

# Applying Natural Cooling to Slab Floors

presented by

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# What is Natural Cooling?

- Uses natural heat transfer forces without a refrigeration process
- Direct evaporative cooling can efficiently cool water
- Multiple stage evaporative cooling is less efficient but generates lower temperatures
- Most efficient natural water cooling process uses radiation to clear night sky

# Naturally-Cooled Slabs

- Circulate naturally-cooled water through tubing in concrete slabs
- Water is cooled by evaporation or night sky radiation
- Coolest water can be generated at night
- Slab mass “stores cooling” and delay delivery
- Cool slab delivers radiant cooling and lowers mean radiant temperature

# Technology Benefits

- Low cost cooling storage strategy
- Large mass improves natural cooling efficiency
- Cooled floor improves occupant comfort
- Synergistic with ceiling fans
- Excellent combination with radiant floor heating, an industry with strong growth
- Can shift load to pre-peak periods

# Technology Status

- Patent awarded in 1996
- 12 projects completed to date
  - » 3 demonstration residences
  - » 3 privately-funded residences
  - » 2 multi-story San Francisco apartments
  - » 4 commercial projects totaling 62,000 ft<sup>2</sup>
- other projects in design

# Three Featured Projects

- **Texaco “DualCoolPlus”**
  - » new 3600 ft<sup>2</sup> Davis CA convenience store
  - » pre-cooler added to rooftop unit
- **580 Howard Street**
  - » 5 story, 30,000 ft<sup>2</sup> historic SF building
  - » cooling tower runs at night to cool slabs
- **All Weather Manufacturing**
  - » new 6,300 ft<sup>2</sup> plant office in Vacaville CA
  - » NightSky system cools slabs and tank

# Convenience Store Project

- New 3600 ft<sup>2</sup> store, opened early 1998
- located 20 miles west of Sacramento
- “co-branded” with two fast food outlets
- 24 hour operation
- already designed, ready to build
- base case had 15 ton RTU w/5 hp.  
blower motor
- 5500 cfm total, 870 cfm ventilation air

