Agenda

- **Pre-cooling and demand response control in extreme hot weather climates**
- **Demand response quick assessment tool for large commercial building**
  - **Demo**
  - **Modeling and calibration**
- **Demand response quick assessment tool for small commercial building**
- **Discussion and future work**

Pre-cooling and demand response control in extreme hot weather climates

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Sponsored by the California Energy Commission through the Demand Response Research Center

Executive Summary

- Pre-cooling and demand shed strategies worked well in the office buildings tested under extreme hot weather and were able to reduce cool load significantly (20~30% in hot days).
- Compared to the baseline days, the test days show a slight decrease in the percentages of persons who rated their productivity as ‘enhanced’.
- Properly controlled exponential temperature setup in the shed period can maximize the load reduction.
- Pre-cooling strategies were more effective in extreme hot days than in cool days.

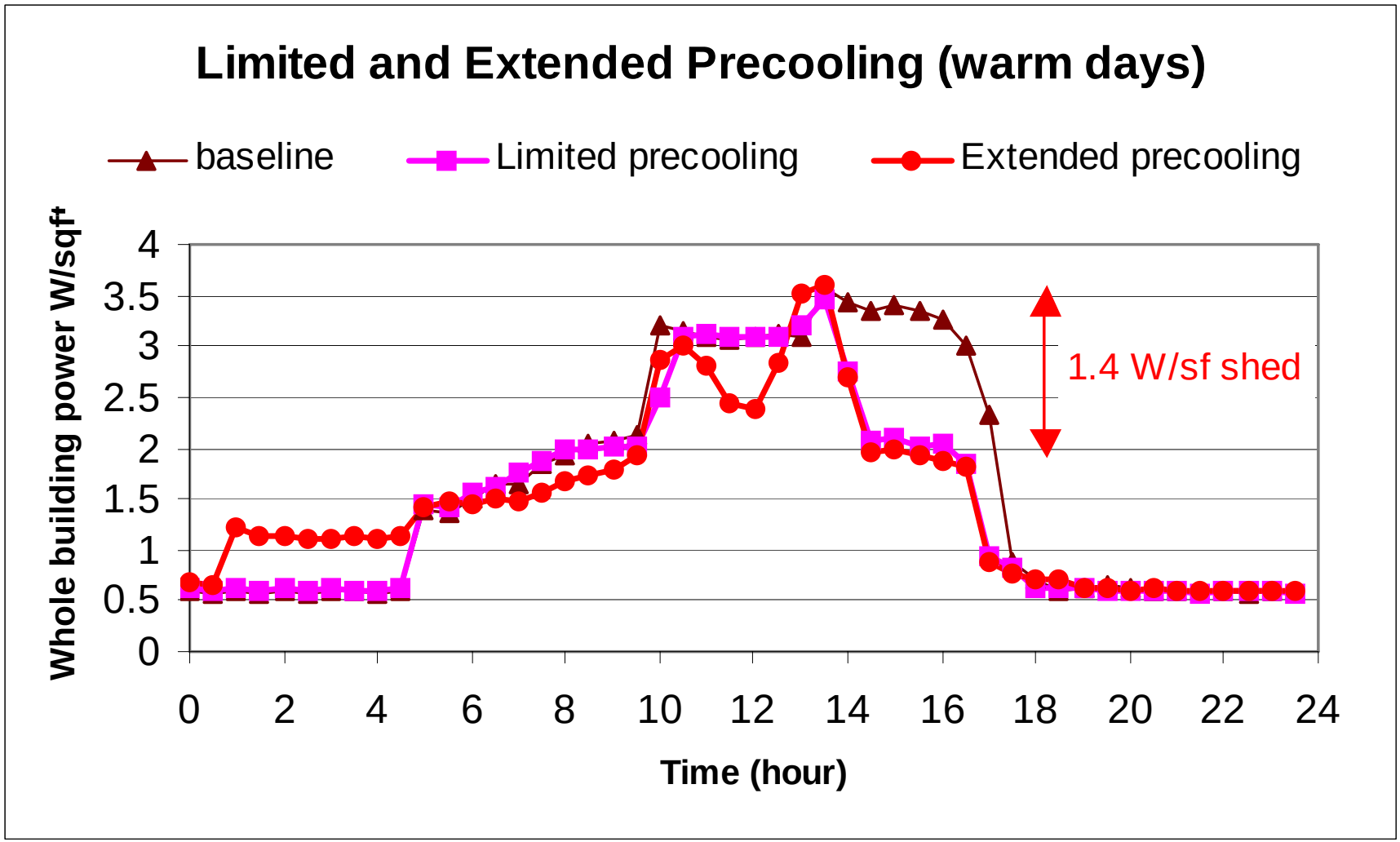
Demand Shifting With Thermal Mass

- Precool at night during off-peak hours
- Adjust daytime setpoints to control discharge
- Cooled structure reduces daytime, on-peak cooling loads
- Savings due to
  - Reduced on-peak energy and demand usage
  - High COP at night and early morning
  - Night ventilation

