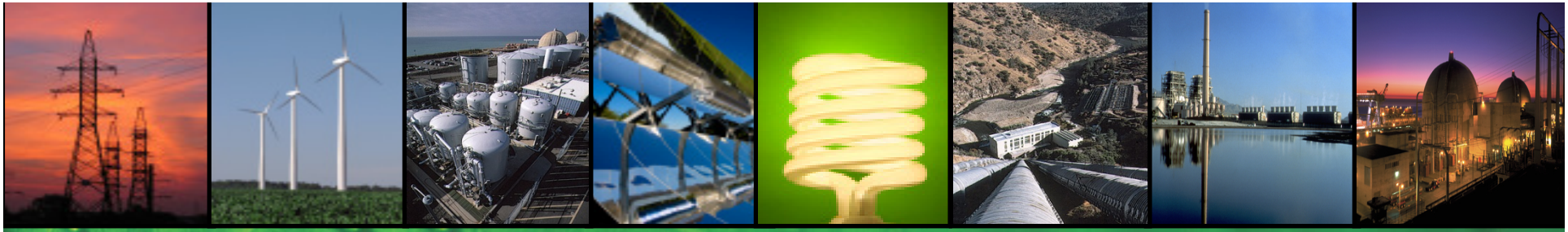


# Phase Change Materials: Are They Part of Our Energy-Efficient Future?


**Brian James**

**Emerging Technologies Program**


**October 17, 2012**

SOUTHERN CALIFORNIA EDISON®
An *EDISON INTERNATIONAL*® Company

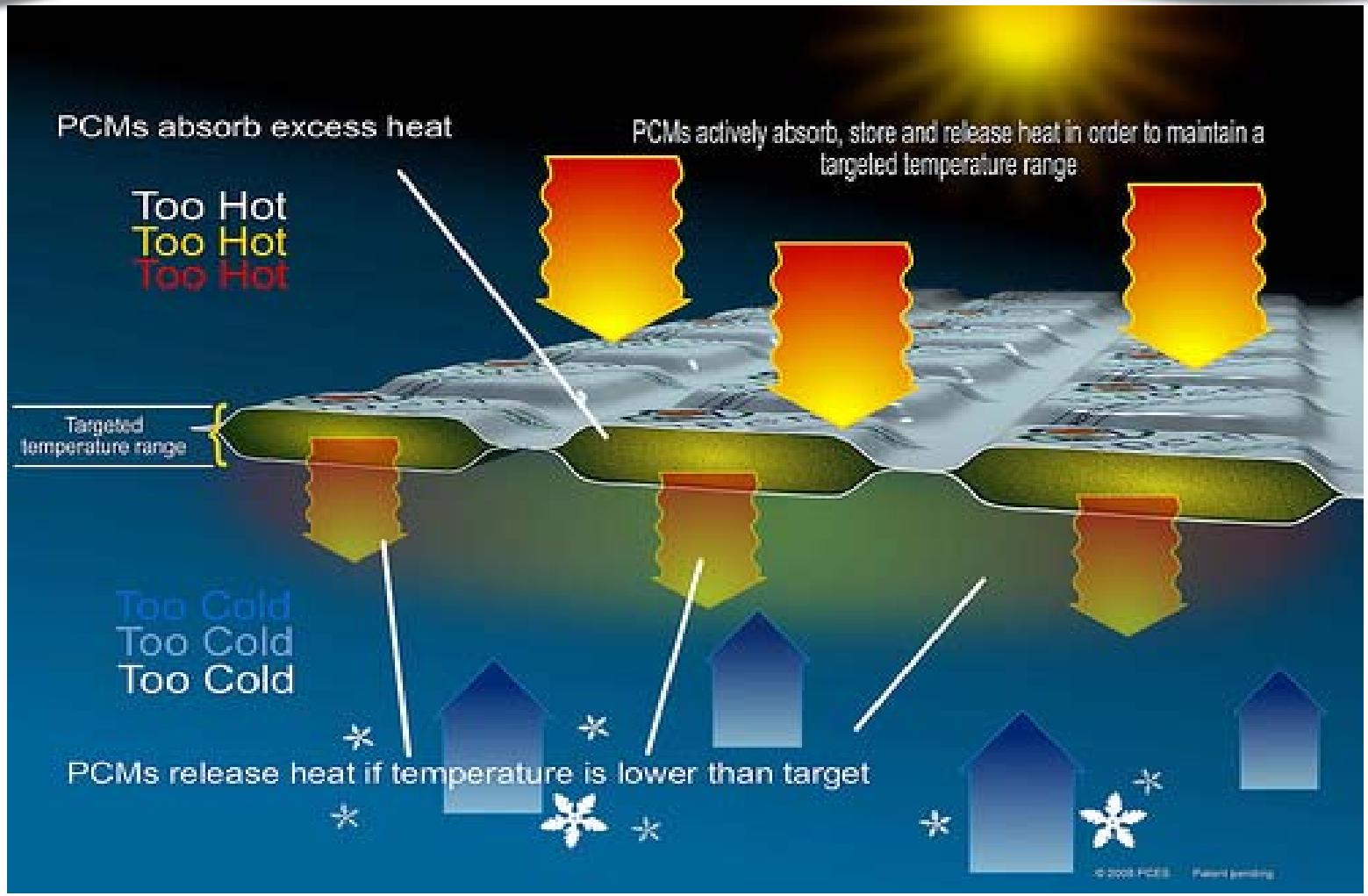
# Overview

- Introduction
- How PCM Works
  - Products & Applications
  - PCM Properties
  - PCM vs. Conventional Thermal Mass
- What climates make the most sense?
- Commercial Market Sectors
- Technical Potential
- **Simulations**
- Challenges
- Future Work

# Introduction

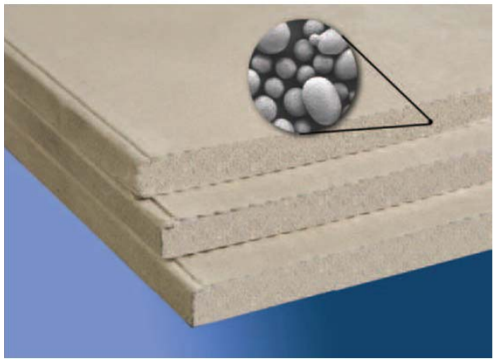
- GOAL:
  - Investigate current PCM market and PCM's future in commercial buildings
- FOCUS:
  - PCMs in commercial building applications to offset cooling and heating loads
- BIG PICTURE:
  - California Long Term Energy Efficiency Strategic Plan
- SCE's ROLE:
  - ET Program assessing the viability of EE technologies for adoption into incentive programs

