Programmable Communicating Thermostats
for Demand Response in California

Alex Do
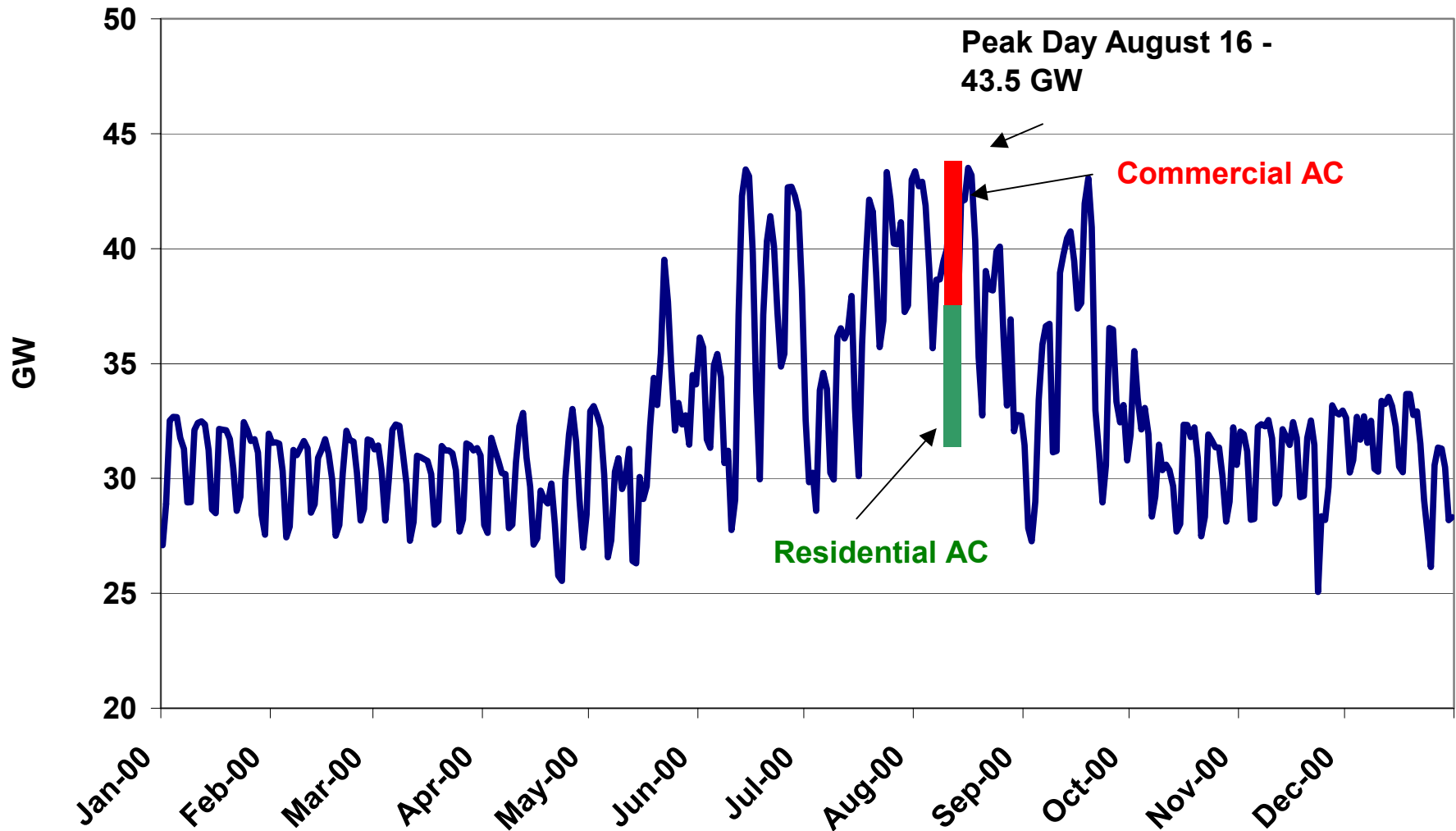UC Berkeley
do@oxy.edu

DR ETD Workshop
June 11, 2007

PCT Research at UC Berkeley

- PIER-funded research team:
  - PI's: D. Auslander, R. White, P. Wright
- Since 2006: support regulators and industry stakeholders by researching key technical and safety issues:
  - Strawman "minimum functionality" PCT concept and bill of materials
  - Proof-of-Concept demonstration
  - Research technical implementation issues for PCT interfaces and advise industry working group
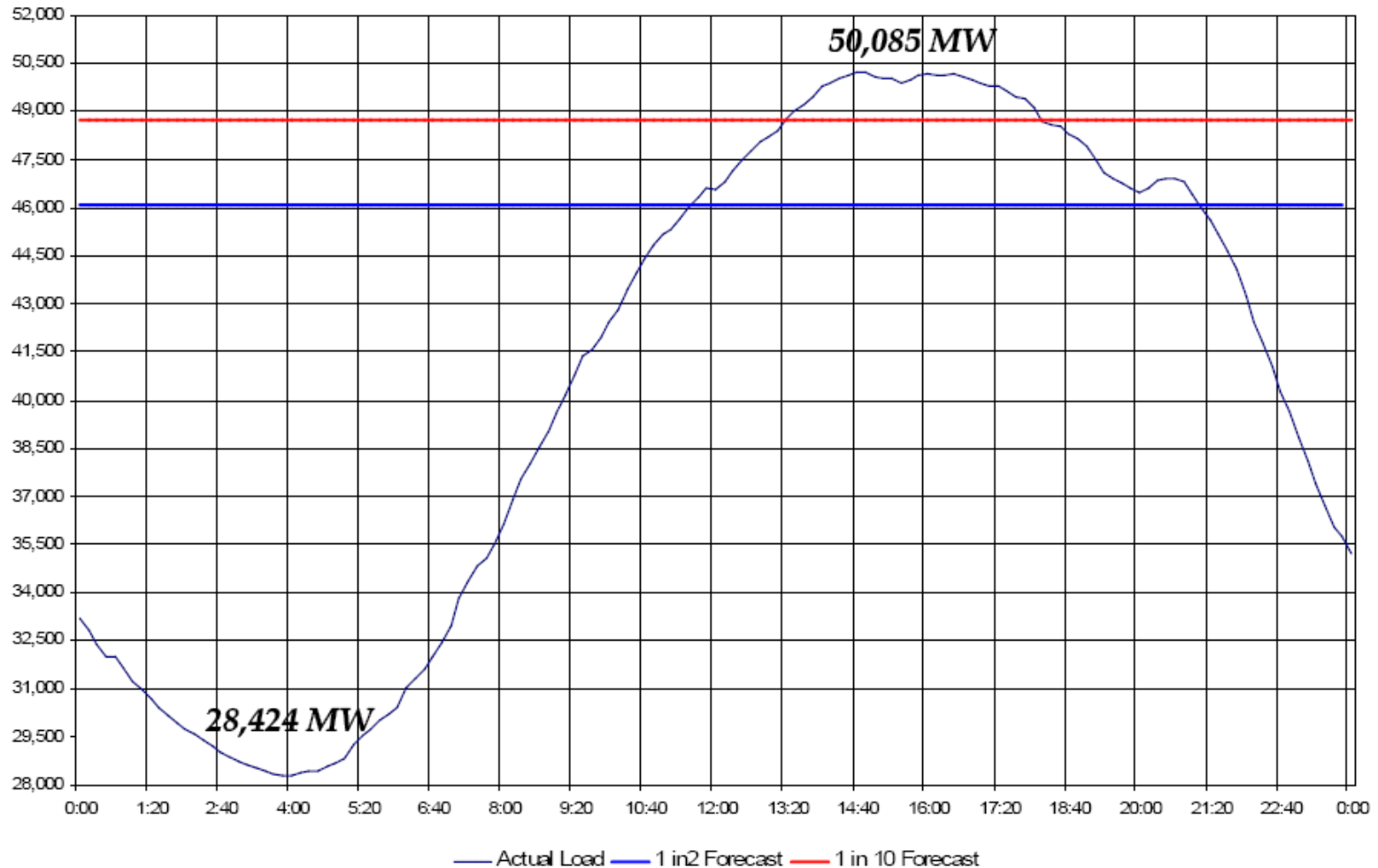 - Simulate aggregate effects of PCT's on electricity grid