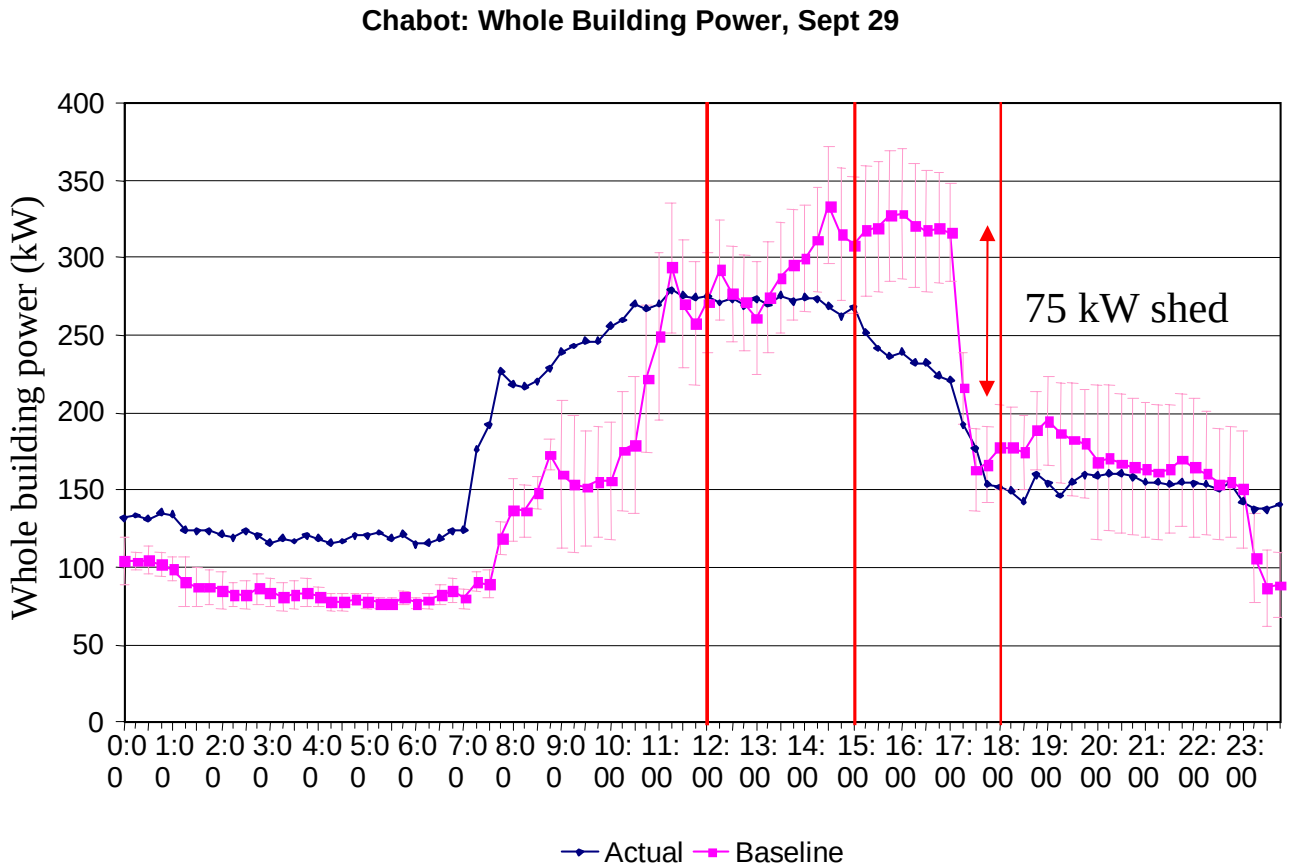
Field Test Summary

	# of Sites	Peak reduction	% (whole building)	Strategies	Comfort	Peak outside temp
2003	1 (Santa Rosa)	2.3 W/ft^2	~60%	Preclg + temp set up (one step)	No complaints	90-95 ^{o}F
2004	2 (Santa Rosa, Sacramento	0.5~2.0 W/ft^2	10~66%	Preclg (w/o) + temp set up (one step)	Comfort survey	85-90 ^{o}F
2005	2 (Oakland	0.5~1.0 W/ft^2	10~25%	Preclg (w/o) + various shed and recovery strategies	Comfort survey + indoor monitors	80-85 ^{o}F
2006 2007	2 (Visalia, San Bernardino)	0.5~1.0 W/ft^2	20~30%	Preclg (w/o) + various shed and recovery strategies	Comfort survey + indoor monitors	100-110 ^{o}F

Case study in mild climate



Case study in mild climate



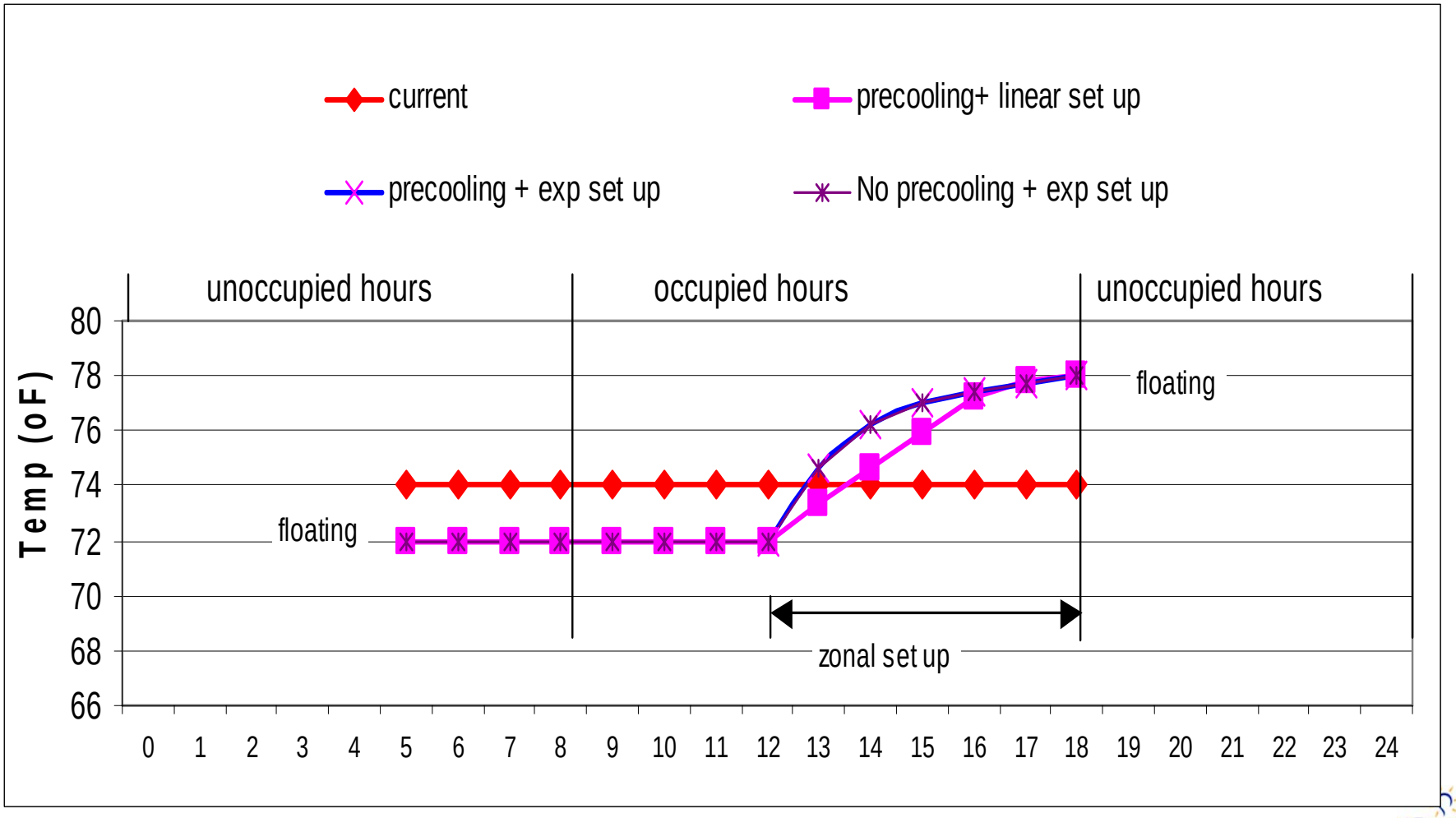
The building was pre-cooled at 68°F from midnight to 5am, and at 70°F from 5 am to 12 pm. After 12 pm, the temperature was gradually raised to 76°F. The maximum shed period was from 3pm to 6pm (high price CPP period).

Case study in hot climate

Questions to answer

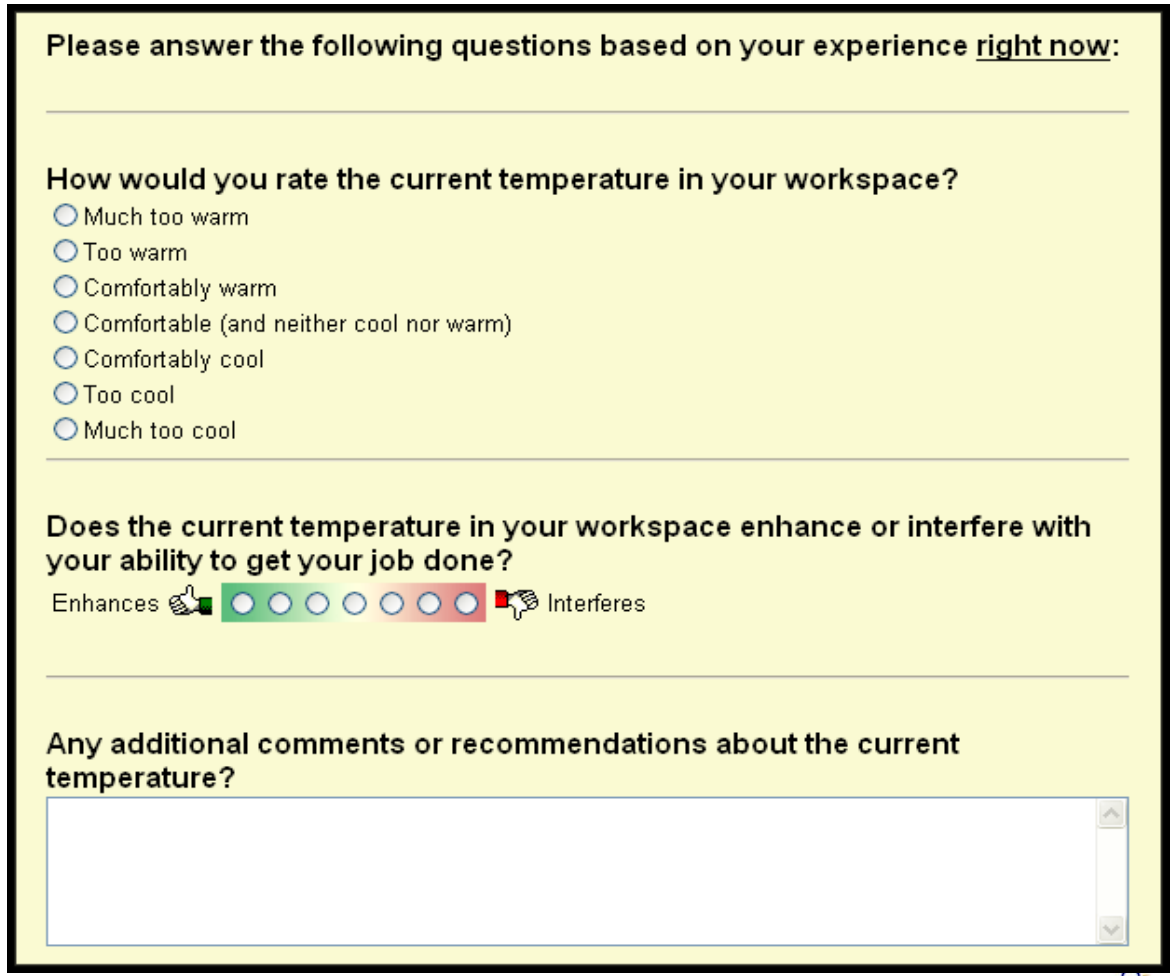
- Will the strategies work equally well in extreme weather conditions?
  - Critical peak pricing would typically be invoked on extreme hot days
  - Will the comfort reaction be different?
  - Will load shed be large enough?
  - Will sheds last long enough?

