Radiant Cooling as a Hot Climate Strategy for Improving EER

Residential Energy Efficiency Technical Update
Meeting August 9-11, 2011 – Denver, Colorado

Project Goals

- Primary Objective – Evaluate the construction process and performance of air-to-water heat pump (AWHP) systems.
  - Ability to provide more efficient space conditioning while improving zoning and comfort.
  - Potential to eliminate or downsize air distribution systems and reducing distribution system losses.
  - Ability to raise cooling temperature setting through lower mean radiant temperature

Gaps & Barriers

- Need to better evaluate alternative space conditioning systems (i.e. Hydronic Delivery)
- Need to provide good distribution and comfort in low load buildings
- High cost and performance limitations of high performance HVAC.

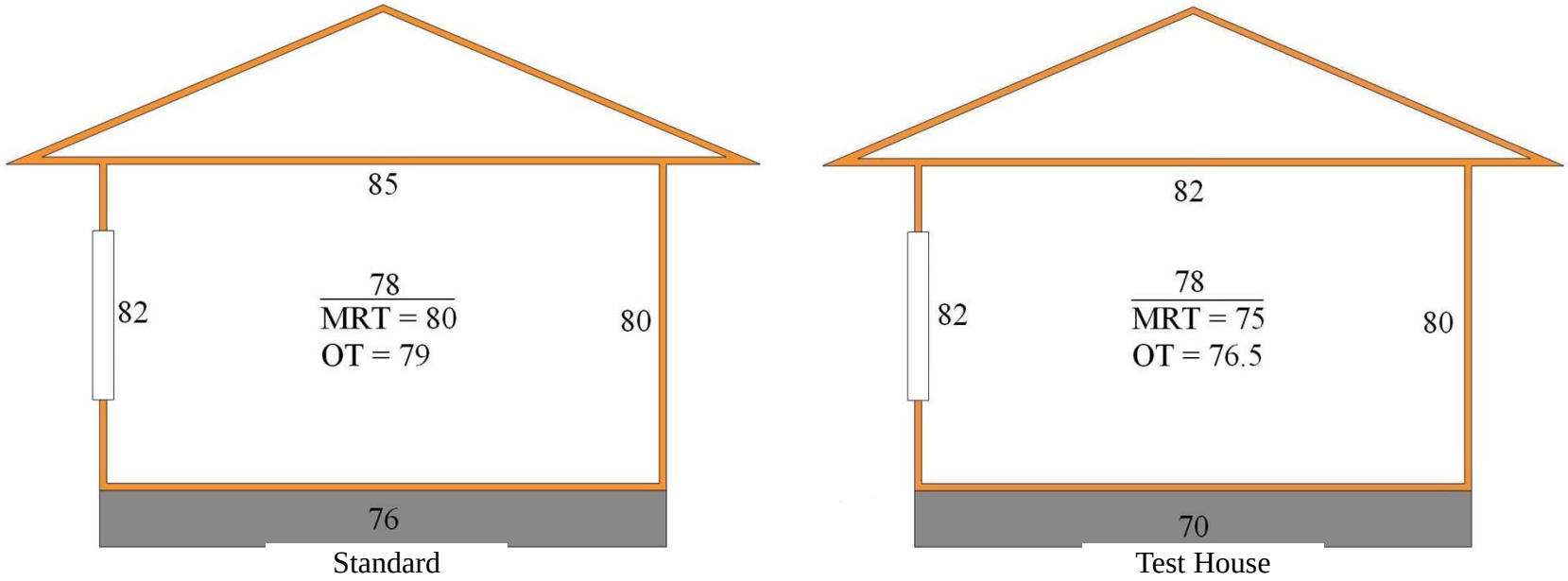
Research Questions

1. How does the distribution efficiency of the mixed-mode system compare to that of a typical forced air delivery system with ducts in unconditioned space?
2. What are the average effective cooling EERs?
3. How does the cost-effectiveness of air-to-water heat pumps compare to high efficiency air-to-air systems?
4. Climate limitations of AWHP systems with mixed-mode distribution?
5. Is the fan coil and latent cooling it provides necessary for dehumidification and to prevent floor condensation during design load conditions?
6. Can TRNSYS reliably predict performance of the two systems tested?
7. How effective is night time pre-cooling in improving efficiencies and reducing cooling energy use?