# How PCM Works



# Products & Applications


***Many others!***



| Application | PCM Product |
|---|---|
| Micro-encapsulated Paraffin Wax | Wallboard |
| | Ceiling Tile |
| | Floor Panel |
| | Interior Wall Construction |
| Bio-based (Organic) Materials | Interior Wall Construction |
| | Attic/Drop Ceiling Plenum Floor |
| Eutectic Salt Mixtures | Interior Wall Construction |
| | Attic/Drop Ceiling Plenum Floor |

Phase Change Energy Solutions 2011, Jaworski, Abeid 2004

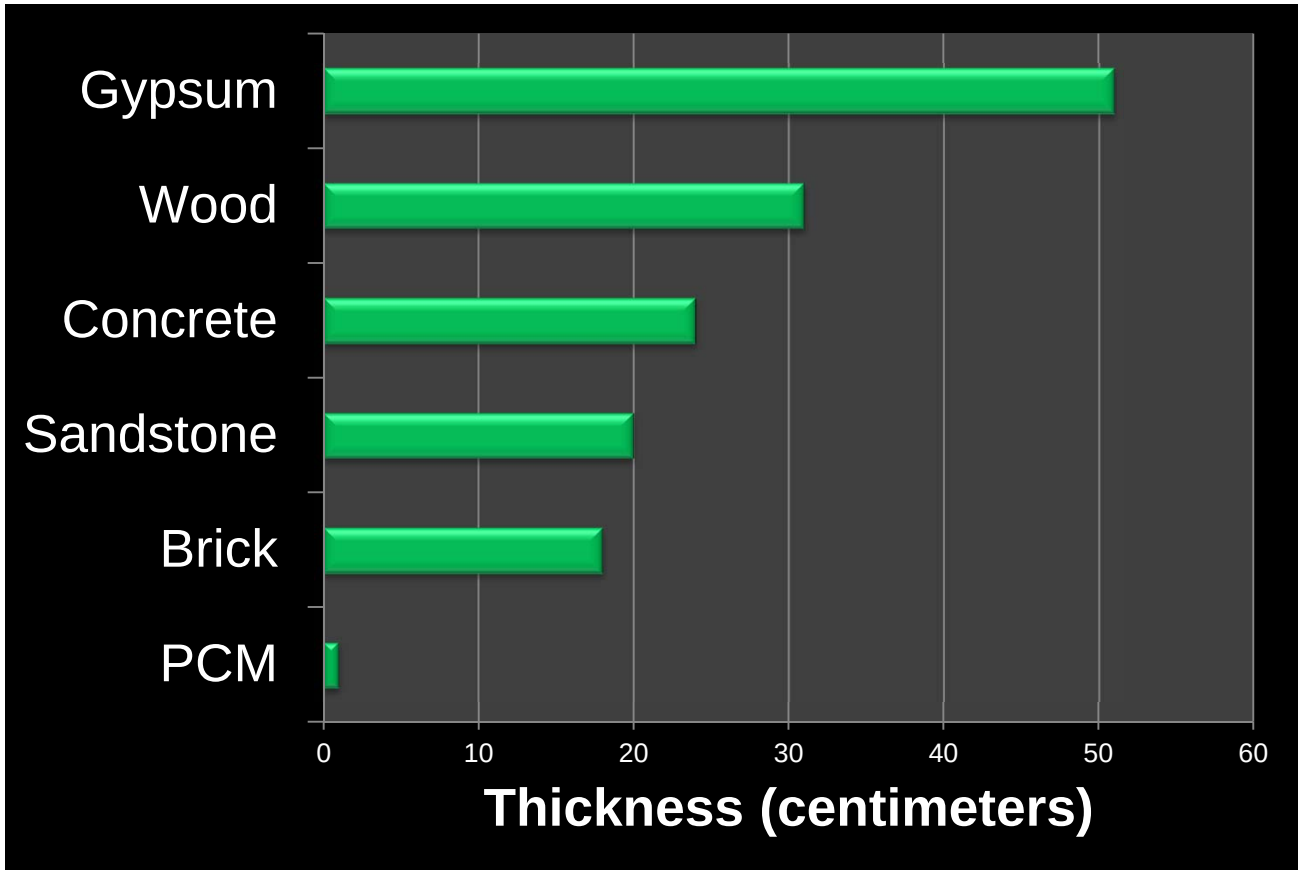
# PCM Thermal Properties

| PCM Product | Melting Temperature Range (°F) | Heat of Fusion (Btu/lb) |
|---|---|---|
| Micro-encapsulated Paraffin Wax[1, 2] | 73-80 | 75 |
| Bio-based (Organic) Materials[3] | 73-79 | 71-86 |
| Eutectic Salt Mixtures[4] | 77-80 | 55-81 |
| Water | 32 | 144 |

Source: 1. Thermal Core 2012, 2. Demirbas 2006, 3. Phase Change Energy Solutions 2011, 4. Zalba et al. 2003

- Thermal properties can be “tuned” by manufacturers to obtain melting temperatures suitable for desired application