Demand Shed Strategies



Web based comfort survey

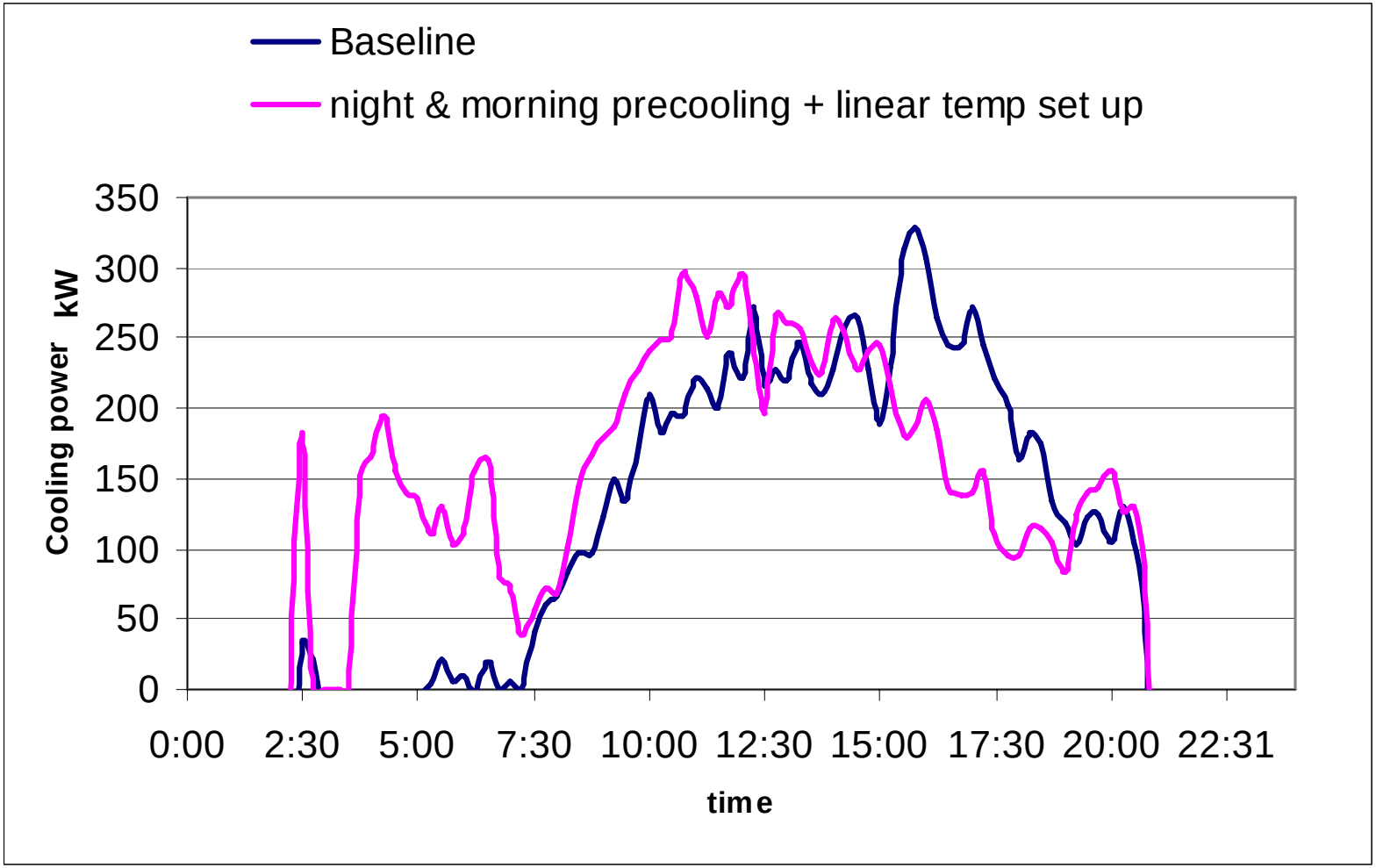
- Sent survey request emails twice a day
- Two self-assessed questions