Cal ISO Daily Peak Loads
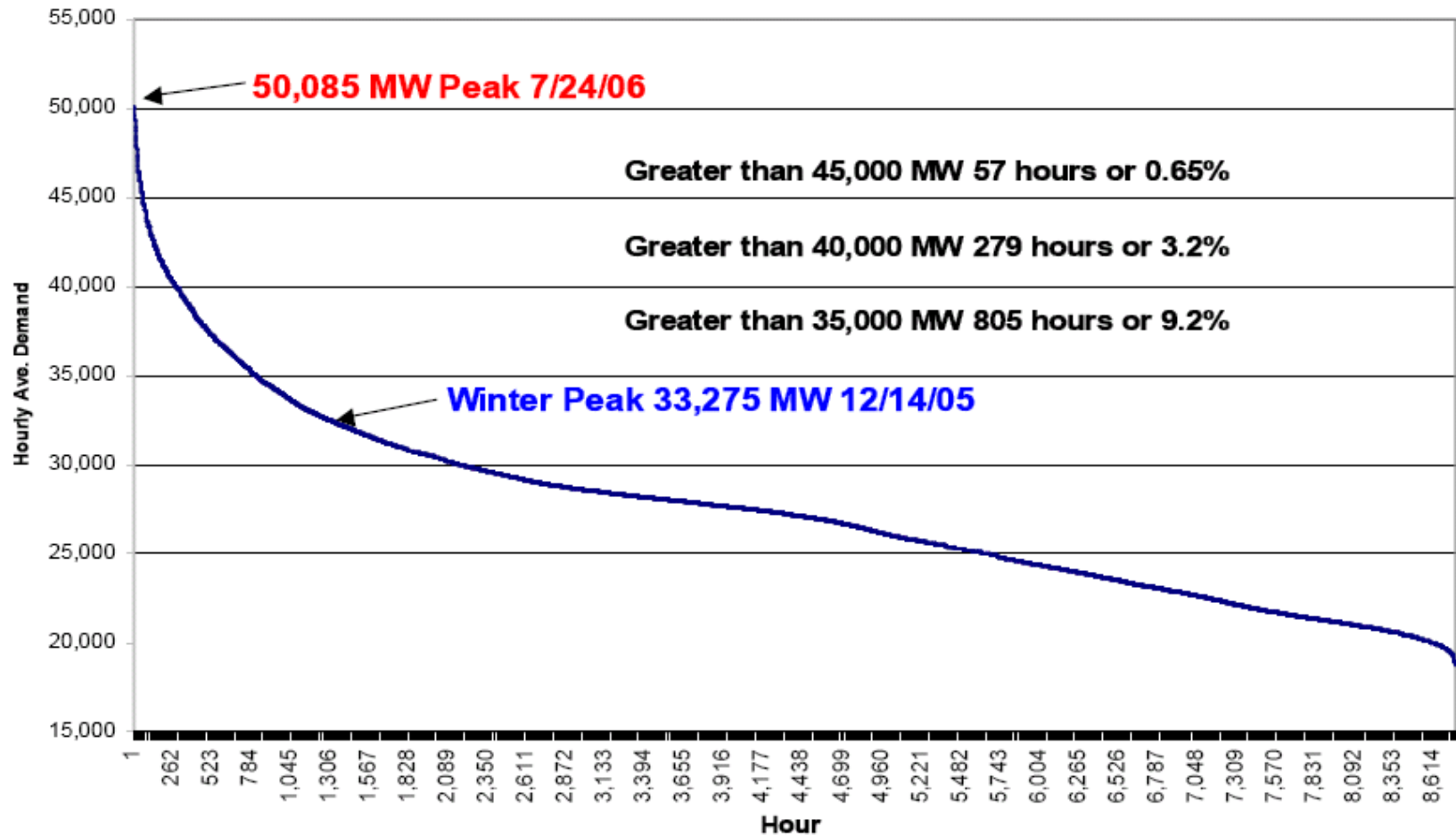## January 1, 2000 - December 31, 2000

CAISO Load Curve July 24, 2006

CAISO Load Duration Curve

Sept '05 to Sept '06

50,085 MW Peak 7/24/06

Greater than 45,000 MW 57 hours or 0.65%

Greater than 40,000 MW 279 hours or 3.2%

Greater than 35,000 MW 805 hours or 9.2%

Winter Peak 33,275 MW 12/14/05

Y-axis: Hourly Ave. Demand (15,000 – 55,000)

X-axis: Hour (1, 262, 523, 784, 1,045, 1,306, 1,567, 1,828, 2,089, 2,350, 2,611, 2,872, 3,133, 3,394, 3,655, 3,916, 4,177, 4,438, 4,699, 4,960, 5,221, 5,482, 5,743, 6,004, 6,265, 6,526, 6,787, 7,048, 7,309, 7,570, 7,831, 8,092, 8,353, 8,614)

PCT History

- Thermostats and load switches used to manage residential load since the 1970's

- 1-way and 2-way communication technologies: radio, paging, telephone, Internet

- Carrier released ComfortChoice PCT in 2000, widely used in residential and light-commercial pilot programs

- SCE Energy$mart Program demonstrated potential of PCT's to curtail ~0.3 kW/ton (A/C size)