Characteristics of an Ideal Cooling System

- High EER
  - High Evaporator Temperatures
  - Low Condenser Temperatures
  - Low Parasitics
  - Minimize Distribution Losses
- Utility Perspective
  - Minimize Peak Operation
- High Degree of Comfort
- Reduced Building Load
  - through lower mean radiant temperature

Effect of Lower MRT



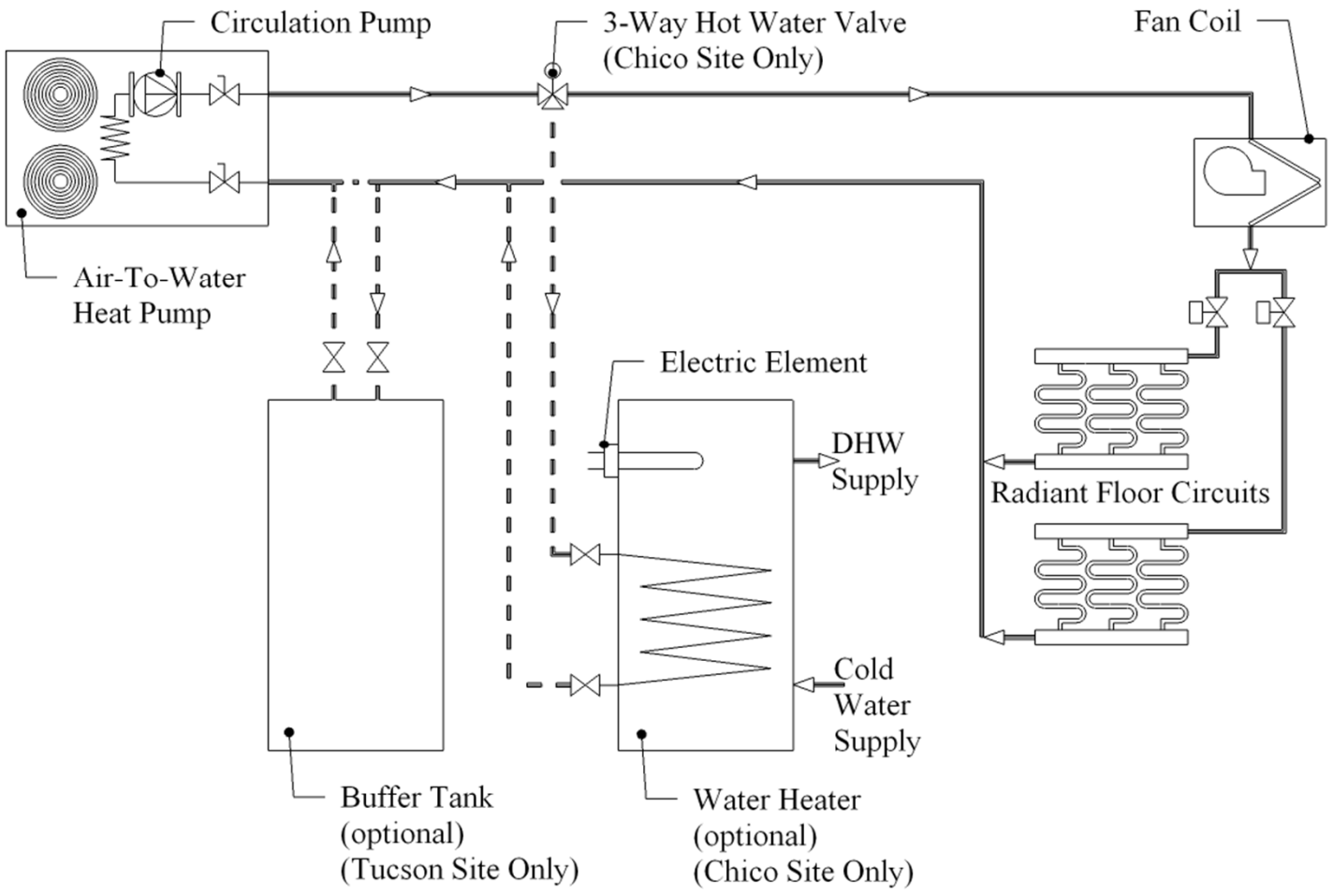
Lower operative temperature and potential to achieve cooling energy savings with higher cooling set point.