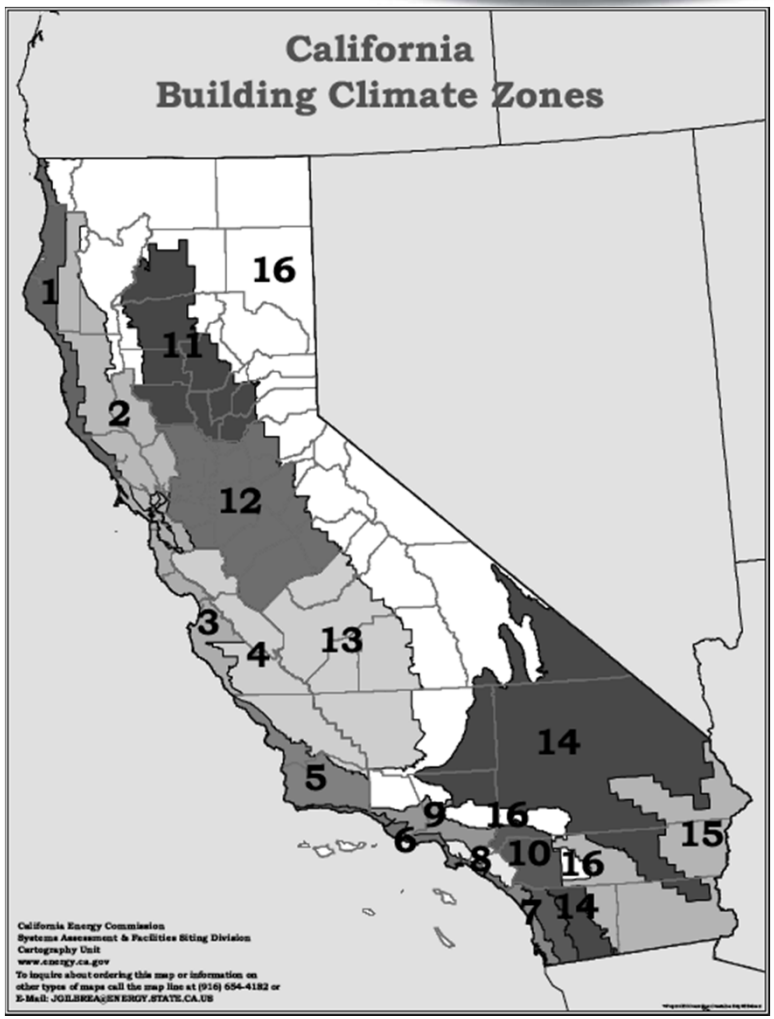
# PCM vs. Conventional Thermal Mass

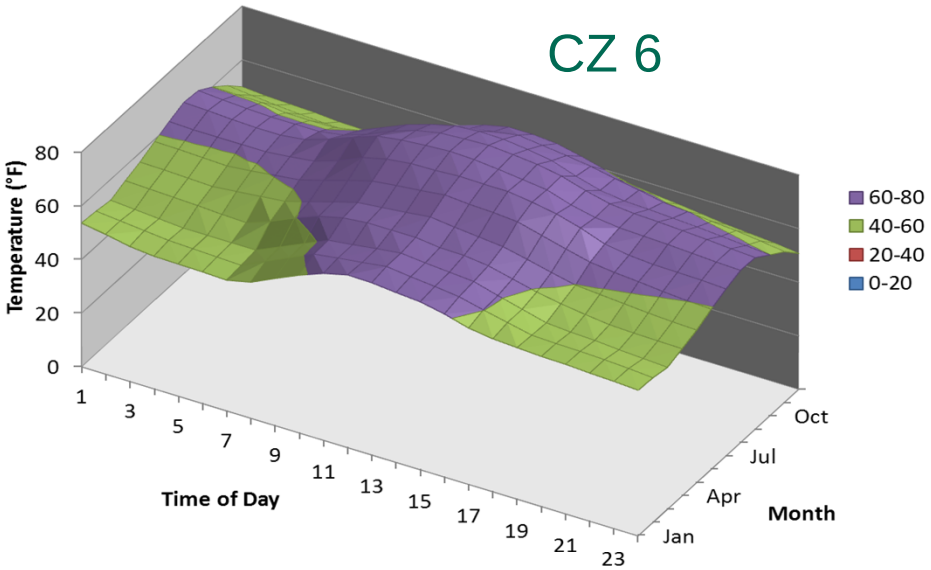

Source: Konstantinidou 2010

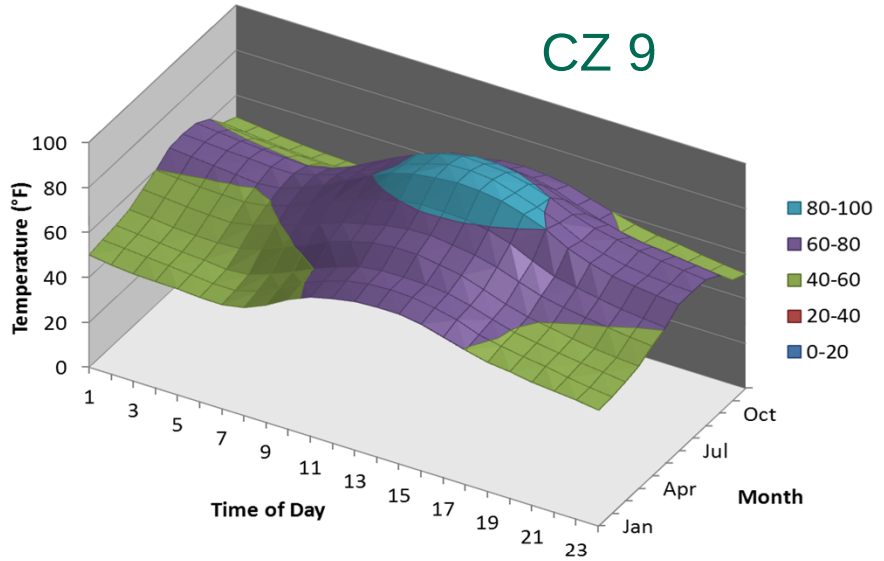
# What climates make the most sense?

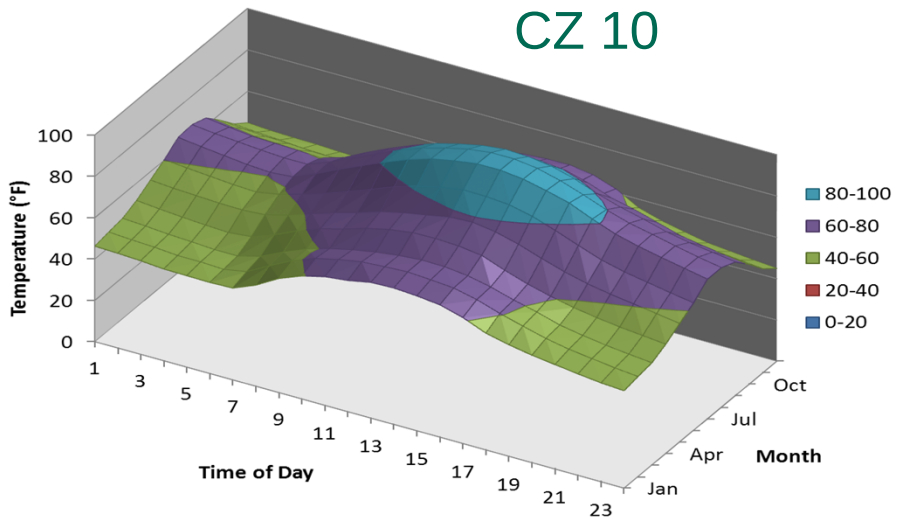
- CA has 16 climate zones (CZs)
- Ideal CZ will have a diurnal temperature swing that fluctuates around the PCM melting temperature
- For simplicity, assumed PCM melting temperature was 80°F
- Typical Meteorological Year (TMY) 3 data