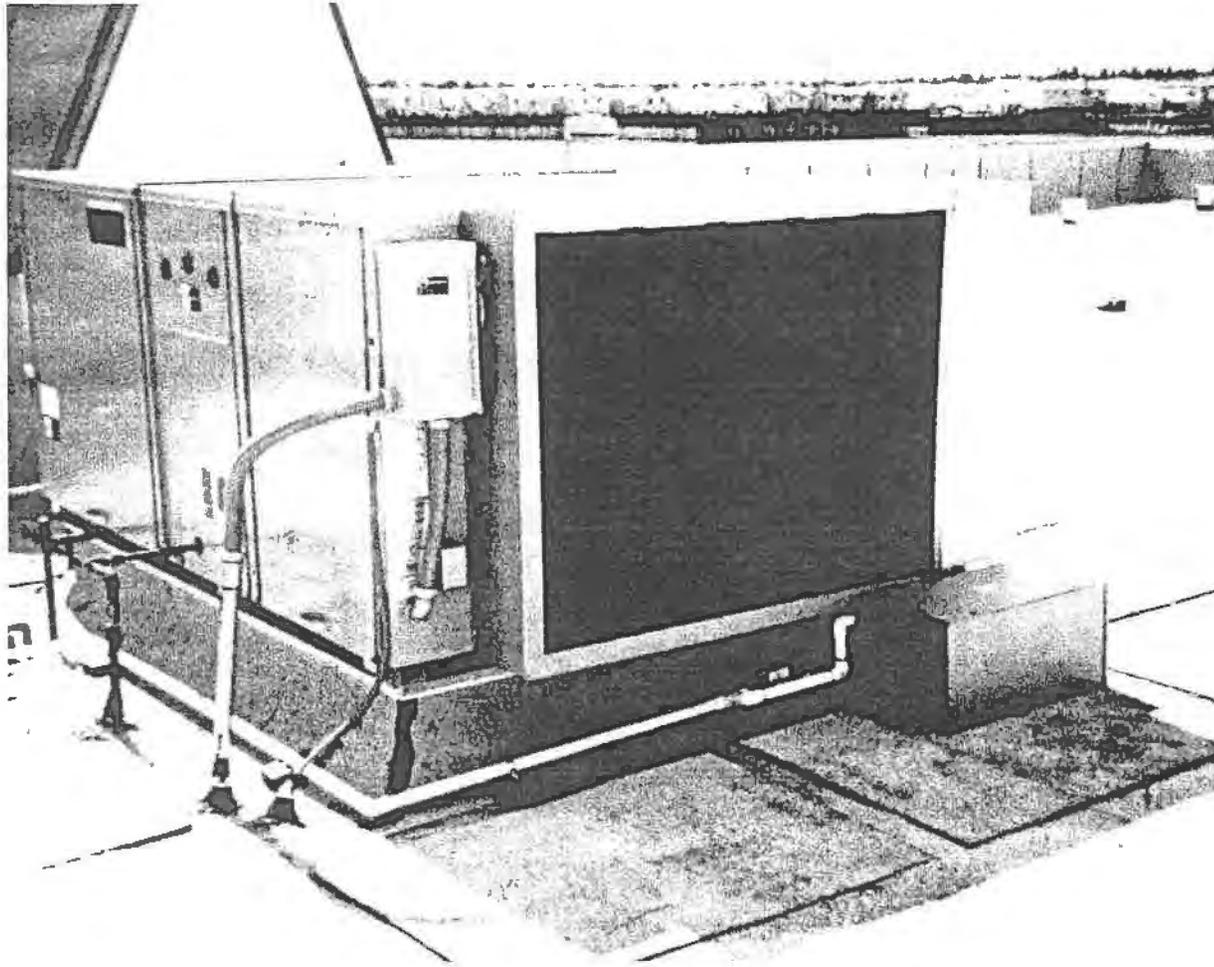
# Convenience Store Project

View from northeast



# Convenience Store Project

Installed RTU with Pre-Cooler



# Convenience Store Project

- The DualCoolPlus System

- » pre-cools condenser air
- » pre-cools ventilation air
- » operates at night to pre-cool floor
- » uses tubing in sand layer under floor

- Downsizing

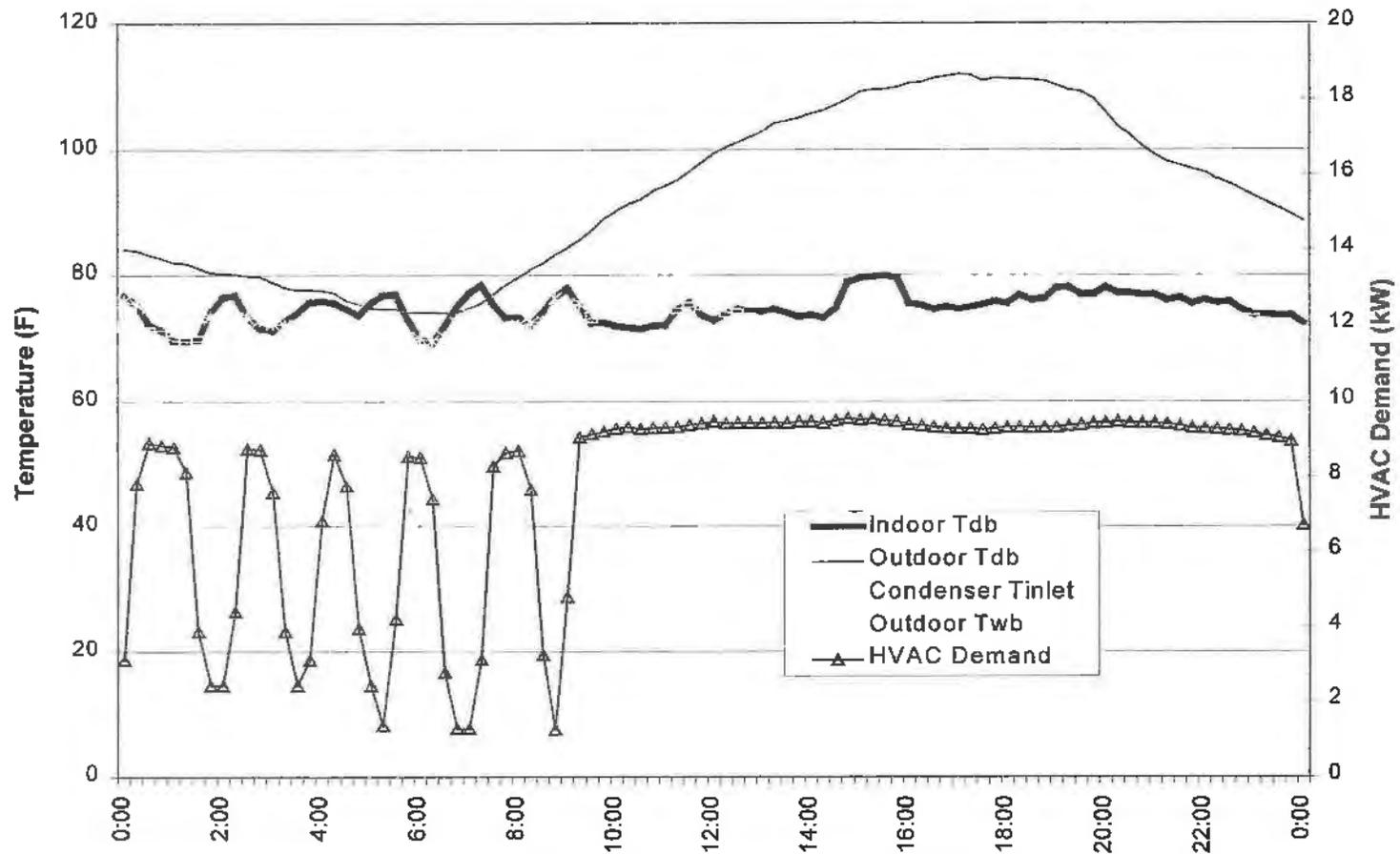
- » 15 ton RTU down to 10 tons
- » 5 hp. blower motor down to 2 hp.
- » Ductwork down for 33% less supply air