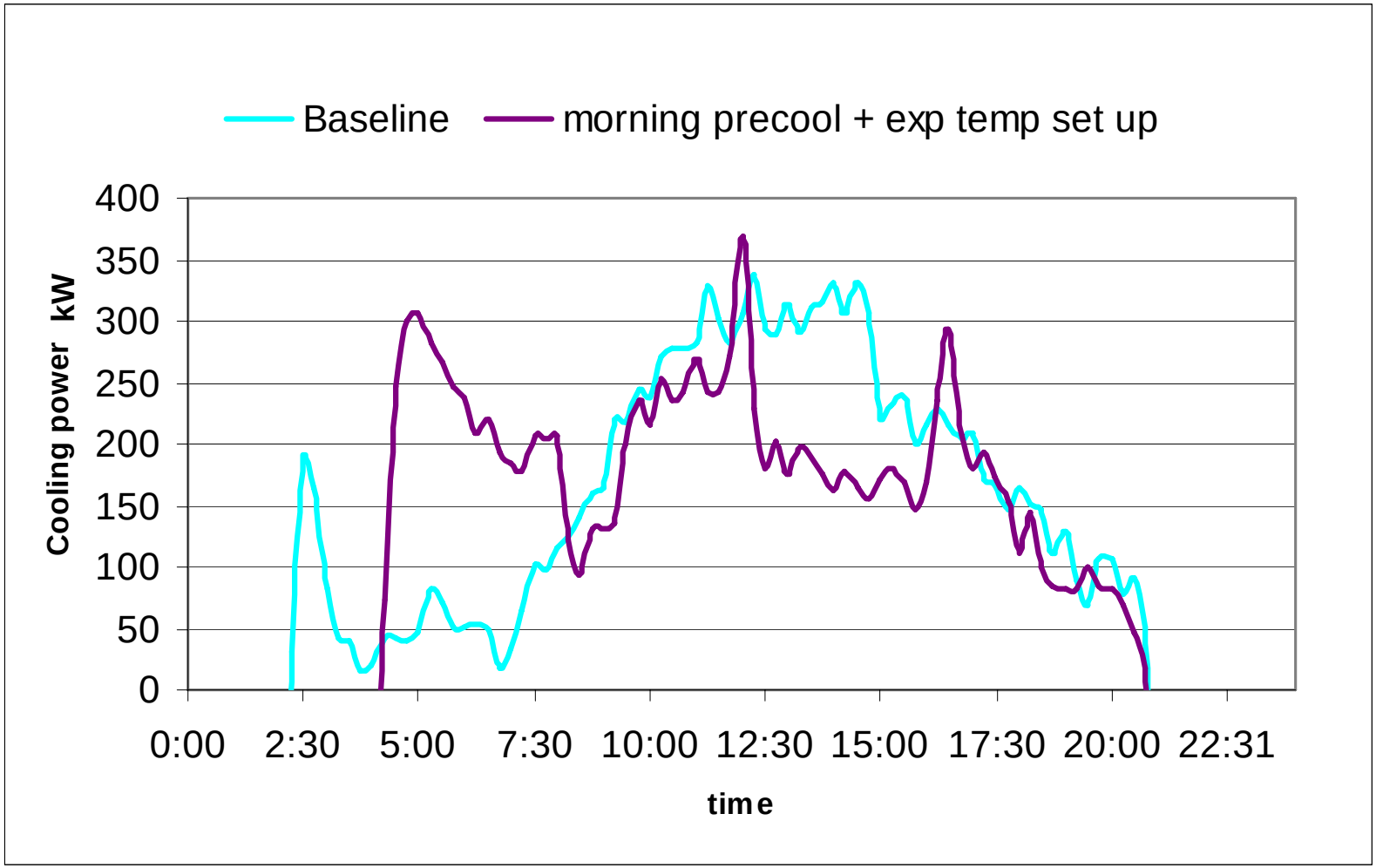
Cigna Building in Visalia

- Met all basic criteria
  - Required some minor programming changes to their existing EMS system
  - 130,000 Sq. Ft.
  - Single Occupant
  - Very motivated and cooperative property manager