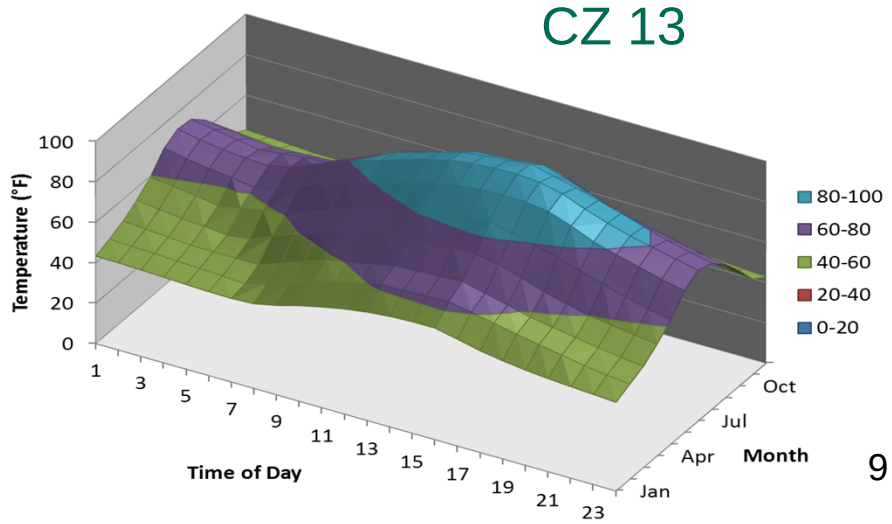


# Climate Zone Summary

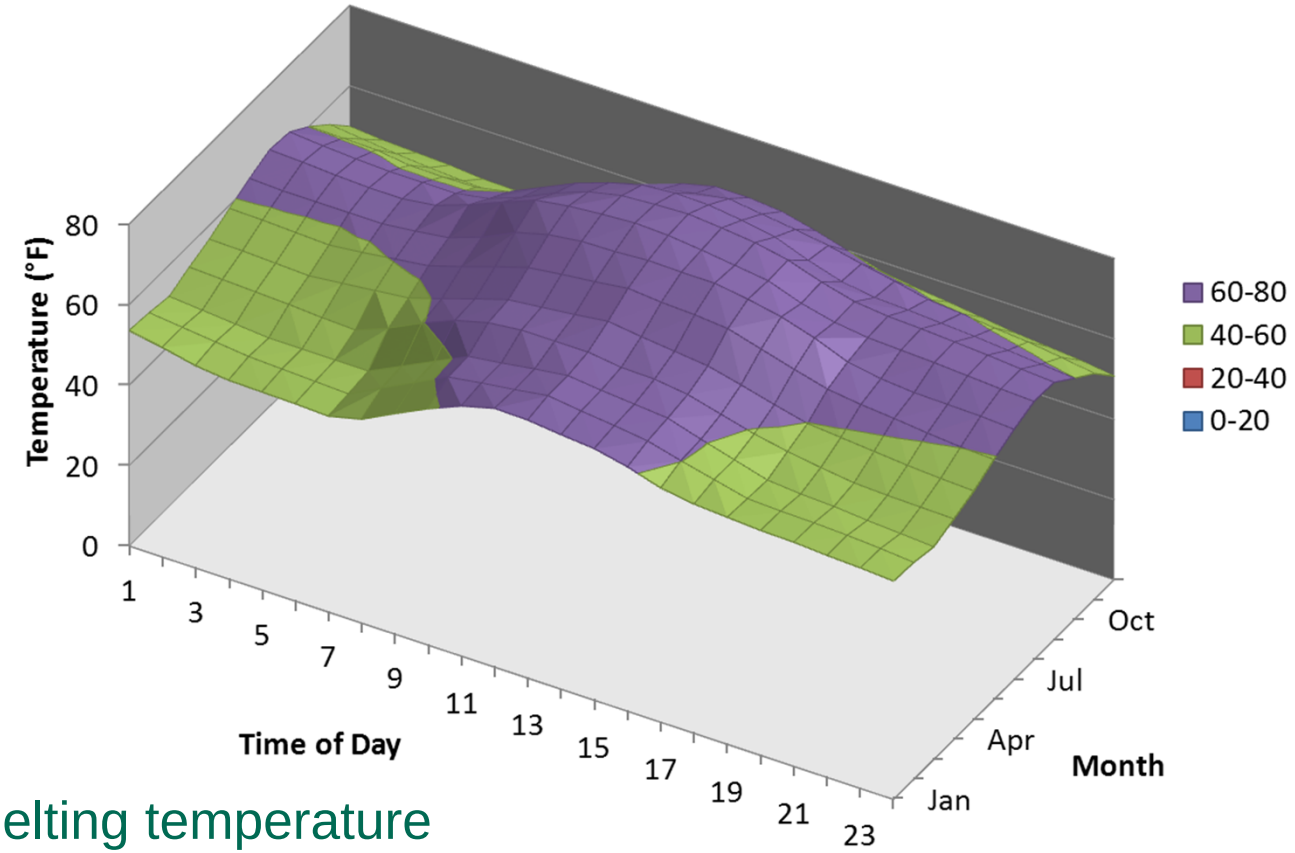


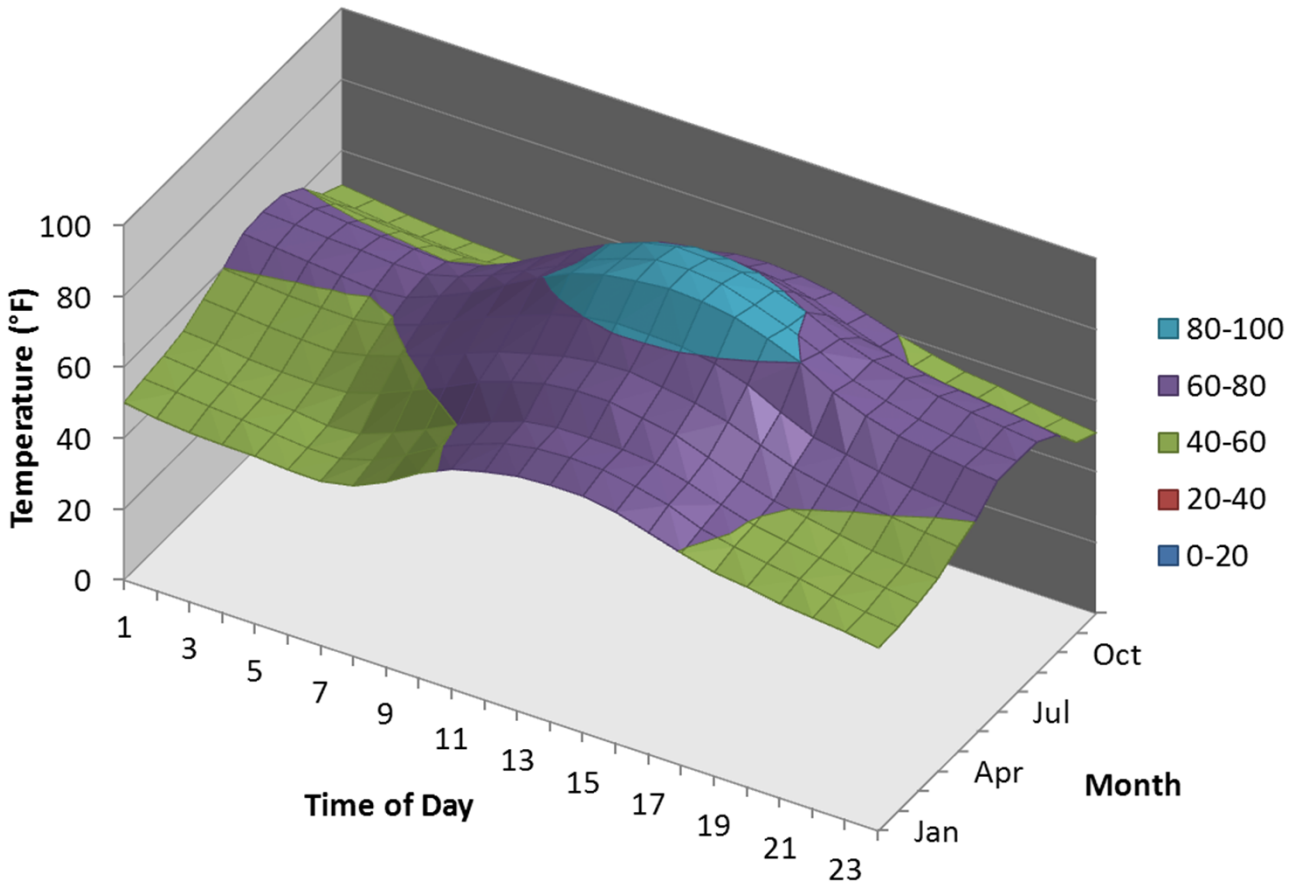