Test Sites

La Mirada Homes – Tucson Arizona

Cana House – Chico California

System Schematic



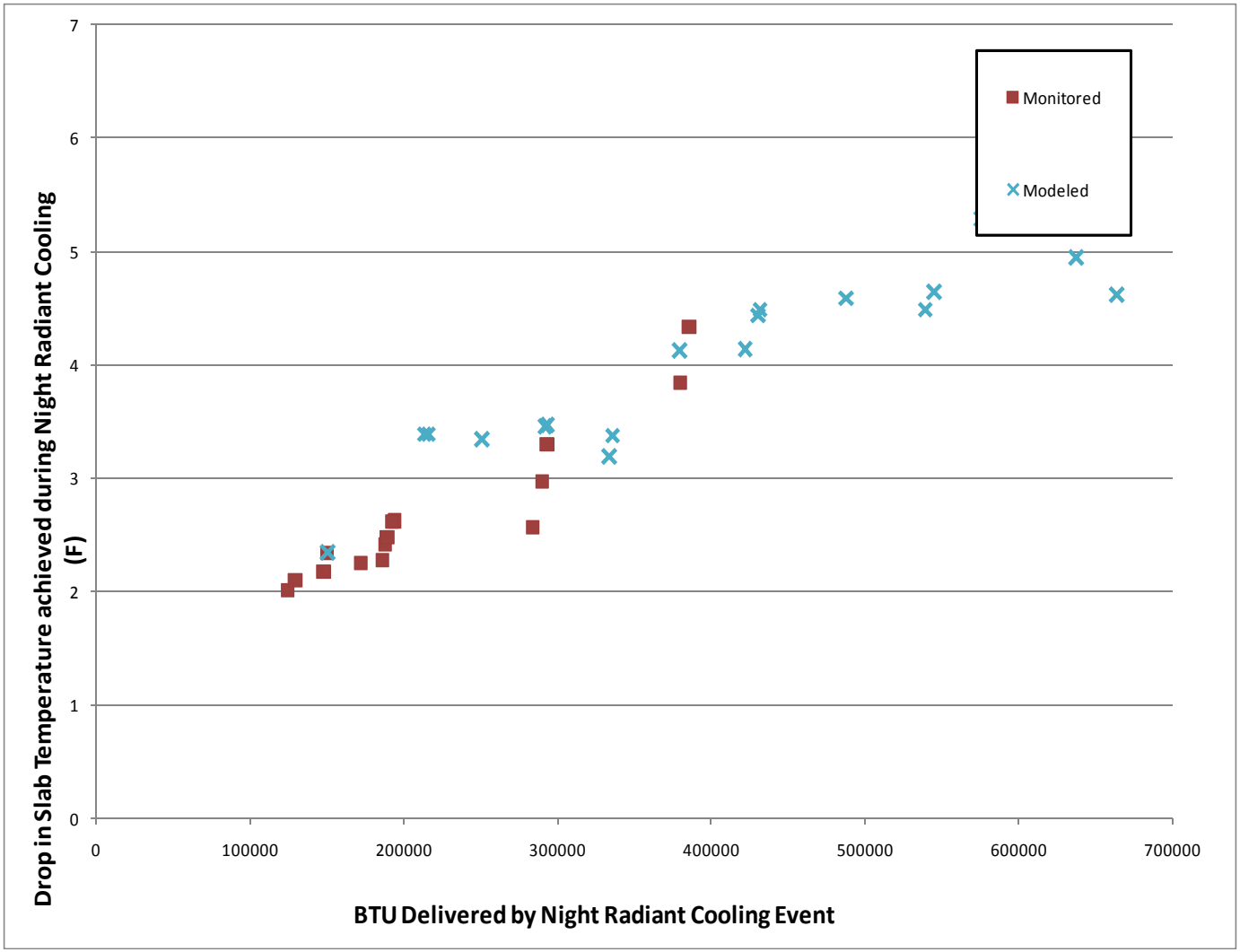
Cooling Strategies

- Night Slab Precooling (Cool & Coast)
  - 78 deg cooling setpoint
  - Run floor cooling 1 - 6 am w/ 5 degree setback (73°F)
- Constant 77°F Cooling Set point
  - Equal to average temp of “cool and coast”
- Compare relative EER’s and cooling energy use