# DualCool Plus Results

- Monitored w/PG&E support 6/98-11/98
- Satisfied loads on 112F peak day
- Lowered condenser air 20-30F on-peak
- Data used to calibrate simulation
- Full year simulation used for economics
- Key Results:
  - » 46% peak demand savings
  - » 50% annual energy savings
  - » Payback < 1 year w/downsizing credits

# DualCool Plus Results

Figure 2: Peak Summer Day Performance (August 4, 1998)



# DualCool Plus Results

## Payback by Feature

<u>Component</u>	<u>Annual</u>	<u>Sizing</u>	<u>Added</u>	<u>Years</u>	
	<u>Savings</u>	<u>Cost</u>	<u>Credit</u>	<u>Cost</u>	<u>Payback</u>
Pre-cooler	\$1,544	\$5,865	(\$4,825)	\$1,040	0.7
<b>Floor cooling</b>	<b>\$838</b>	<b>\$3,450</b>	<b>(\$1,176)</b>	<b>\$2,274</b>	<b>2.7</b>
<u>Ventilation air</u>	<u>\$622</u>	<u>\$1,035</u>	<u>(\$1,749)</u>	<u>(\$714)</u>	<u>Immediate</u>
<b>Package</b>	<b>\$3,004</b>	<b>\$10,350</b>	<b>(\$7,750)</b>	<b>\$2,600</b>	<b>0.9</b>

# Night Roof Spray Project

- New 70,000 mfg. plant completed 3/98
- built in Vacaville CA, 50 miles east of SF
- “state-of-the-art” window manufacturer
- showcase building with 6300 ft<sup>2</sup> offices
- “tilt-up” plant with lower, barrel-roof offices
- 23 ton base case system with five zones