# Climate Zone 6



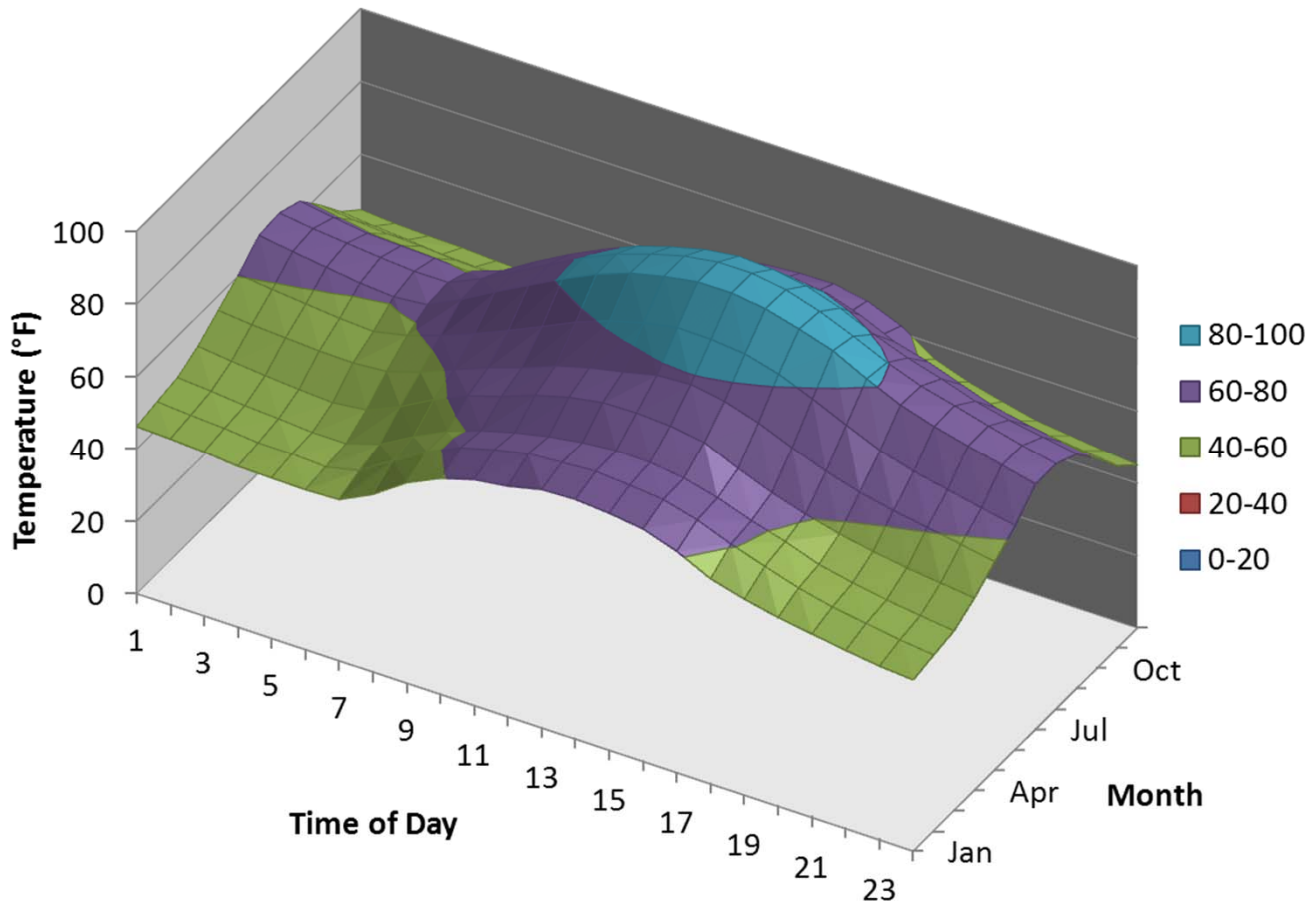

- Diurnal swing below melting temperature
- PCM should be tuned to low 70s
- Potential application for high internal load buildings