CEC's PCT Vision

- Mandate residential PCT's through 2008 Title 24 building standard

- Potential for several GW of curtailable load – "negawatts cheaper than megawatts"

- Prevent rotating blackouts, increasing public safety and equity

- Managing A/C at t-stat provides better comfort and communication to customer

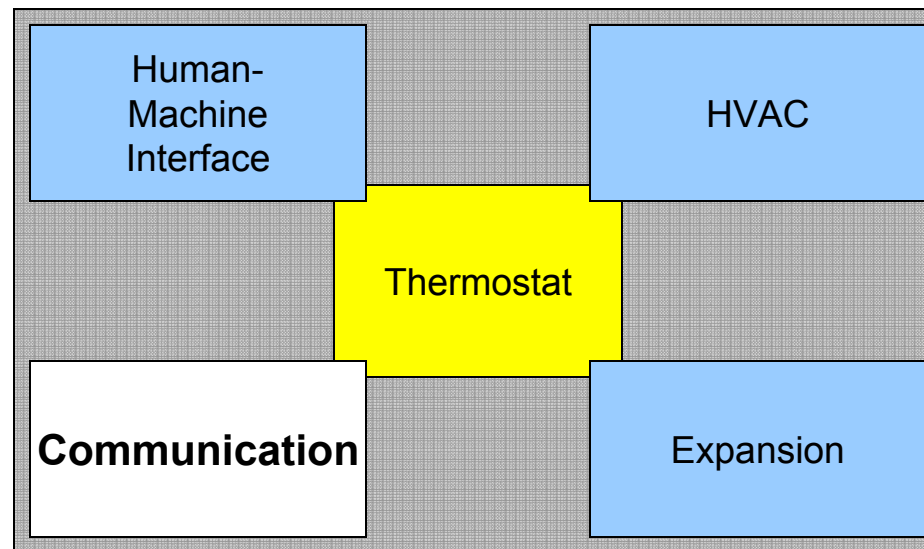- Statewide standards for "interfaces" to reduce overall cost
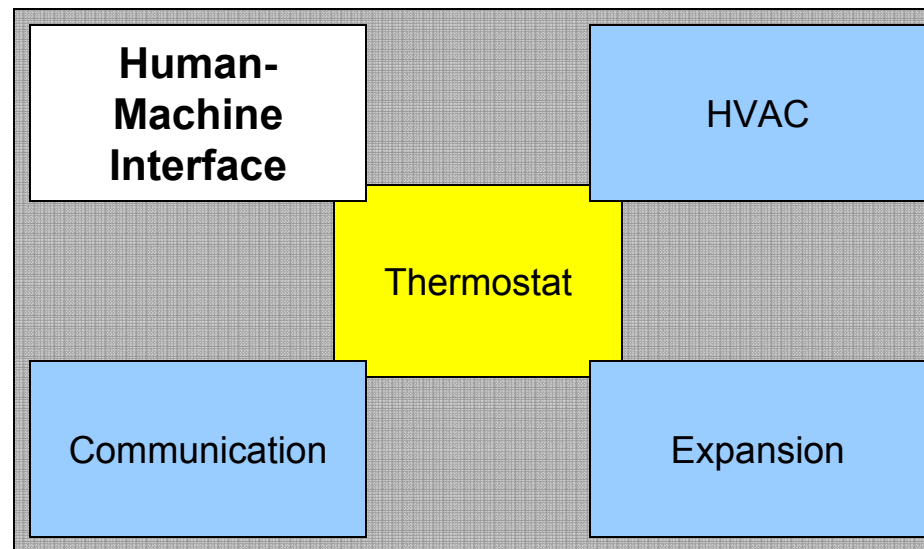
PCT Key Interfaces
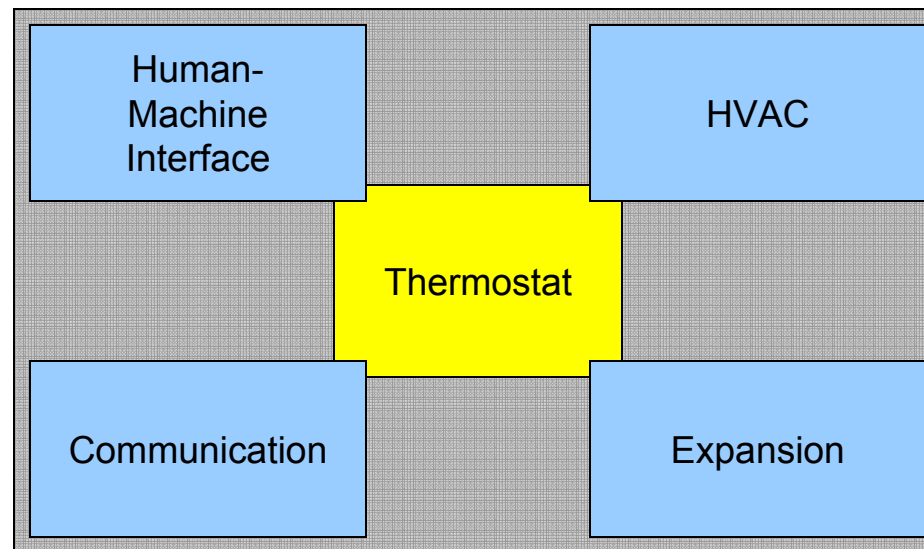
PCT Key Interfaces

Standard 1-way receiver built-in for DR signals

PCT Key Interfaces
Requirements for information presented to the resident
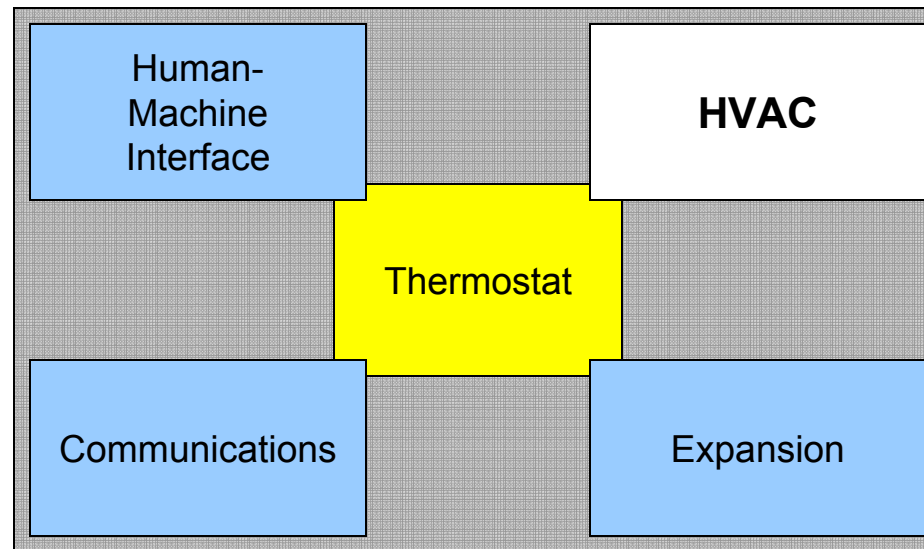and necessary inputs (i.e. override a curtailment)