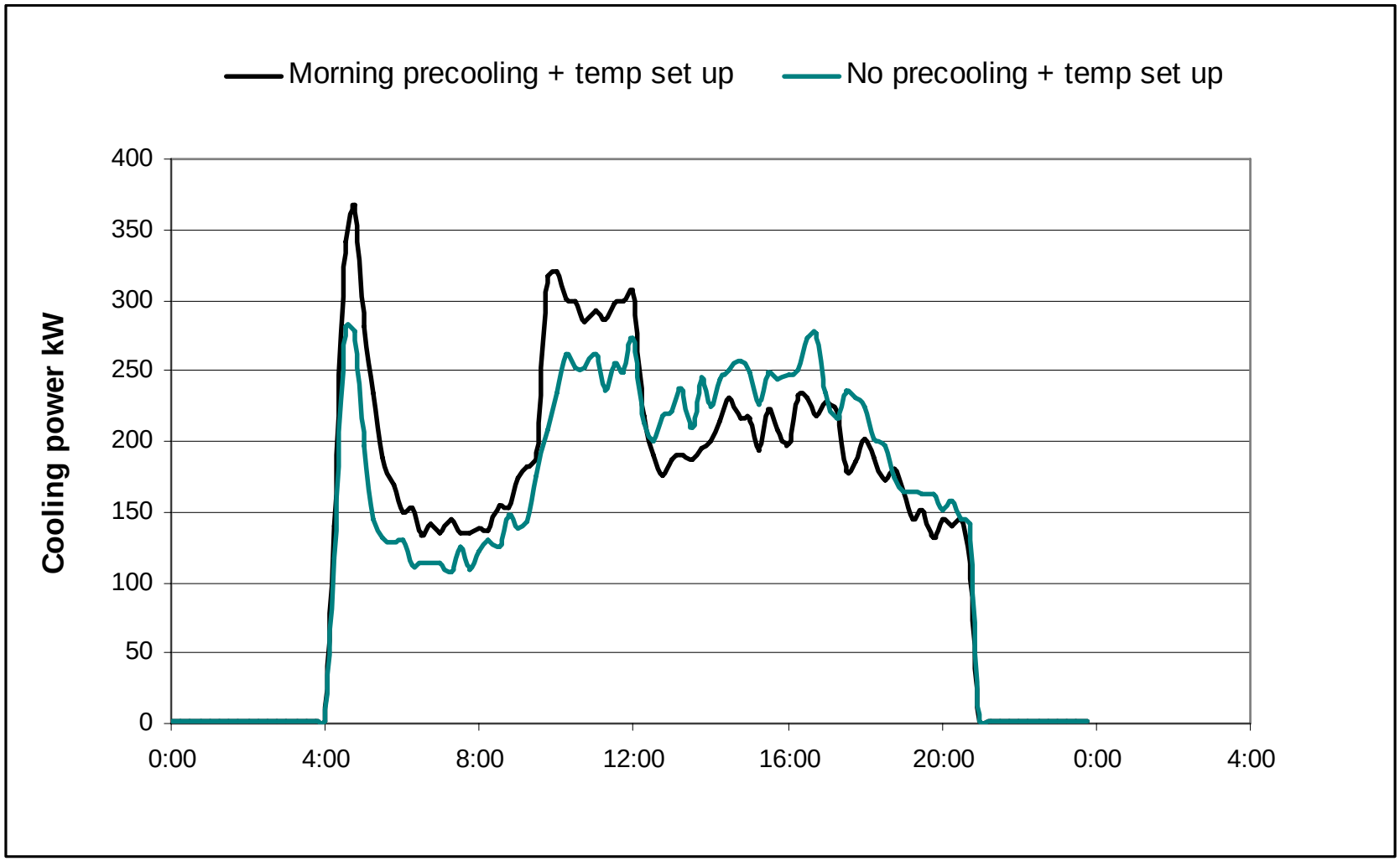
Precooling + linear temp reset



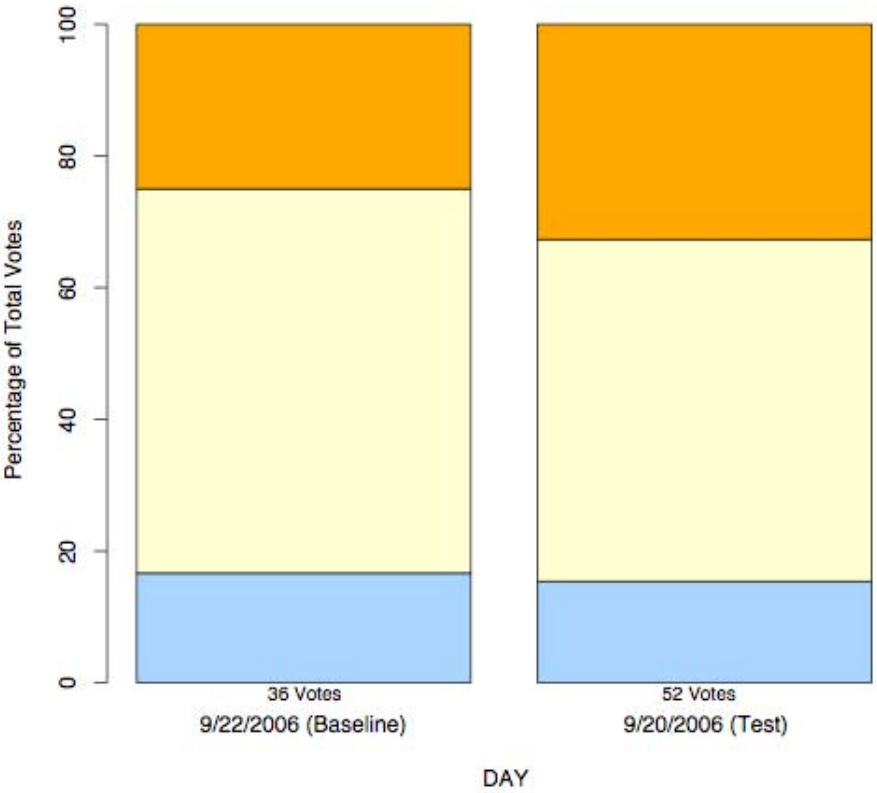
Precooling + exp temp reset

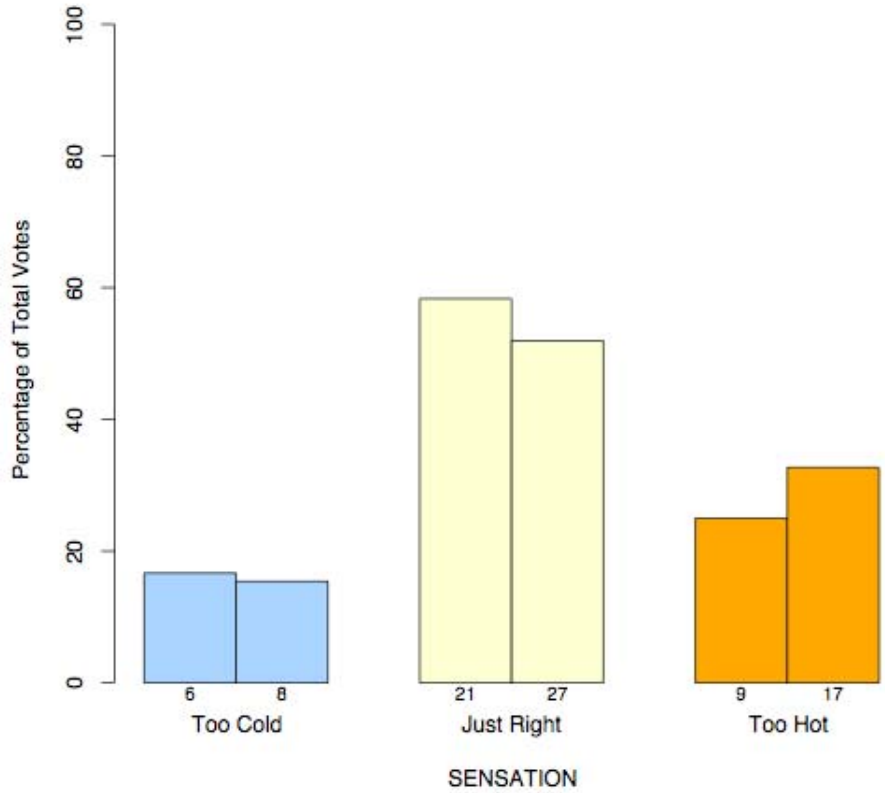


Precooling versus no precooling



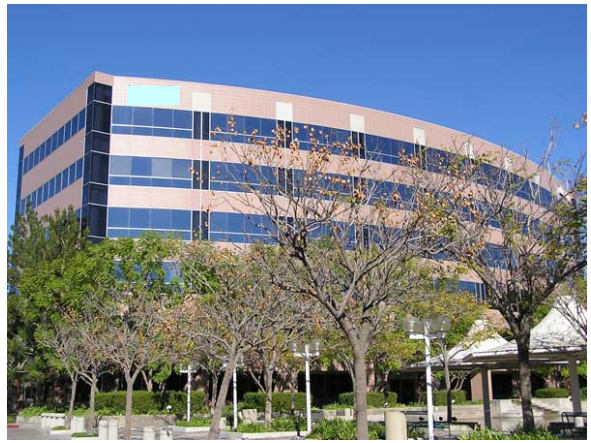
9.20.2006 Test: Sensation





Office Building in San Bernardino

- AutomatedLogic Control, Full DDC at zone level
- 99,000 Sq. Ft.
- Single Occupant
- Built in 2005
- Three rooftop Units & VAV