# Climate Zone 9



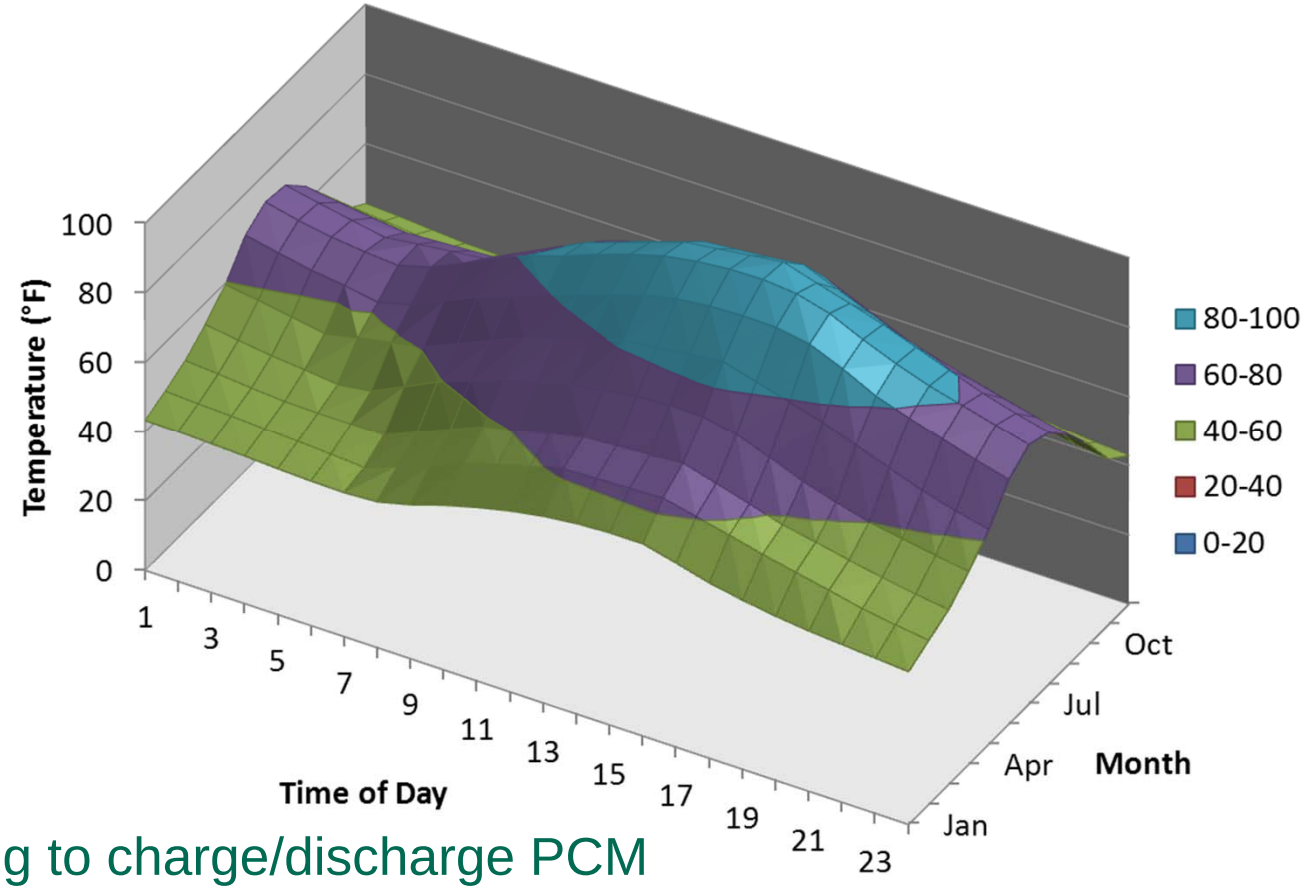

- Diurnal swing fluctuates around PCM melting temperature
- Ideal for absorbing daytime heat and recharging PCM at night

# Climate Zone 10




- Greater potential for PCM due to larger diurnal fluctuations
- PCM charged/discharged quicker due to low nighttime and high daytime temperatures

# Climate Zone 13




- Sufficient diurnal swing to charge/discharge PCM
- Longer cooling hours will lead to greater likelihood to mechanically recharge PCM
- Potential to reduce HVAC system capacity

# Commercial Market Sectors

| Building Type | Floor Stock (kft$^2$) | Cooling Electricity Usage (GWh/yr) |
|---|---|---|
| Small Office ( < 30,000 ft$^2$) | 157,884 | 460 |
| Large Office ( ≥ 30,000 ft$^2$) | 227,225 | 899 |
| Restaurant | 61,623 | 483 |
| Retail | 309,601 | 863 |
| Food Store | 63,820 | 229 |
| School | 176,999 | 279 |
| College | 64,809 | 138 |
| ~~Refrigerated Warehouse~~ | ~~30,031~~ | ~~15~~ |
| ~~Unrefrigerated Warehouse~~ | ~~353,765~~ | ~~122~~ |
| ~~Health~~ | ~~106,471~~ | ~~454~~ |
| ~~Lodging~~ | ~~112,405~~ | ~~196~~ |
| ~~Miscellaneous~~ | ~~477,725~~ | ~~659~~ |