Human-Machine Interface		HVAC
	Thermostat	
Communication		Expansion

72.0°

Critical period...
Temperature: 77°

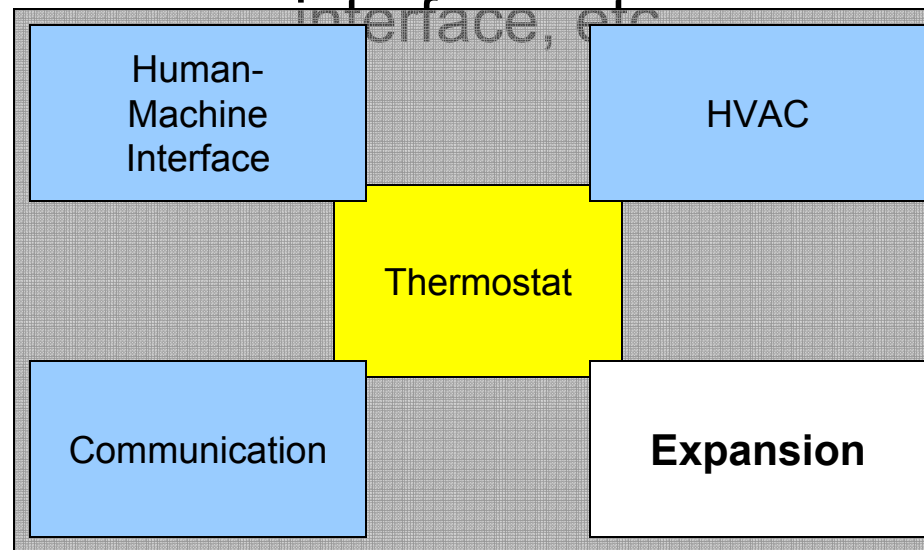3:35p   Day

PCT Key Interfaces

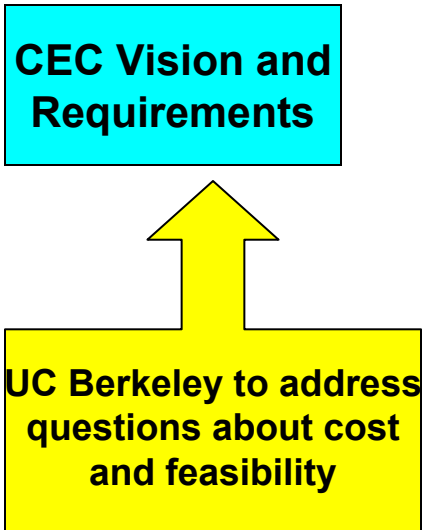Standard statewide interface to legacy (existing) analog HVAC appliances and future digitally-controlled systems

DR ETD Workshop

PCT Key Interfaces

Standard port to support add-on devices: 2-way communication chip, removable memory, diagnostics interface, etc.

Human-Machine Interface		HVAC
	Thermostat	
Communication		**Expansion**

Title 24 PCT Timeline

CEC Vision and Requirements

UC Berkeley to address questions about cost and feasibility

November 2005

Title 24 PCT Timeline

CEC Vision and Requirements

UCB Bill of Materials and Proof-of-Concept

Identify technical issues and survey technology for minimum-functionality design concept
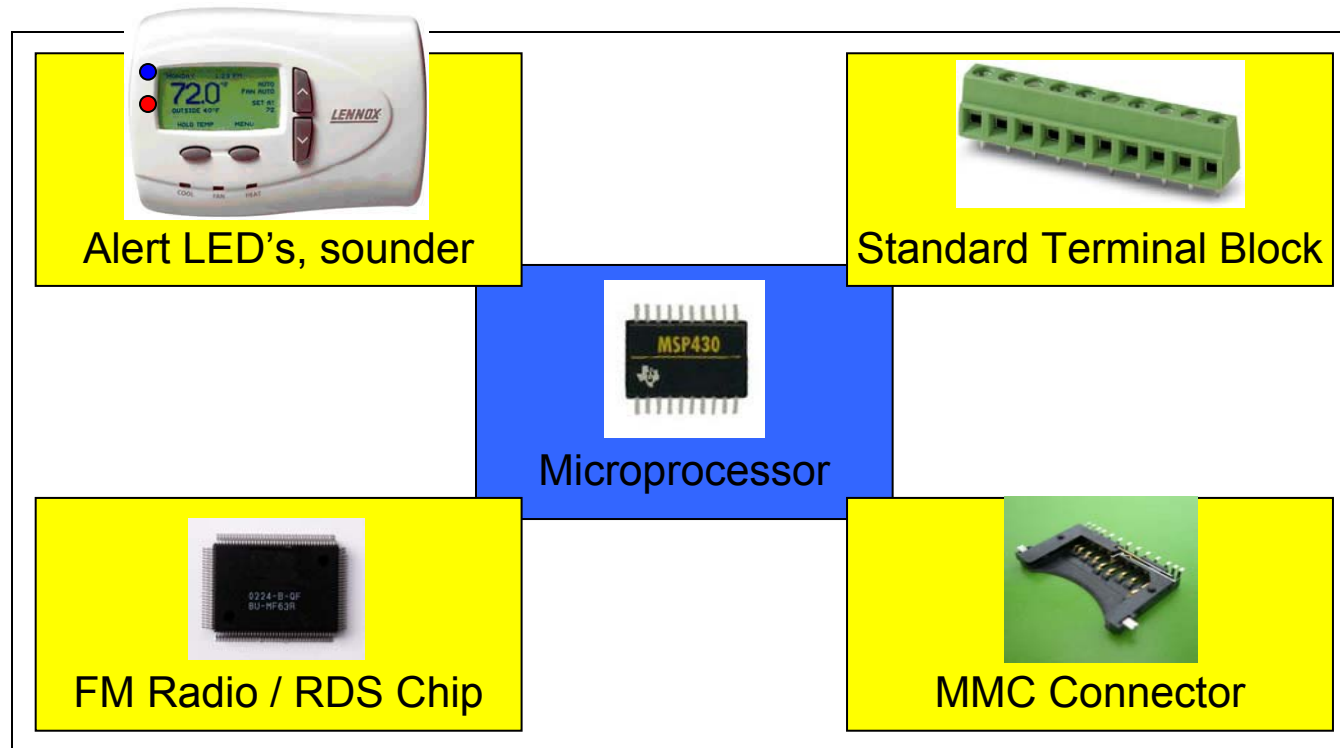
November 2005