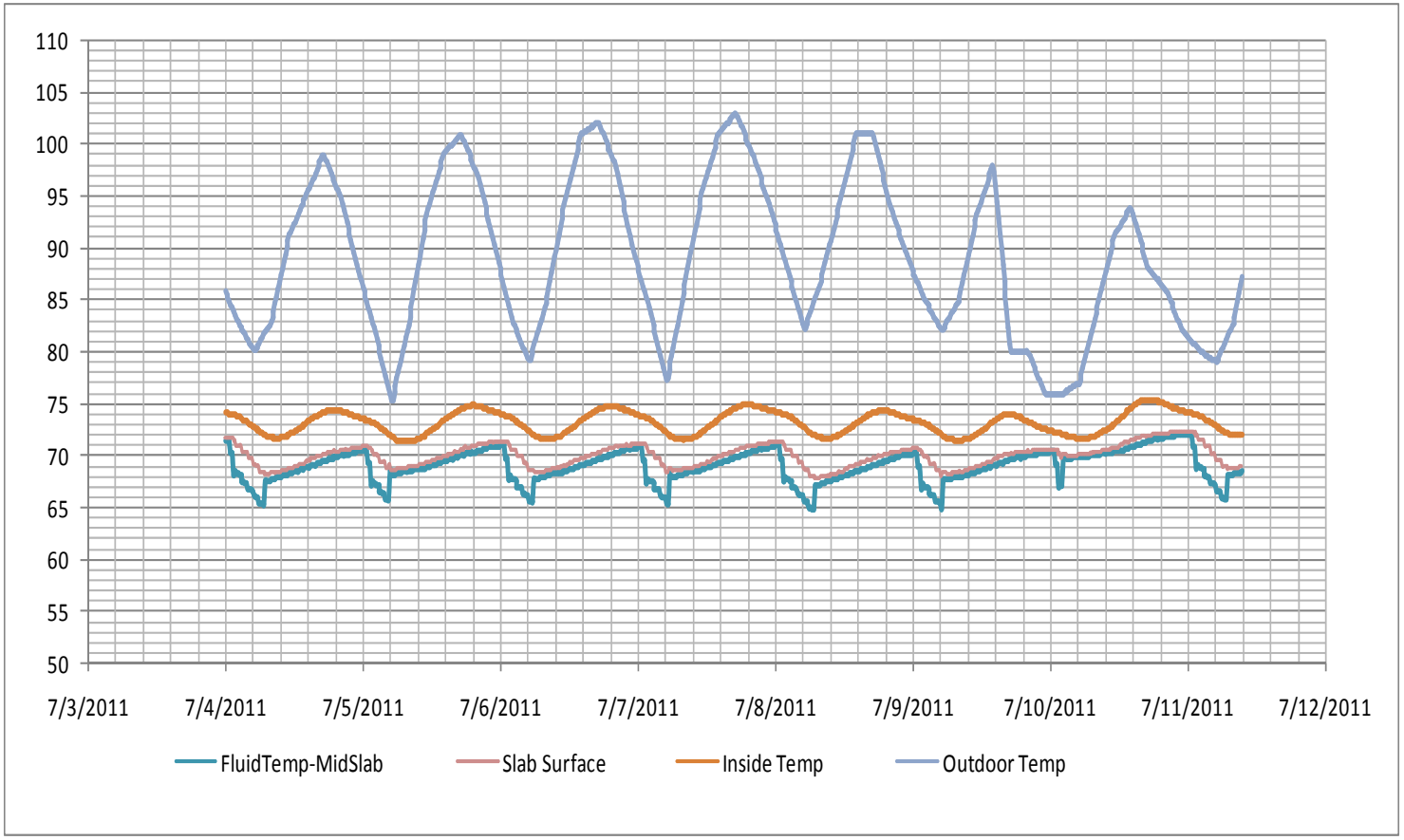
TRNSYS Modeling

- Collaborated w/ TESS to develop TRNSYS model for both system site designs.
- Preliminary TRNSYS calibration results show similar trends to monitored data.
- Further calibration as monitored data is evaluated.