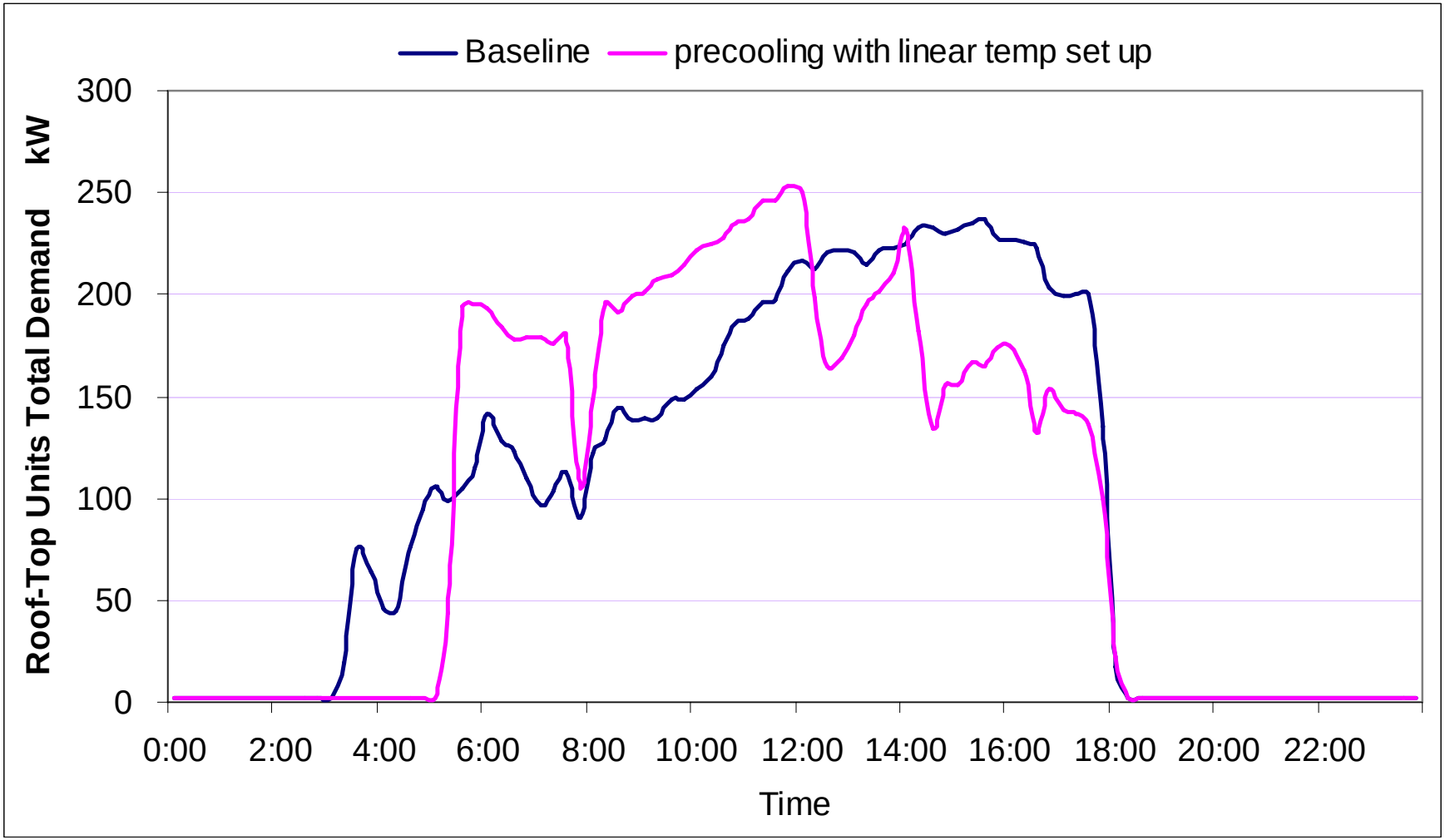


Test schedule

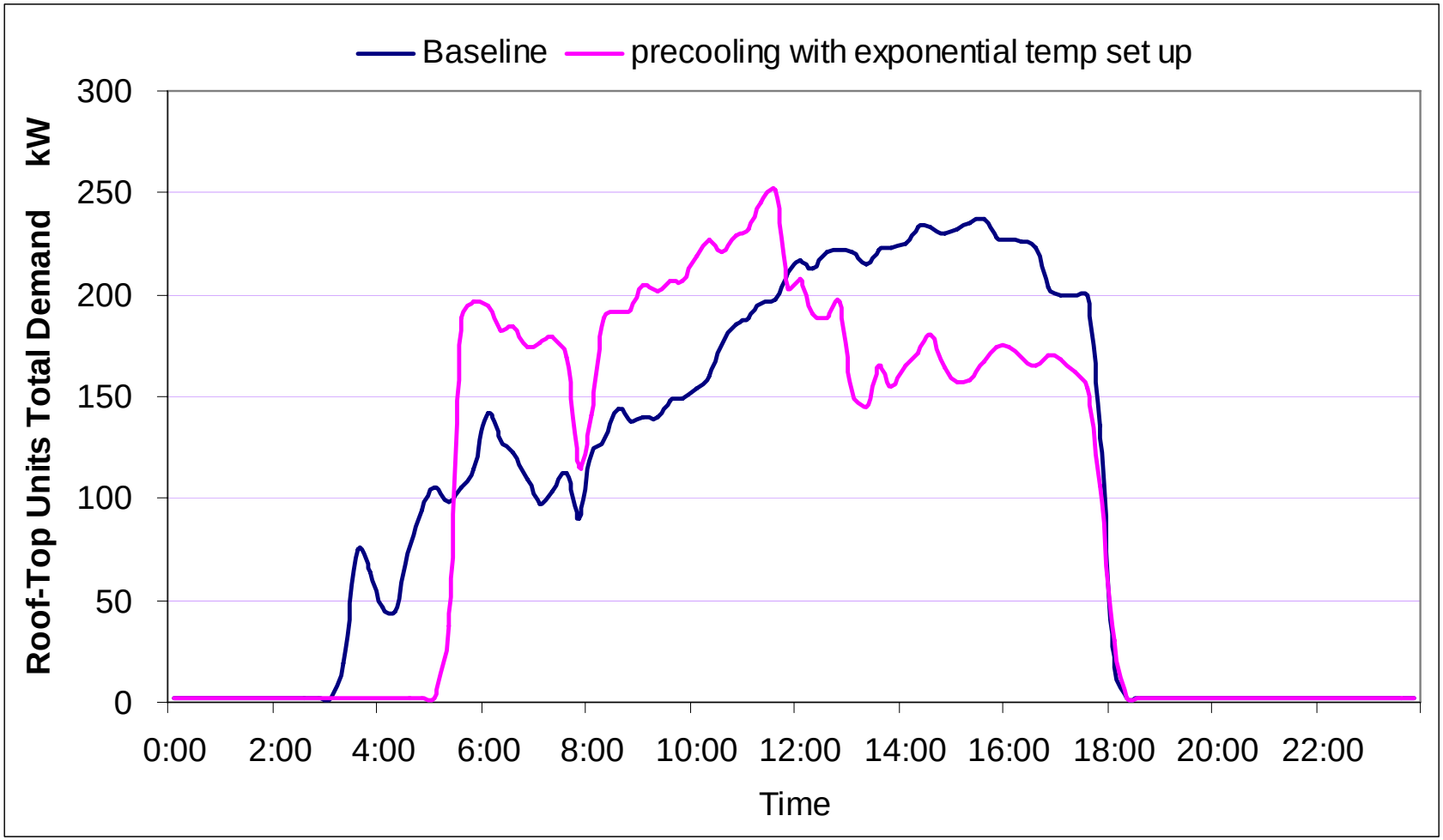
Number	Date	Stragtegies	Peak OA temp
1	8/14/2007	*no-pre-cooling + zonal reset*	104°F
2	8/15/2007	*pre-cooling + linear zonal reset*	104°F
3	8/16/2007	*pre-cooling + exponential reset*	104°F
4	8/17/2007	*Baseline, no comfort survey*	101°F
5	8/28/2007	*Baseline, comfort survey*	103°F
6	8/29/2007	*pre-cooling + exponential reset*	111°F
7	9/18/2007	*pre-cooling + exponential reset*	84°F

Note: Peak Outside Air Temperature is measured from the DDC system

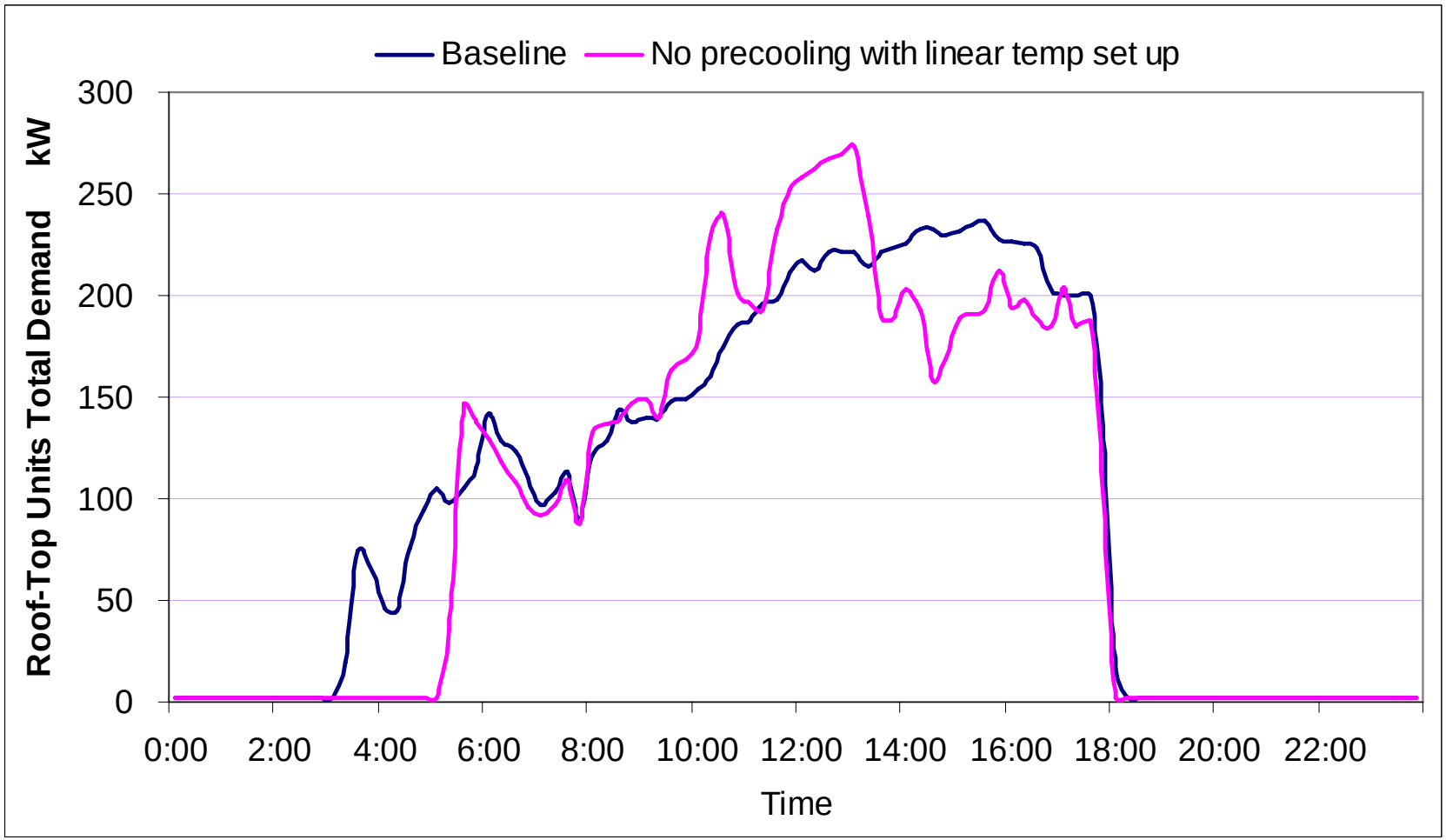
Precooling on hot days (104 ºF)