April 2006

Minimum-Functionality PCT

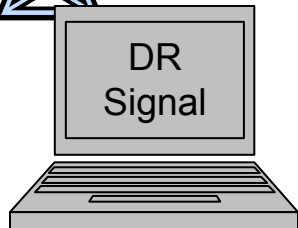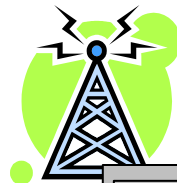- Bill of materials for a minimum-functionality PCT that costs less than $20

Alert LED's, sounder

Standard Terminal Block

Microprocessor

FM Radio / RDS Chip

MMC Connector

Proof of Concept Demonstration

Interactive Display
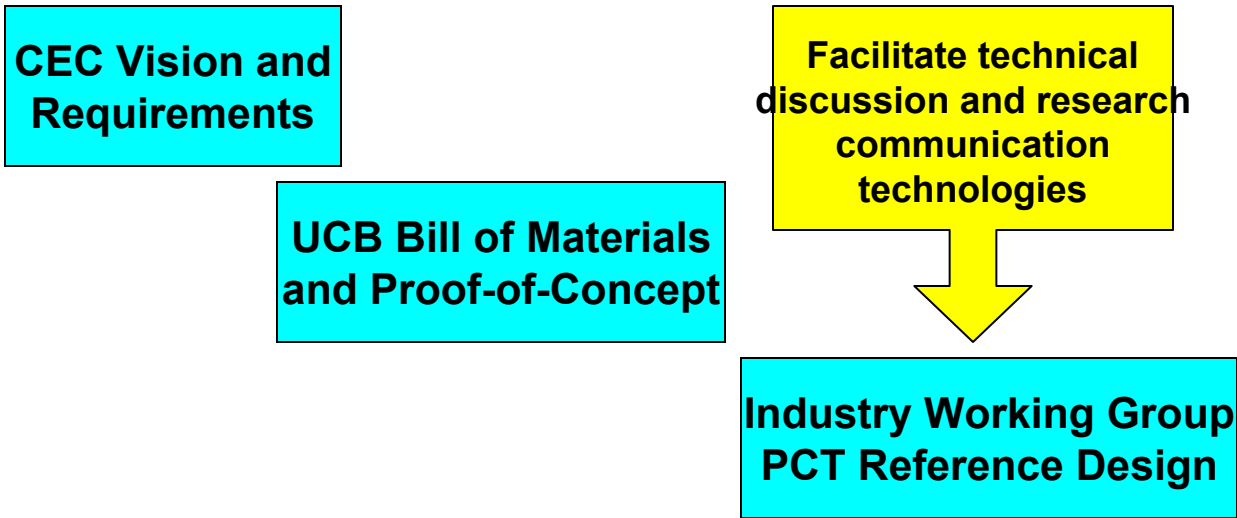
Simulated Load

DR Signal

USB Stick

Title 24 PCT Timeline

CEC Vision and Requirements

UCB Bill of Materials and Proof-of-Concept

Facilitate technical discussion and research communication technologies

Industry Working Group PCT Reference Design

November 2005

April 2006