TRNSYS Calibration



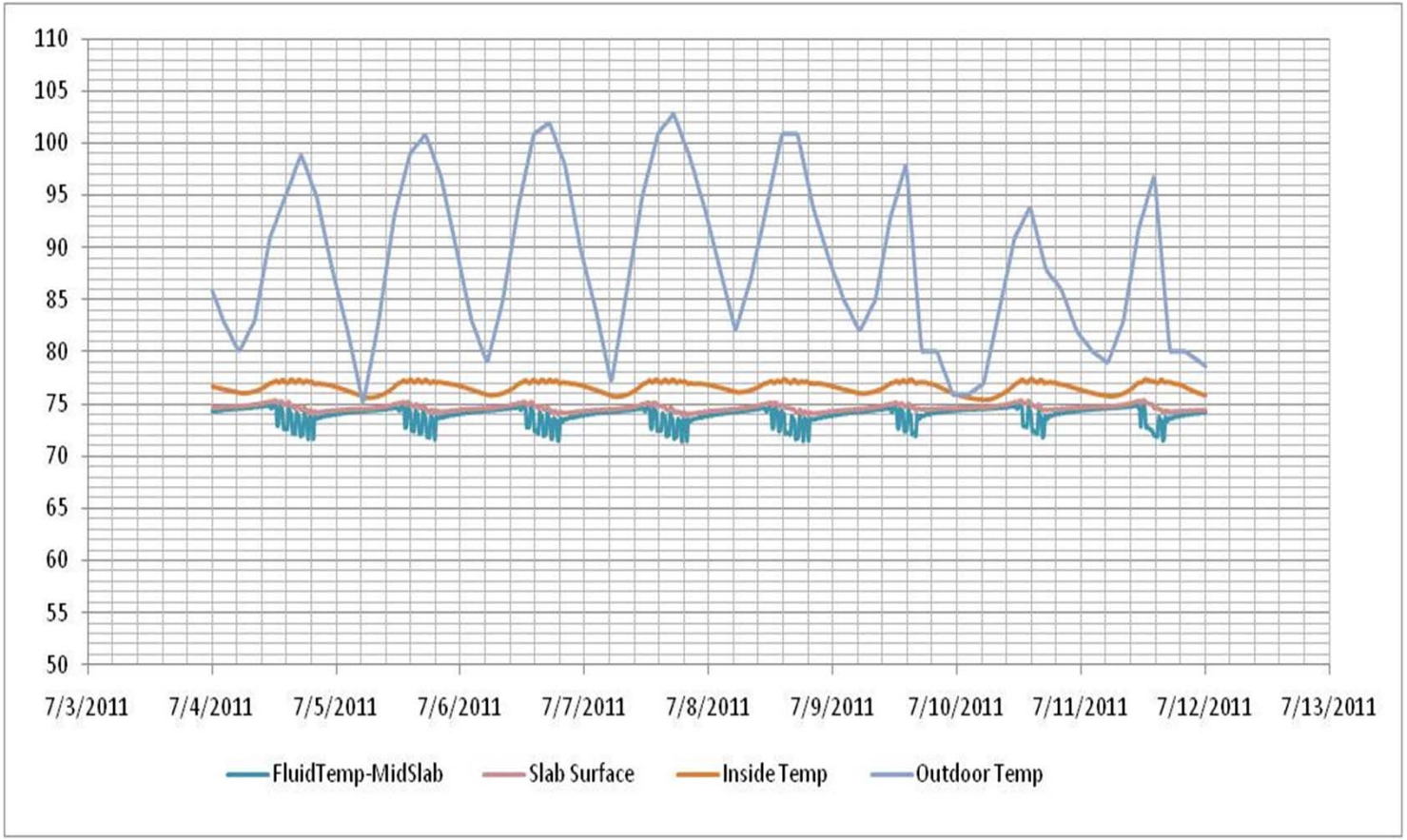
“Cool & Coast”