# Night Roof Spray Project

## All Weather Manufacturing Facility

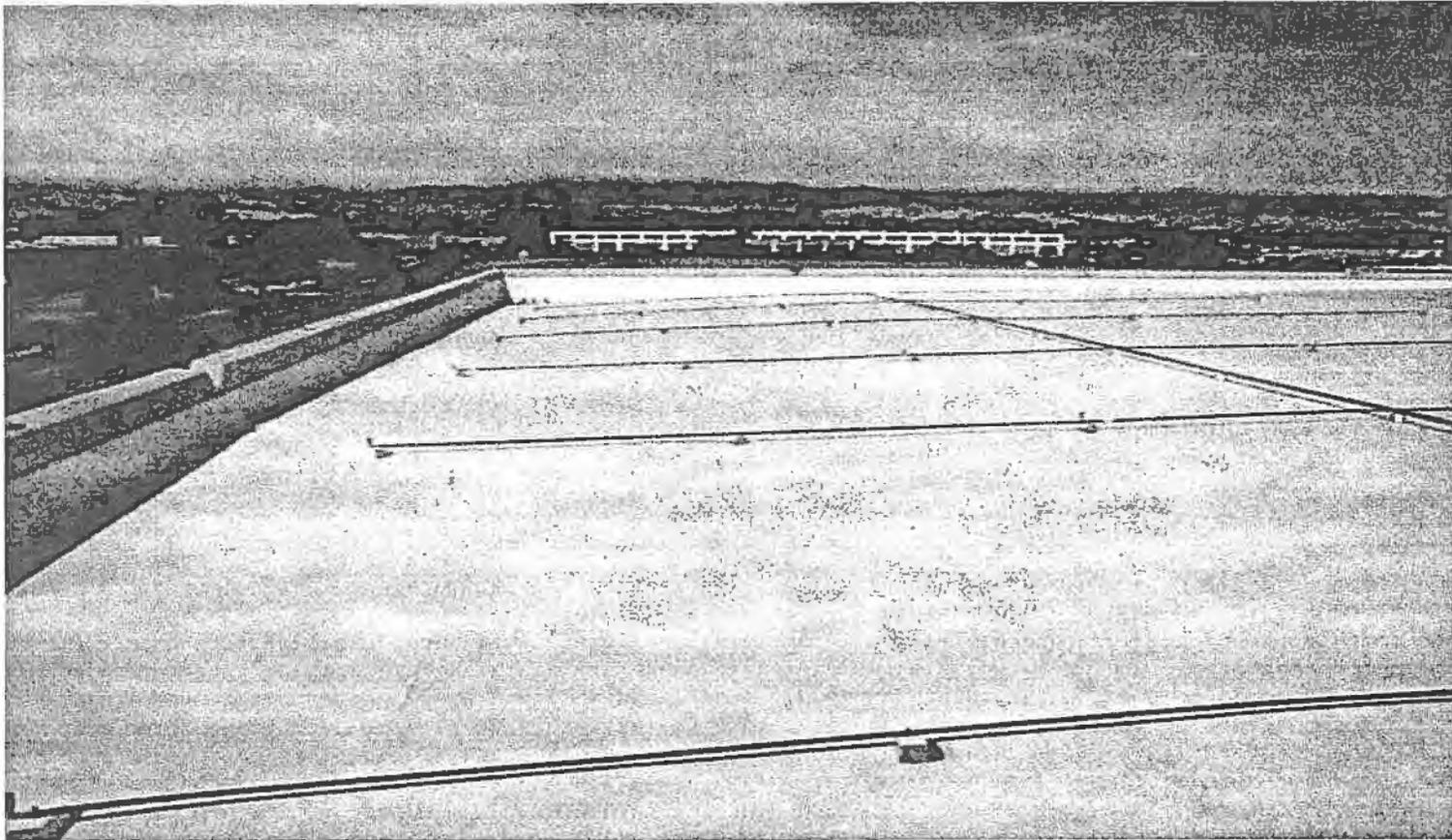


# Night Roof Spray Project

- The NightSky Integrated System
  - » cools water at night with 6500 ft<sup>2</sup> roof array
  - » stores cooling in 8000 gal tank and in floor
  - » delivers cooling & heating through both the floor and five zoned fan coils
  - » floor delivers steadily, fan coils respond fast
  - » includes dedicated vent air fan coil
- Downsizing: auxiliary 10 ton chiller cools tank only when needed