April 2007

Title 24 PCT Timeline

CEC Vision and Requirements

UCB Bill of Materials and Proof-of-Concept

Industry Working Group PCT Reference Design

Demonstration installed next month at Cal. ISO building

Vendor Prototypes
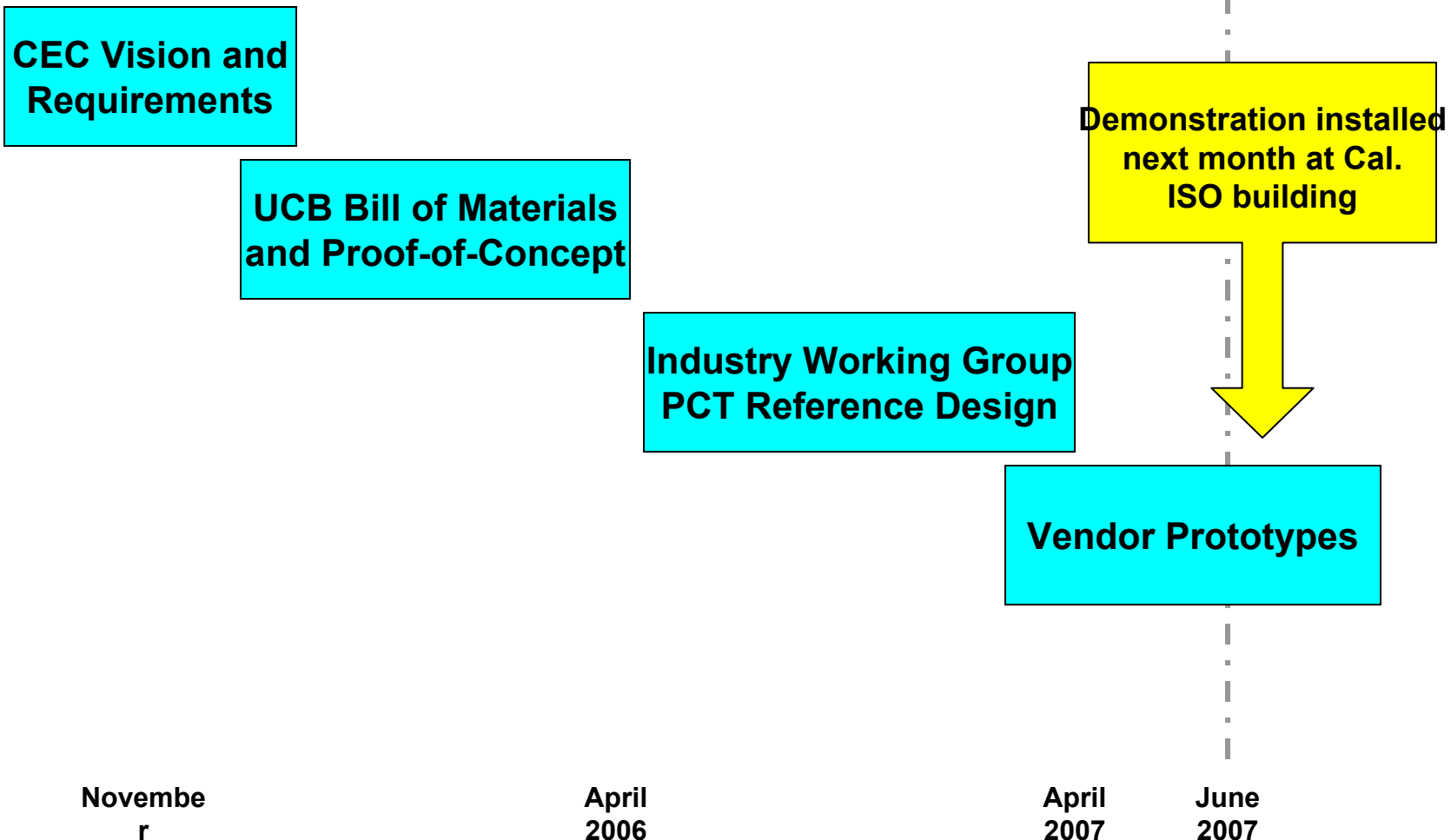
November 2005

April 2006

April 2007

June 2007

ritetemp PCT Working Model

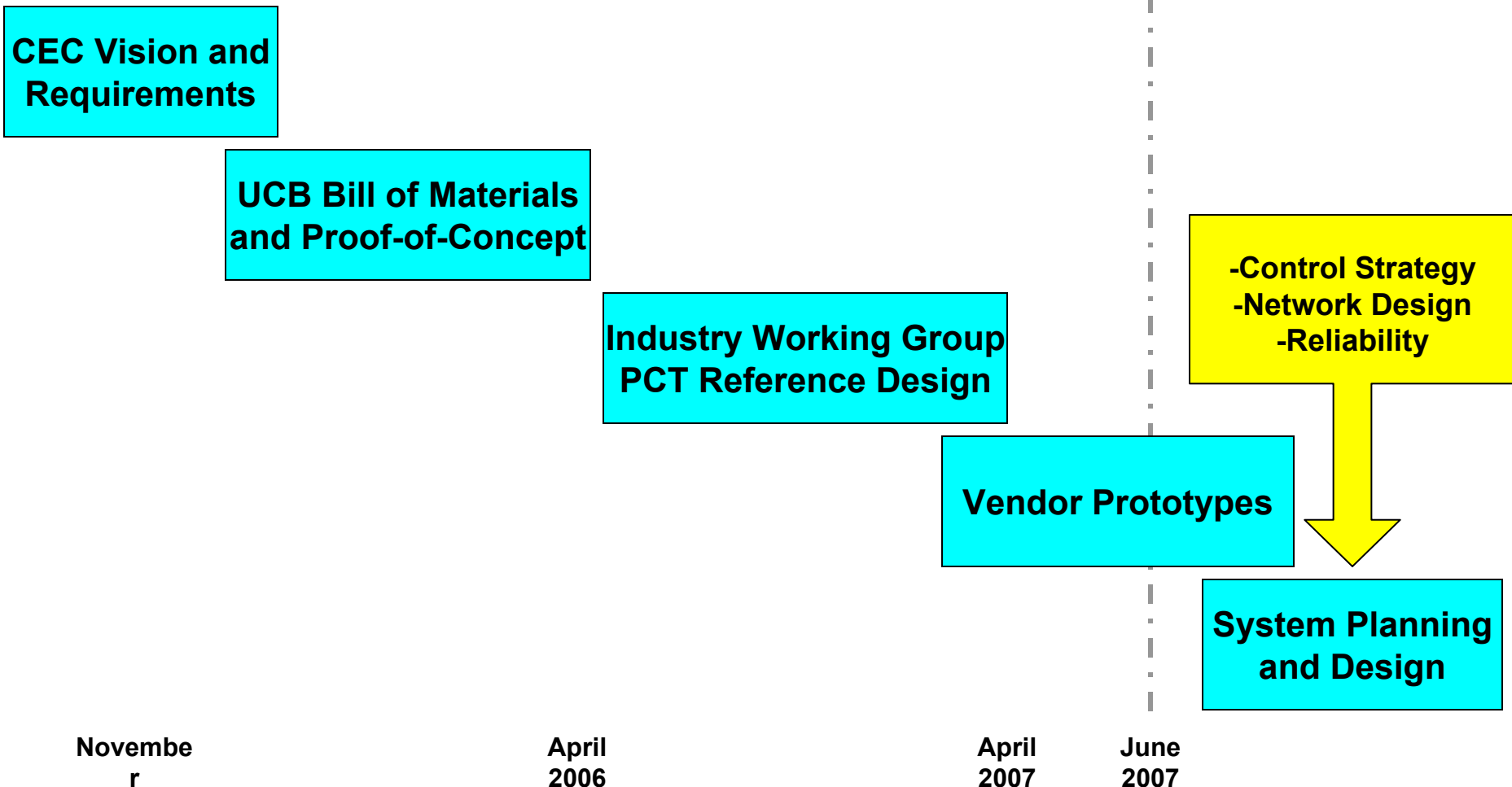**6030 PCT Programmable Communicating Thermostat**

Golden Power Manufacturing's 6030PCT programmable communicating thermostat offers compliance with new energy management features in California's 2008 Title 24 building standards updates—and it's available today! The 6030PCT

