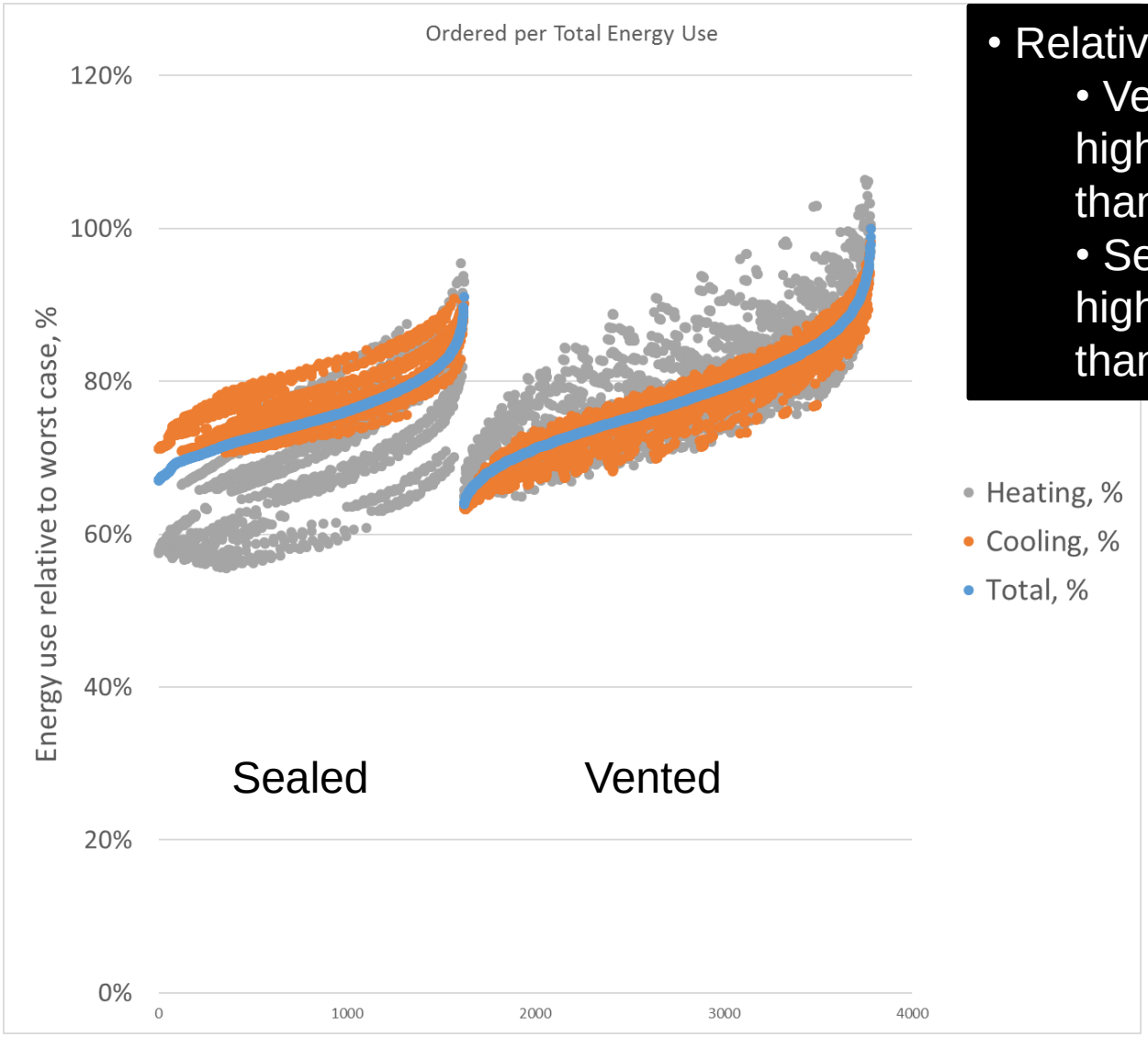
In Summary: All Cases in Order



- Relative savings can be higher for heating than for cooling

Best	Vented	1:300	0.75	d10-R16-L00	R30+R10
Worst	Vented	1:300	0.97	d06-R06-L10	R30

In Summary: All Cases in Order



- Relative savings in
  - Vented attics are higher for heating than for cooling
  - Sealed attics are higher for cooling than for heating