# Night Roof Spray Project

## Roof Spray Array

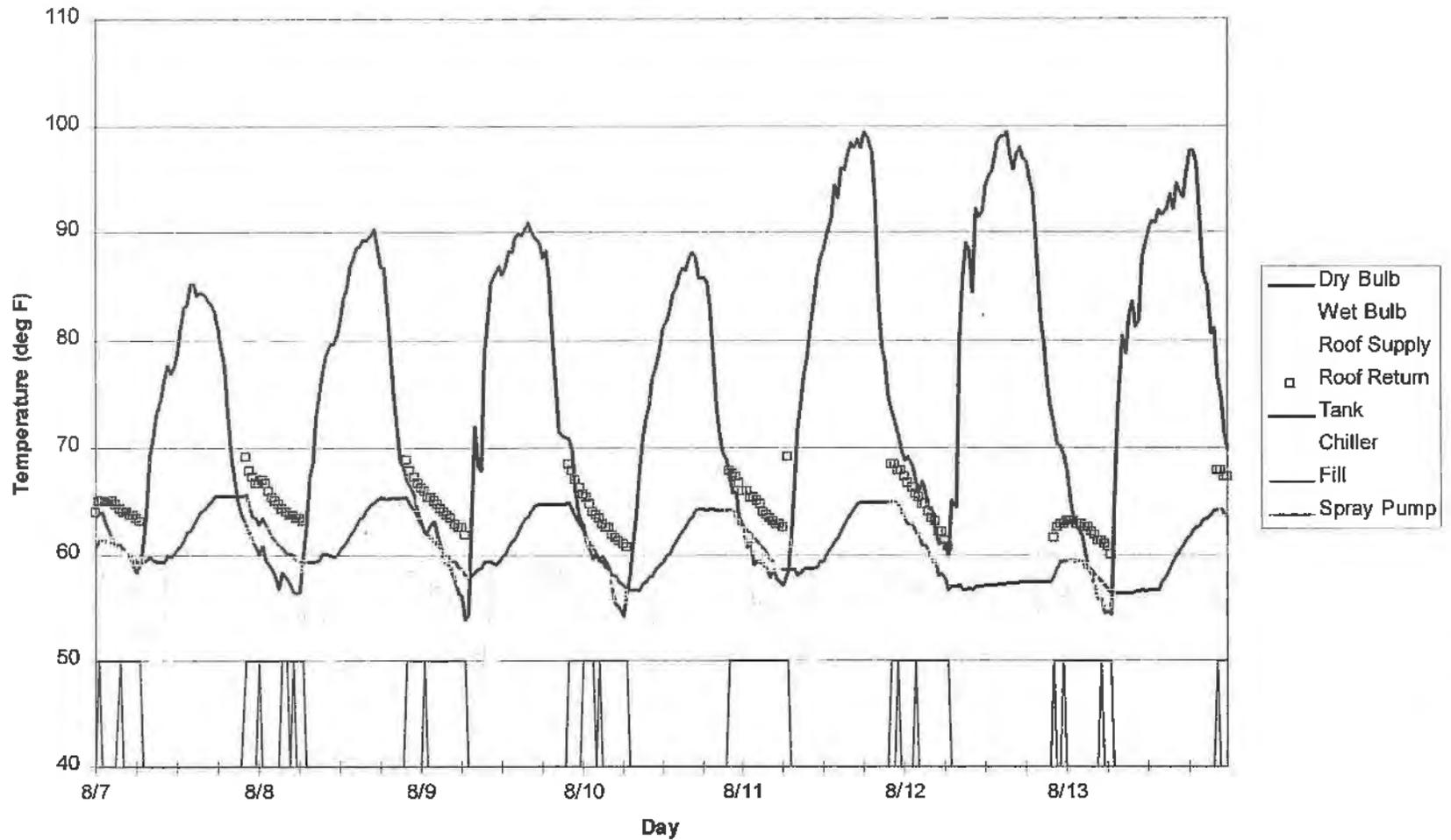


# NightSky Results

- Monitored w/PG&E support 7/98- present
- Satisfied loads on several 112F peak days
- Data used to calibrate simulation
- Full year simulation used for economics
- Key Results:
  - » 87% peak demand savings
  - » 73% annual energy savings
  - » Payback 2.5 years