Title 24 PCT Timeline

CEC Vision and Requirements

UCB Bill of Materials and Proof-of-Concept

Industry Working Group PCT Reference Design

**-Control Strategy
-Network Design
-Reliability**

Vendor Prototypes

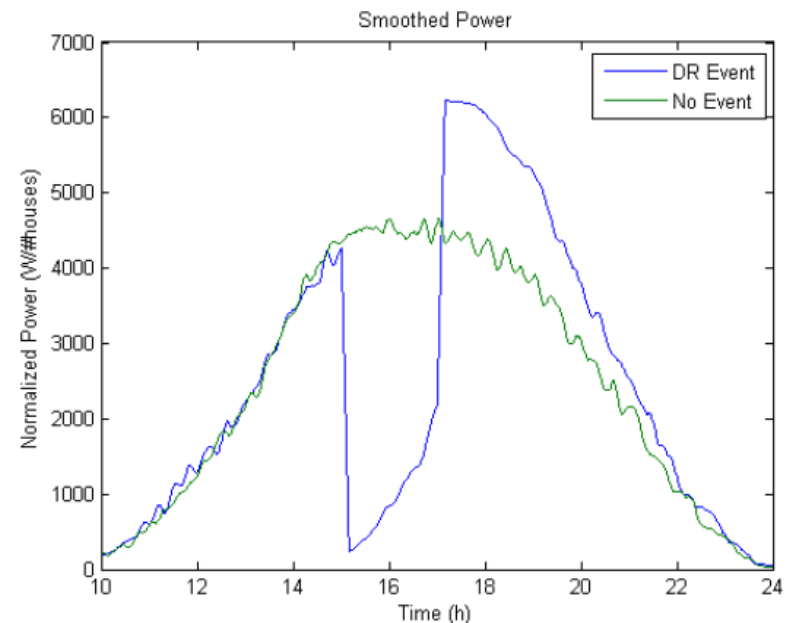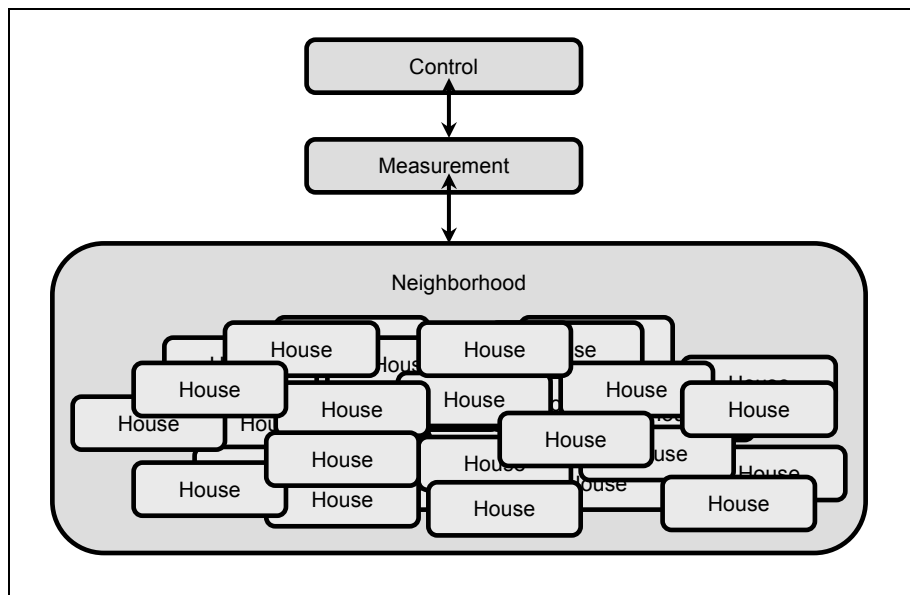**System Planning and Design**
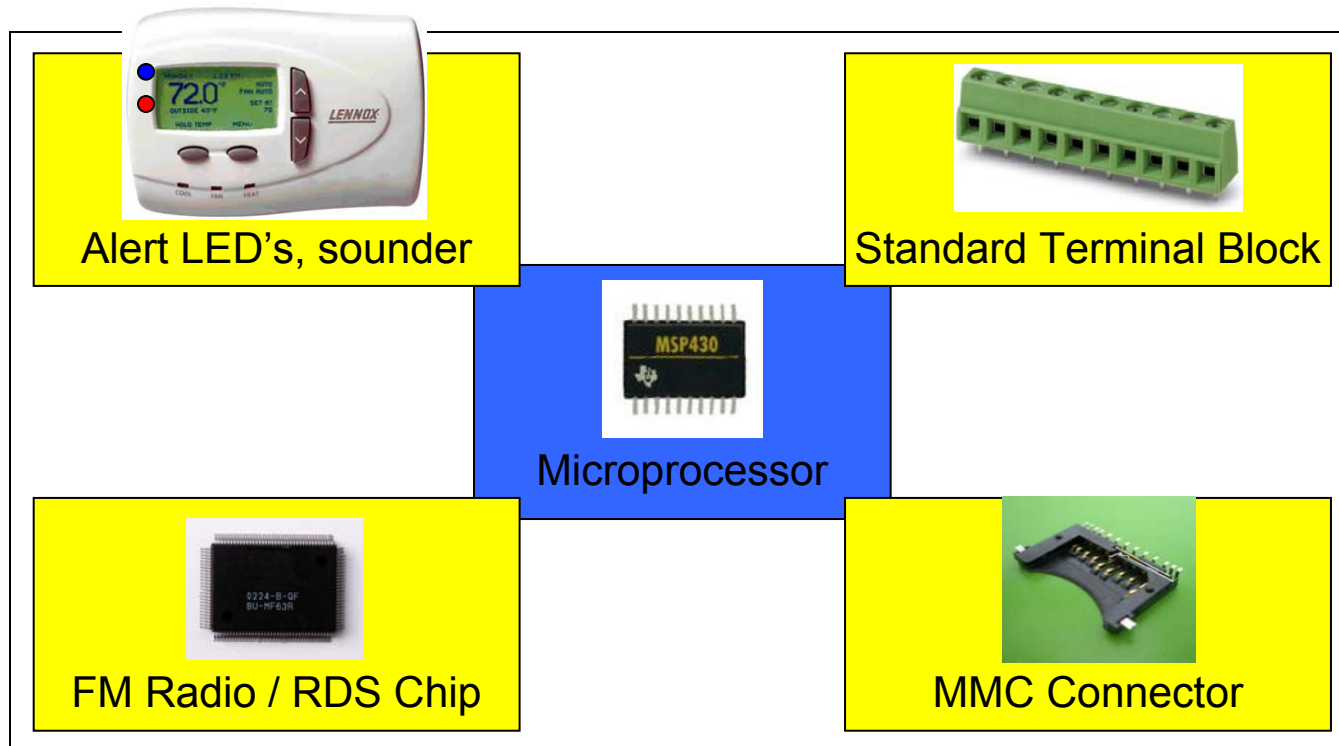
| November 2005 | April 2006 | April 2007 | June 2007 |

PCT Systemic Control

- Simulation tool to investigate aggregate load behavior when PCT-enabled homes respond to DR control signals
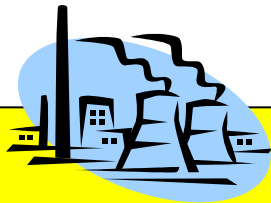
PCT Interfaces