Source: California Commercial End-Use Survey 2006

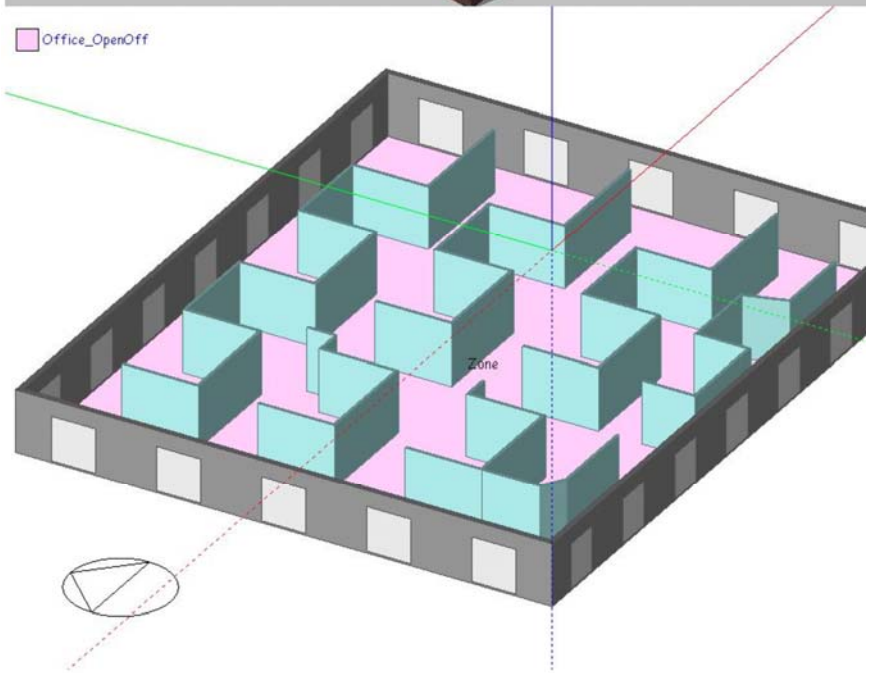
# What does this translate to?

Technical Potential Energy Savings

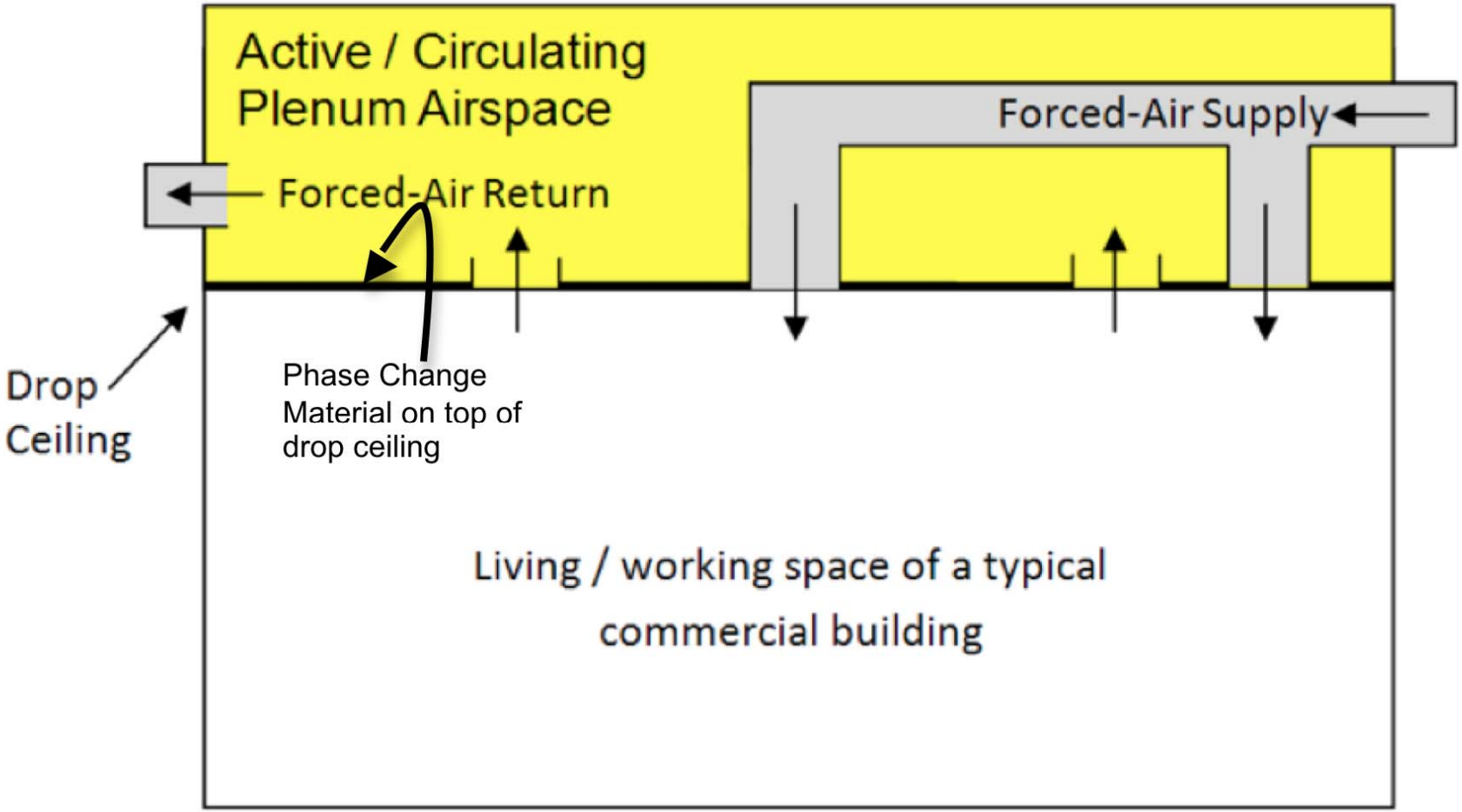
- Assume 10% energy savings
  - **335 GWh/yr**
- Assume 30% energy savings
  - **1,005 GWh/yr**

# Simulations

- 11,000 sf commercial office building
- CZ 9, 10, 14, 15, 16 simulated with PCM "bubblepack" in ceiling plenum of drop ceiling