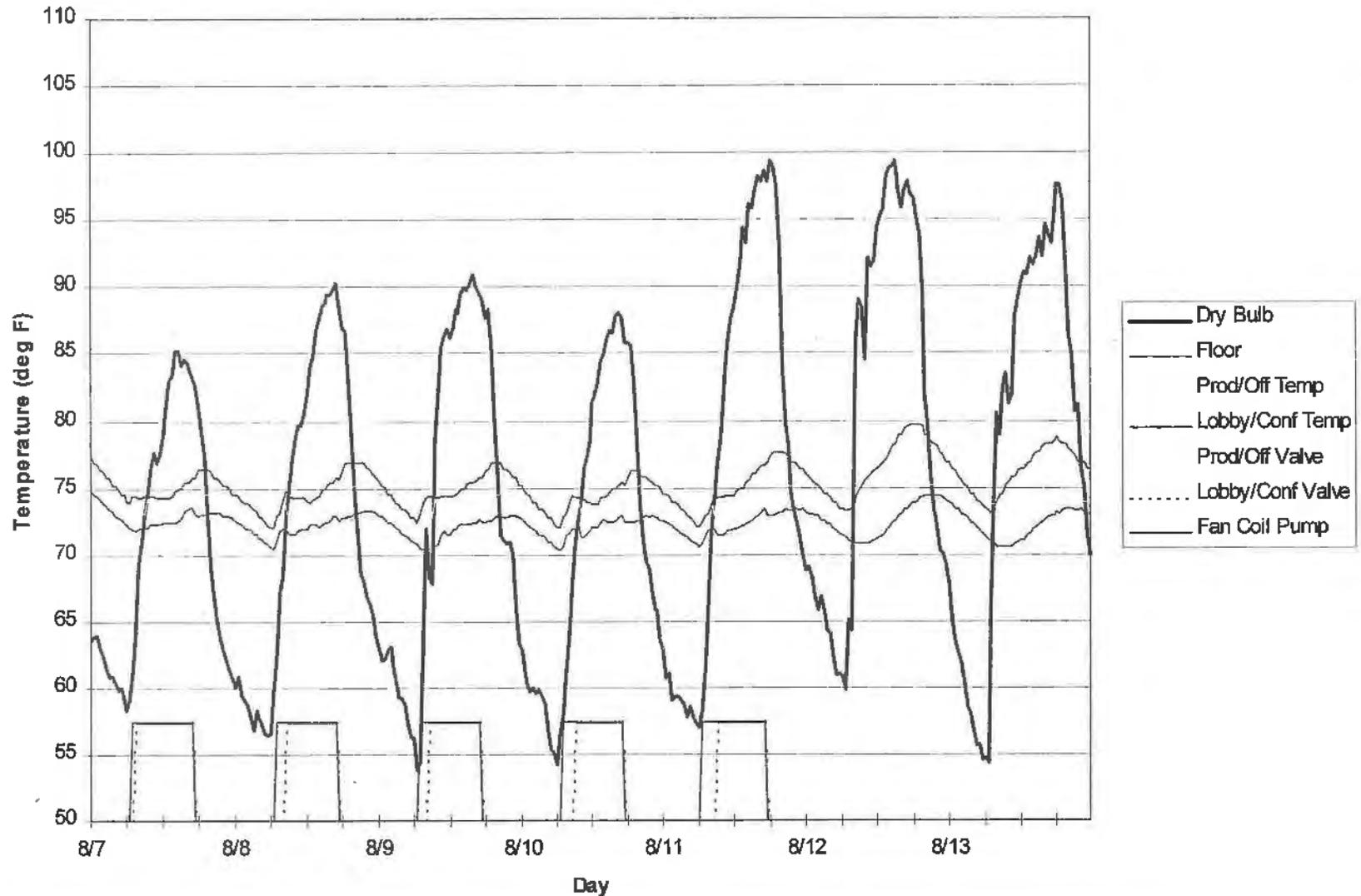
# NightSky Results

## All Weather Night Sky Spray Summary



# NightSky Results

## All Weather Night Sky Temperature Summary



# NightSky Results

## Savings Tabulation

	Base	Night	Savings	% Savings
<b>Annual Energy</b>	Case	Sky		
Cooling kWh	19,587	5,250	14,337	73%
Delivery kWh	17,074	5,733	1,341	66%
Total kWh	36,661	10,983	25,678	70%
<b>Peak Demand</b>				
On-peak kW @ 104F	33.7	4.4	29.3	87%

# Conclusions

- Natural floor cooling saves energy, improves comfort, and helps radiant heating economics
- In Sacramento Valley non-residential applications, floor cooling requires hybrid features to reduce peak day demand
- In hybrid systems, floor delivery facilitates down-sized blowers that save energy all year
- Floor cooling projects to date show excellent economics...that should further improve.