Alert LED's, sounder

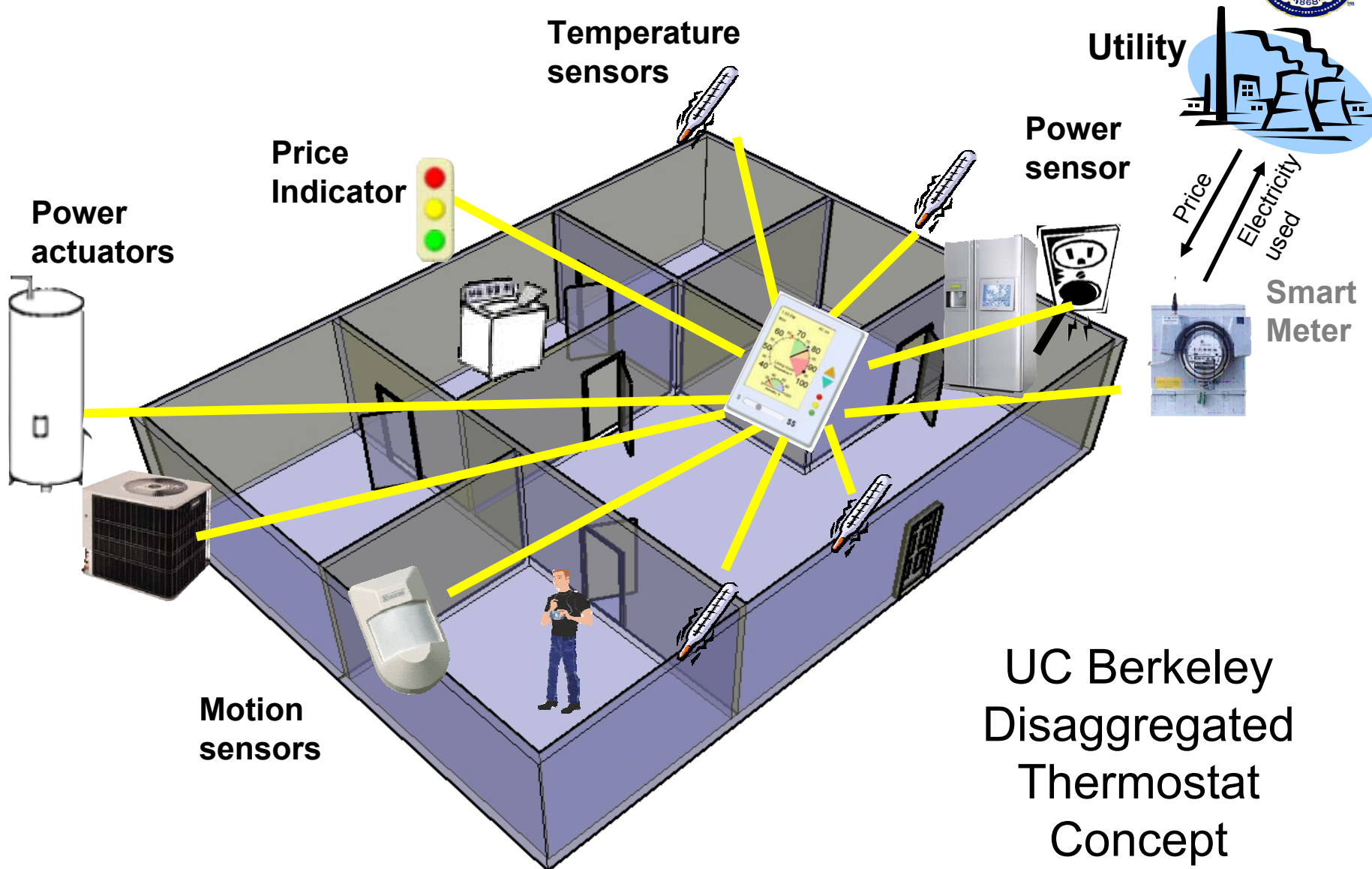Standard Terminal Block

Microprocessor

FM Radio / RDS Chip

MMC Connector

Resident Interaction

HVAC Actuation

Energy Control

Utility Communication Gateway

Expansion Functionality

Temperature sensors
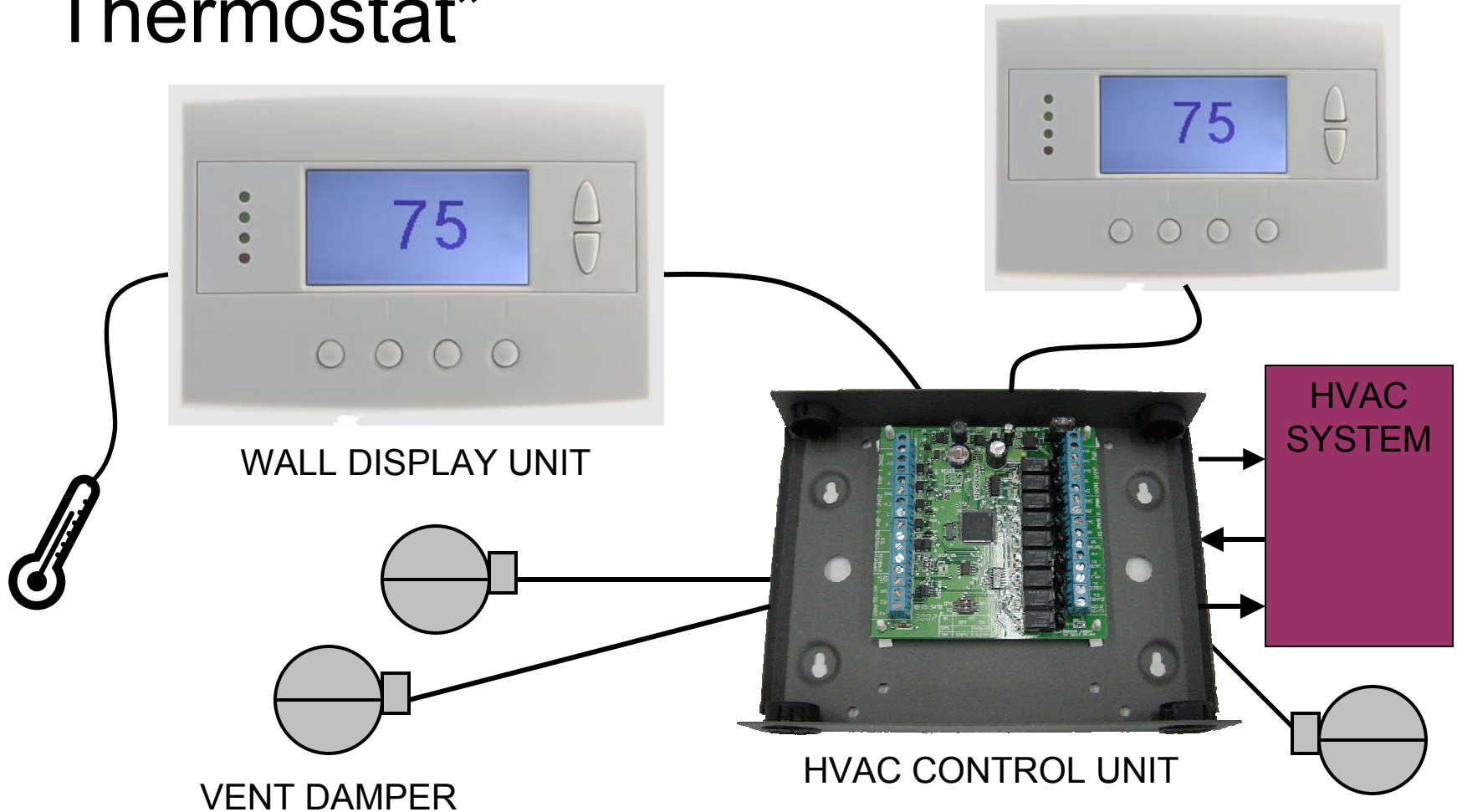
Utility

Power sensor

Price Indicator

Power actuators

Price

Electricity used

Smart Meter

Motion sensors

UC Berkeley Disaggregated Thermostat Concept

RCS Multizone "Disaggregated Thermostat"

WALL DISPLAY UNIT

HVAC SYSTEM

VENT DAMPER

HVAC CONTROL UNIT

Questions?

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- Special thanks to:
  - Ron Hofmann, PIER
  - Gaymond Yee, CIEE