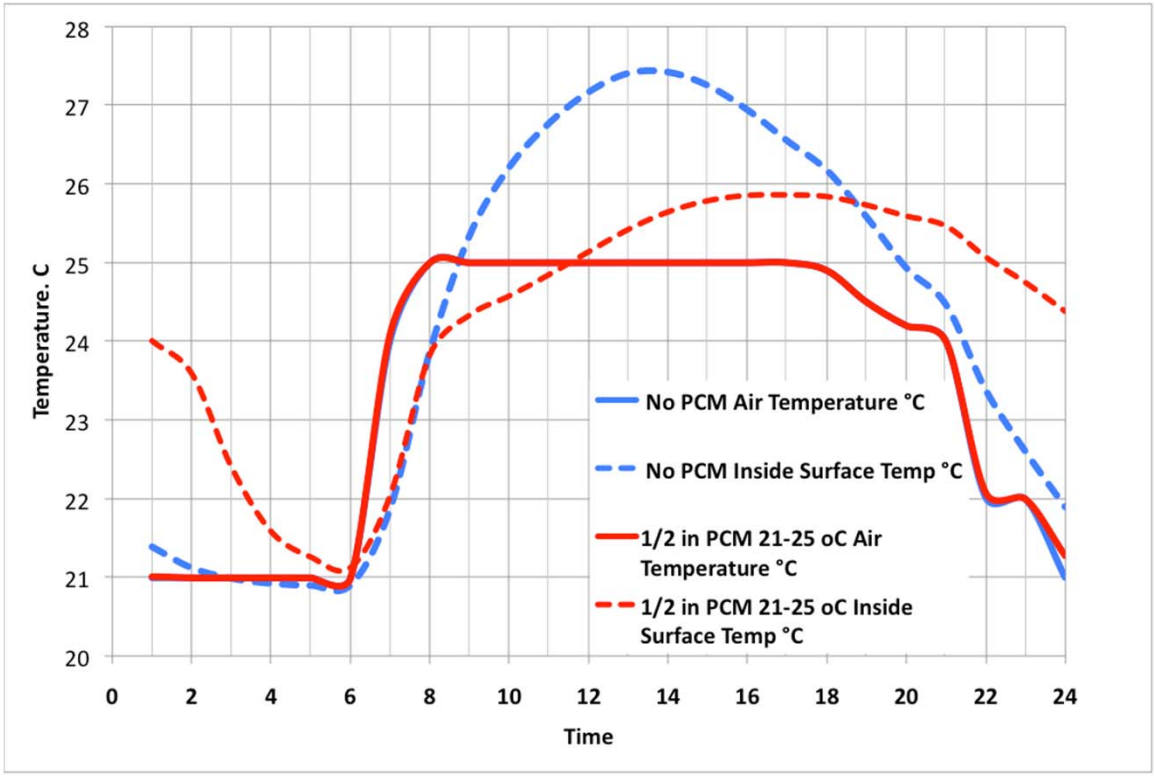



# Simulations



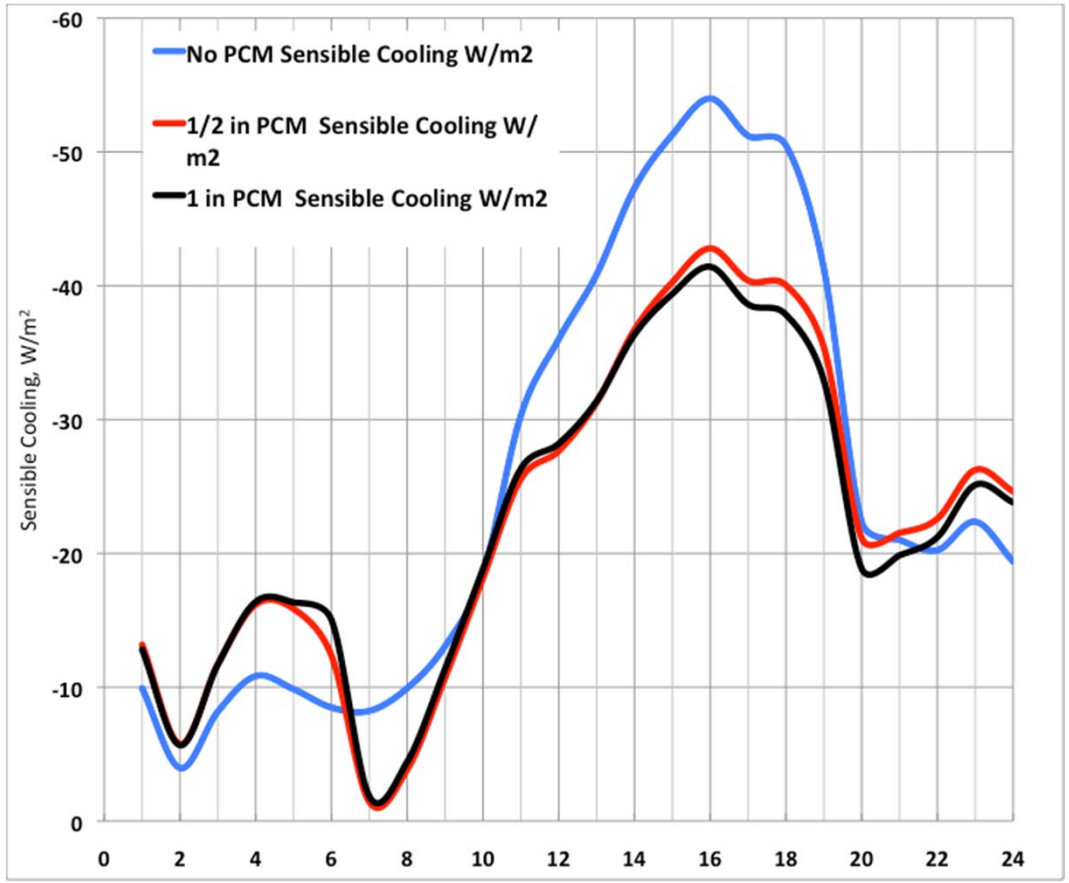
# Simulations Results

- We need large room temperature swings to take advantage of PCM
- CZ 16



# Simulations Results

- Peak cooling loads are reduced with PCM in ceiling plenum
- CZ 16



# Simulation Results

- Setting thermostat at constant temperature shows little results
- Sensible cooling peak reduced by cooling at night at allowing temperature to float during the day
- Peak cooling reduced on order of 25%
- Monthly and annual heating and cooling requirements were reduced in ALL climate zones
- Diurnal room temperatures need to be larger than PCM transition range

# Challenges

- Application of PCM is DELICATE
- Installation specific design/analysis
  - Too many variables!
  - Powerful simulation tools recommended
- HVAC control strategies needed
  - Cycle on/off AC to fully charge/discharge PCM
  - Don’t “set it and forget it”
- Fire Code

# Future Work

- Further simulation studies for PCM installation
  - Building type
  - Climate zone
  - PCM melting temperature
  - PCM application
- Field monitoring
  - Multi-family PCM wallboard
  - Small commercial retail PCM integrated HVAC

# For More Information

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