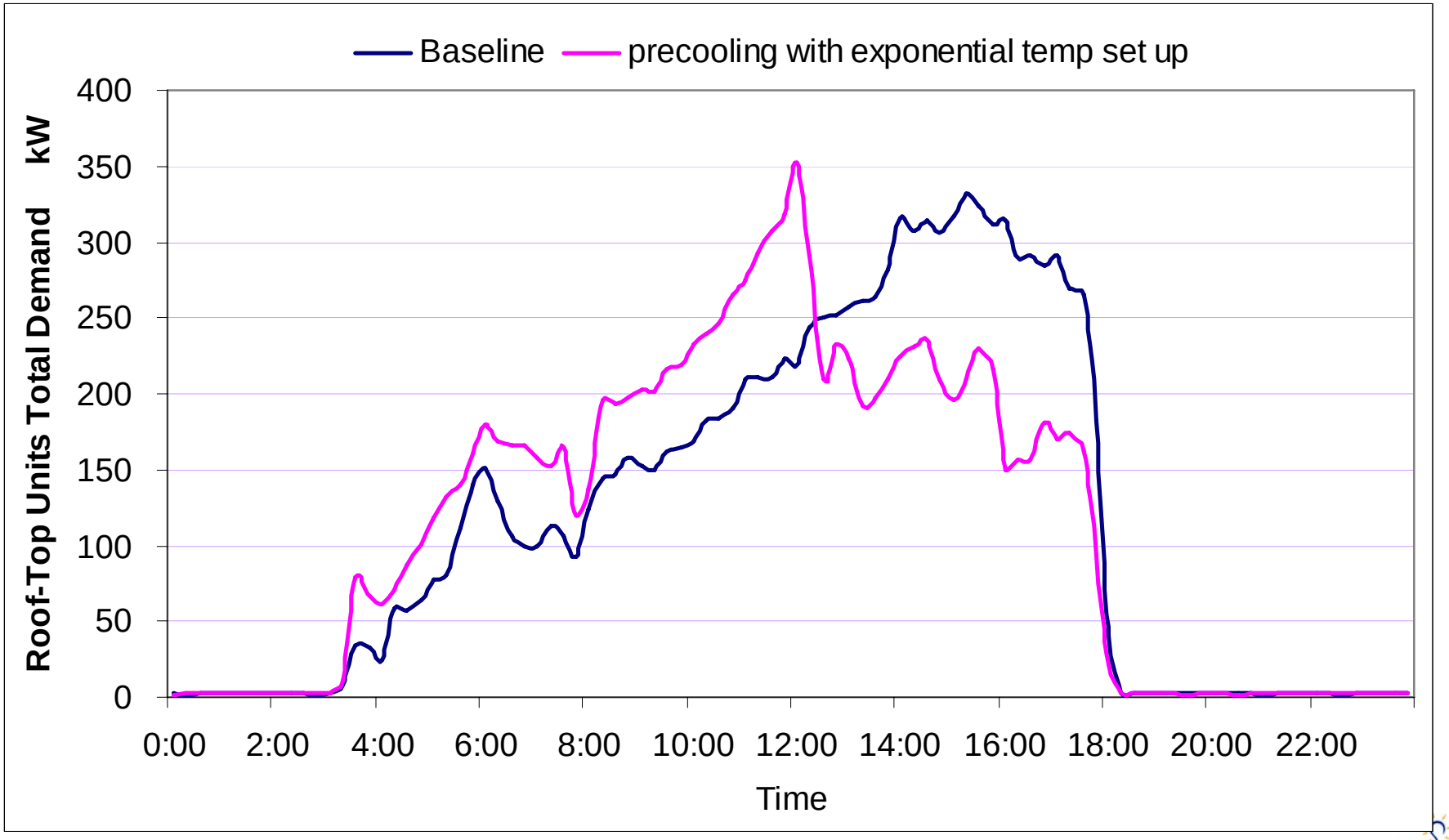
Precooling in hot days (104ºF)



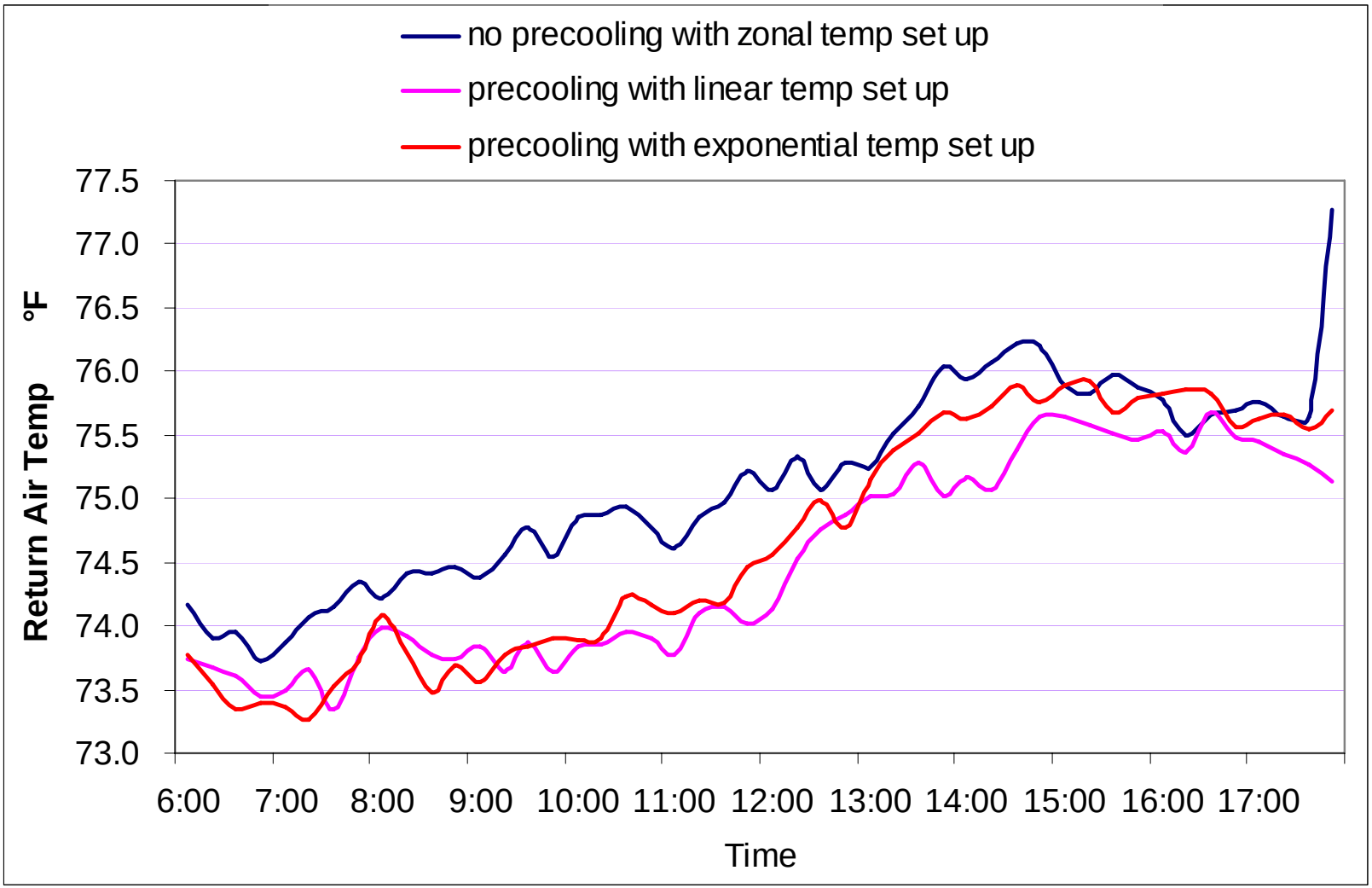
No precooling in hot days (104 ºF)