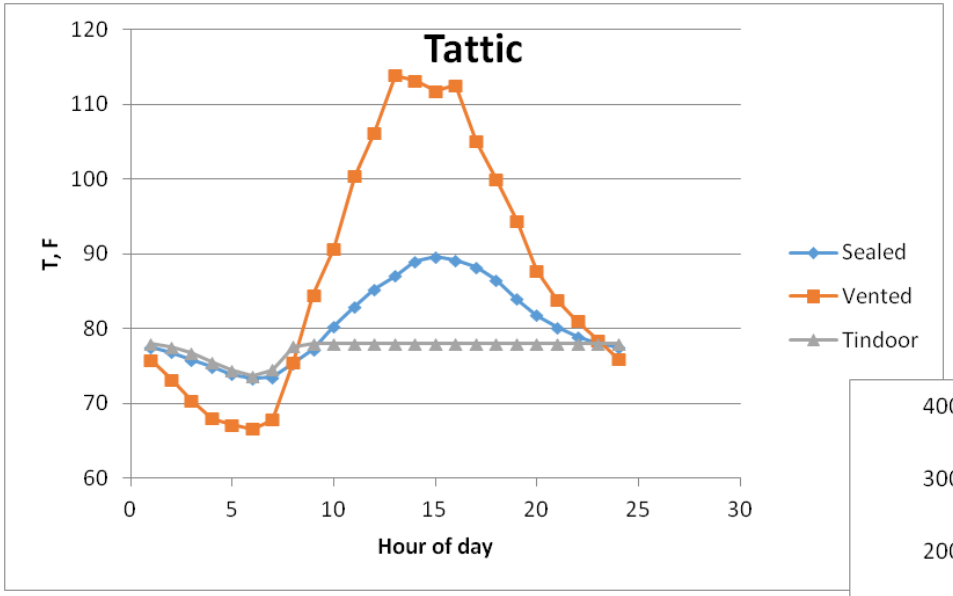
Features and Range of Relative Impact

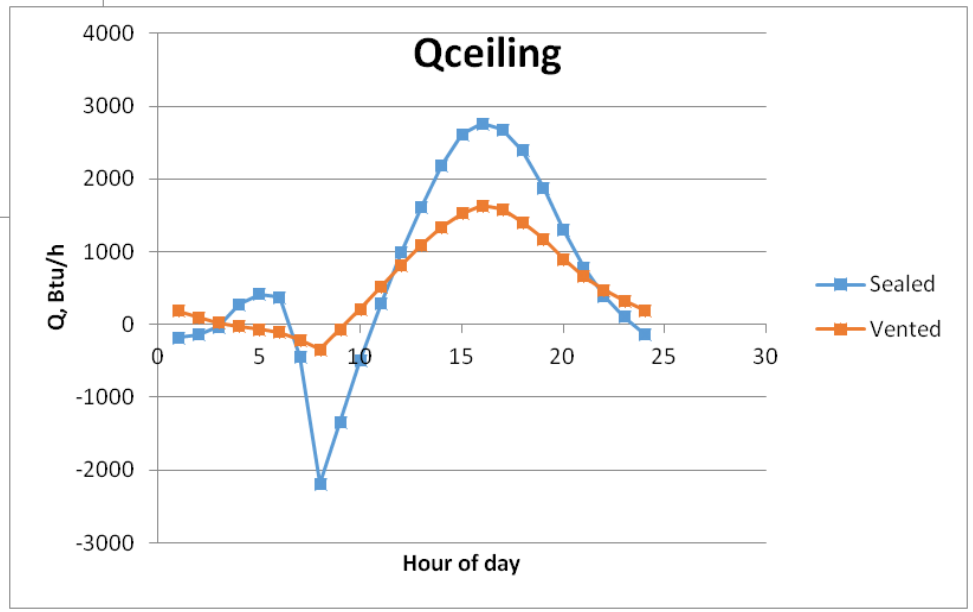
Feature	Vented (Rank) Cooling, Heating	Sealed (Rank) Cooling, Heating
Roof slope and orientation	4%, 11% (4)	2%, 1% (6)
Insulation level	-3%, -6% (6)	-10%, -8% (1)
Attic ventilation/leakage	-8%, +4% (5)	0%, -24% (2)
Roof solar absorptivity	-4%, +1% (7)	-5%, +1% (3)
Duct size	-6%, -14% (2)	-3%, -6% (4)
Duct R-value	-6%, -10% (3)	-1%, -1% (7)
Duct leakage	-15%, -14% (1)	-2%, -4% (5)

Best of Individual Scenarios

Insulation Type	Best case Total Energy (% of worst case)
R30+R10	63.9%
R49	66.9%
R30 boxed FG	67.0%
R30 sealed ocSPF	67.5%
R38	68.1%
R22 draped CFI	68.1%
R30	69.4%
R22 sealed ocSPF	73.5%

Sealed and Vented Attic Dynamics





- Different ceiling temperatures
- Effect on thermal comfort?

Discussion and Conclusions

Results show

- Unvented attics mostly perform better than standard vented attics in the analyzed climates
- Vented attics with well insulated air tight ducts can perform equally well as sealed attics (or even better)
- Hybrid system (R30+R10) outperformed (slightly) other systems
  - Hybrid and ventilated system needs careful testing before introducing it to hot-humid climates
    - Field testing experience has shown high humidity in attic in hot-humid climate
- Presentation tomorrow about buried ducts
  - R25+ and very low duct air leakage is doable

Thank you!