Average Slab Temperature = 70.3°F

Average Space Temperature = 73.2°F

Constant Setpoint



Average Slab Temperature = 74.6°F

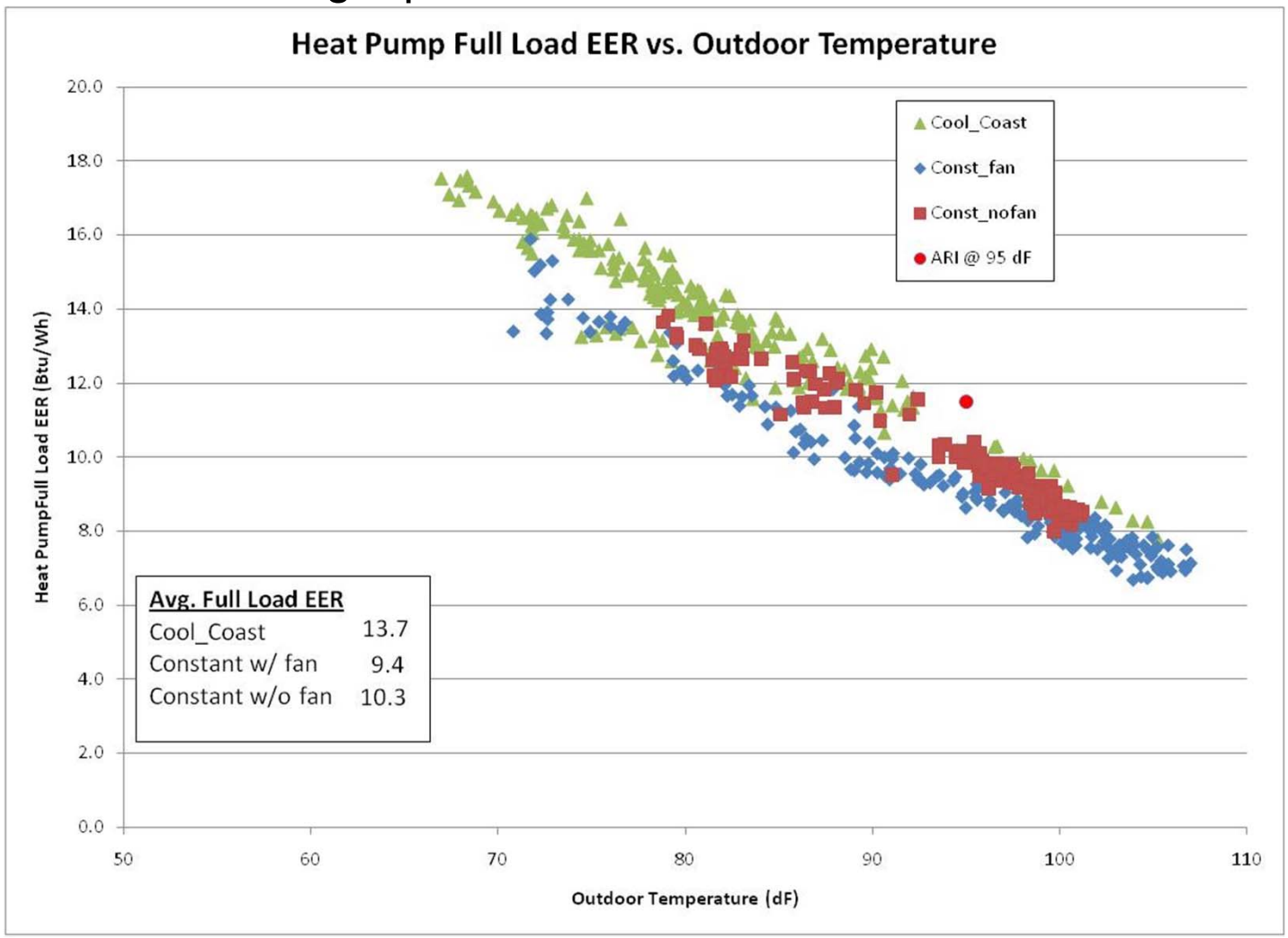
Average Space Temperature = 76.5°F

TRNSYS Modeling

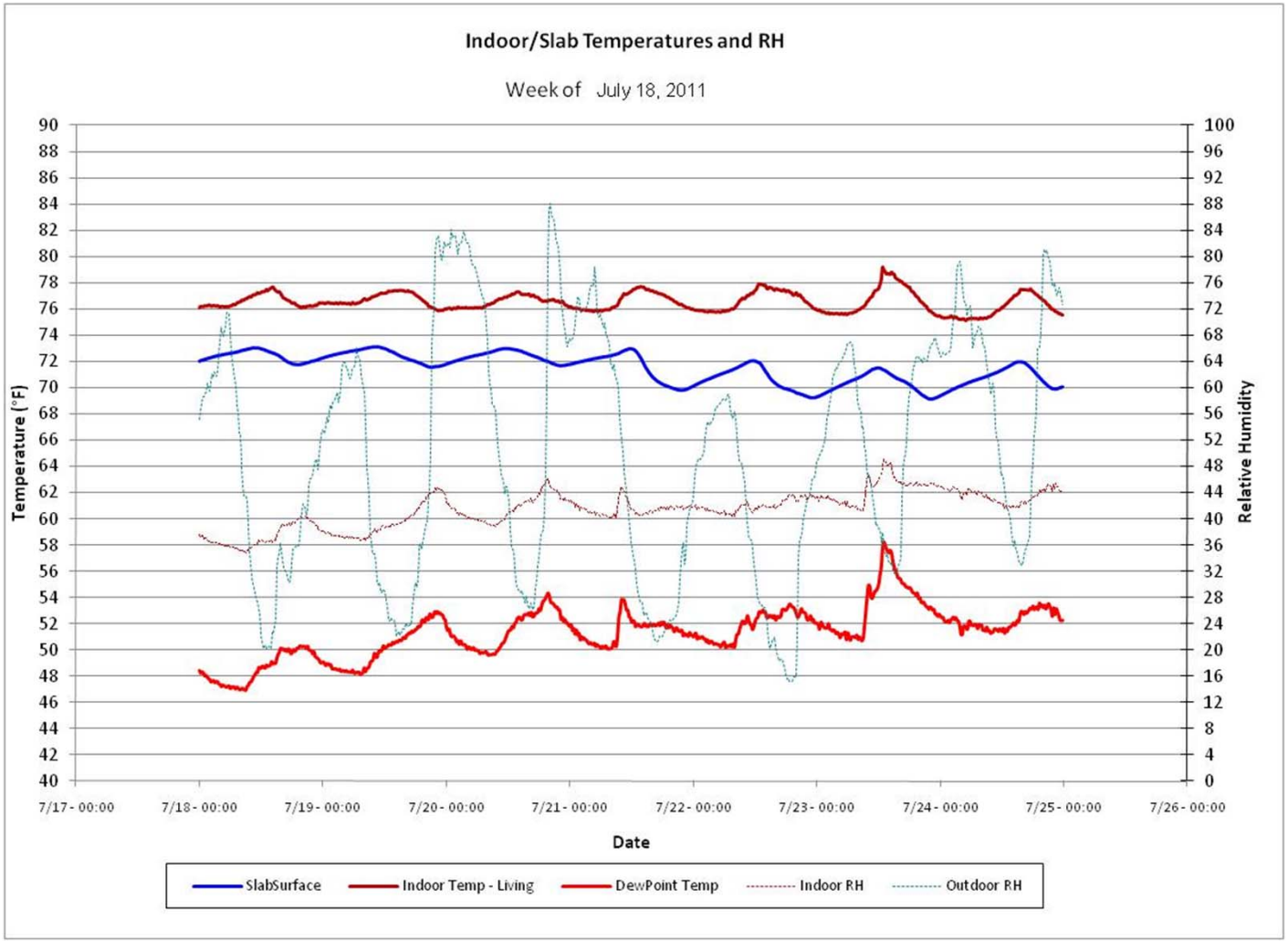
- Preliminary TRNSYS modeling shows 42% reduction in annual cooling energy use with the “cool & coast” strategy.
- Further calibration of model with monitored data.

Monitored Data

Full Load Cooling Operation



Monitored Data



Performance Advantages

- Improved operating efficiencies
  - 13.7 EER vs. 10.3
- Off peak compressor operation – Utility / TOU benefits
- Potential occupant comfort benefits.
- Insulated slab and building mass critical to success. Maximize the useful delivered cooling for next day.

Conclusions

- Benefits of “coast & cool” strategy due to shifting operation to evening when Tout is cooler.
- Fan coil provides 45% of cooling delivery when used. Airflow can be adjusted at Chico installation.
- EERs w/ and w/o fan coil operation similar
  - EER penalty from additional fan power balanced by better compressor EER w/ higher heat pump entering water temperatures