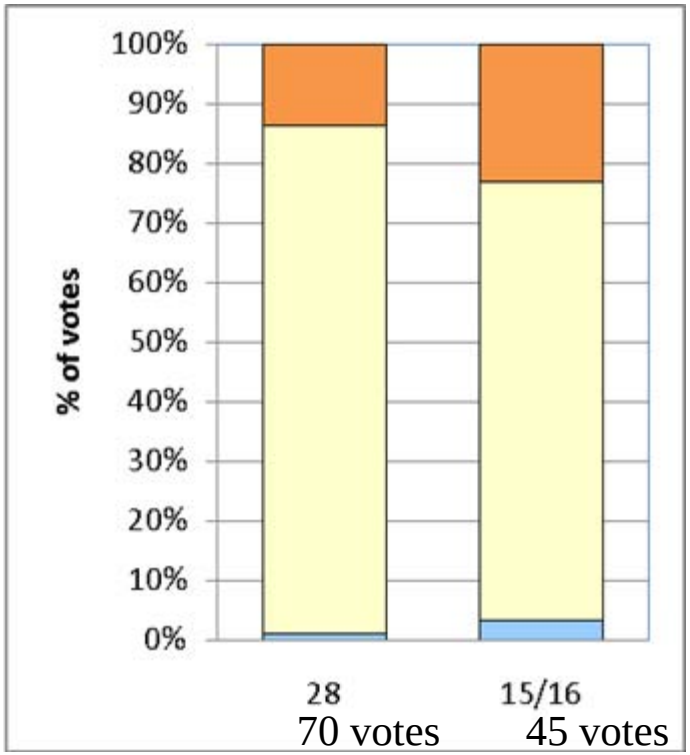
Precooling in extreme hot days (110 ºF)

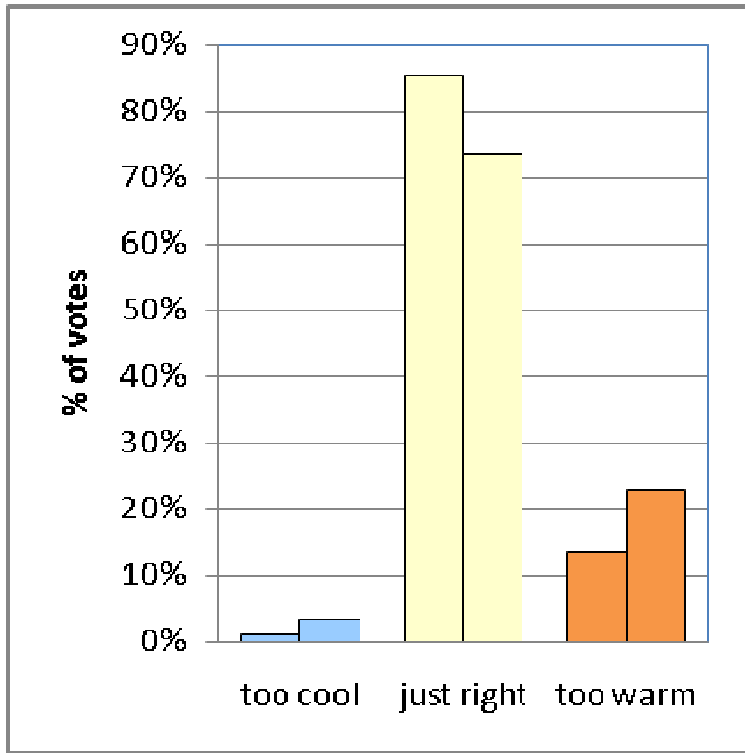


Return air temperature



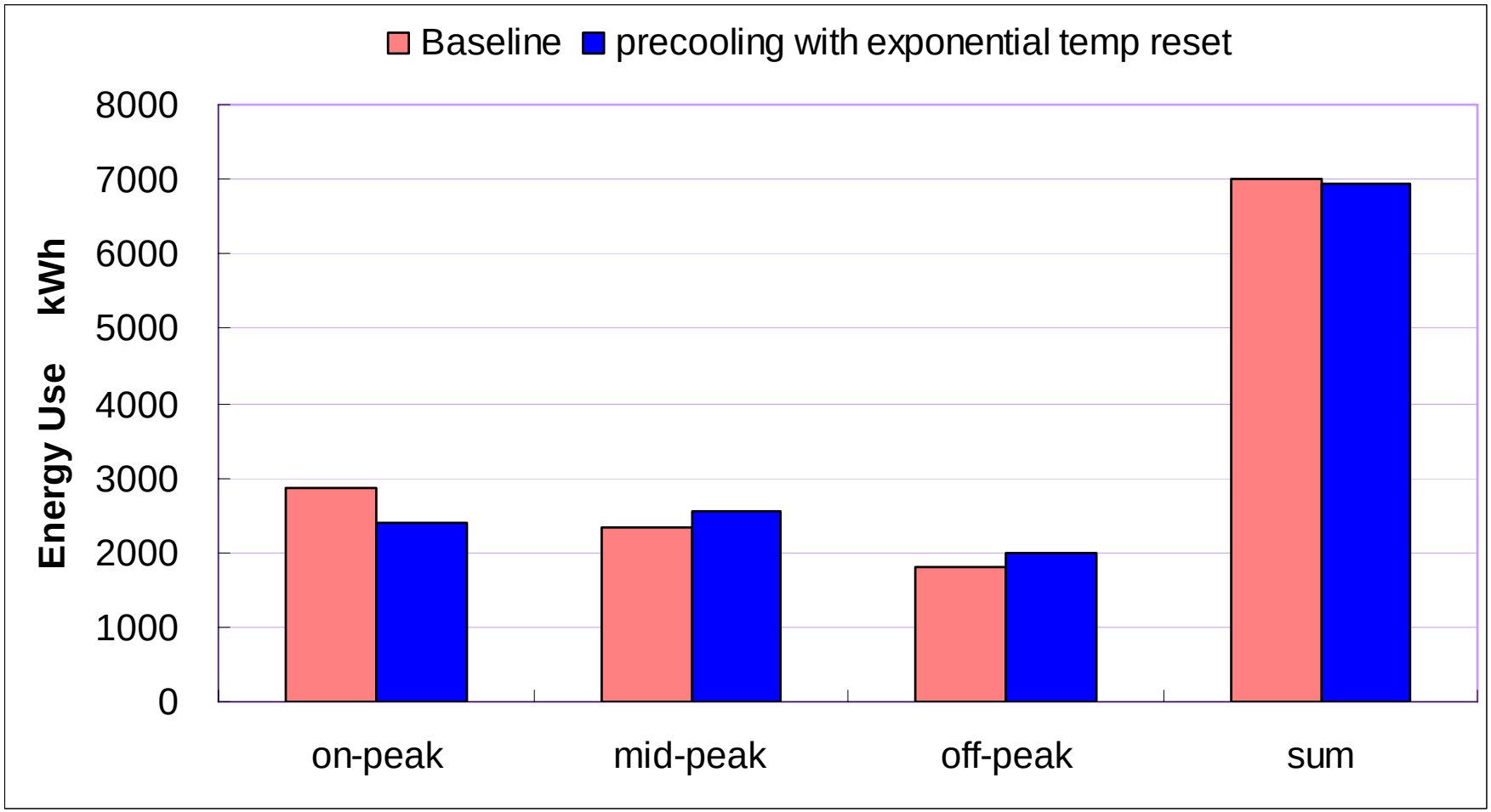
Thermal comfort survey





Breakdown of sensation votes for 8/28/2007 baseline day and combined votes from 8/15/2007 and 8/16/2007 test days.

Electricity usage –extreme hot days



Conclusions

- Precooling and demand shed strategies worked well under both mild and extreme hot weather conditions and were able to reduce cooling loads significantly (20~30% on hot days).
- No noticeable change in thermal comfort if the temperatures are under control.
- Properly controlled exponential temperature setup in the shed period can maximize load reduction.
- The night precooling results are mixed. It worked well in heavy mass buildings and buildings with undersized HVAC system.

Future work

- Develop guidelines for appropriate control strategies according to building characteristics
- Assess the market potential and barriers
- Field study to quantify building thermal mass
- Support pre-cooling strategy implementation
  - 11 buildings in Tri-city corporate center