Getting Energy Use (Cost) Under Control: Leveraging Building Automation Systems

Srinivas Katipamula, Ph.D.
Staff Scientist, Pacific Northwest National Laboratory

21st Annual E source Forum and Exhibits

September 23rd, 2008 – Denver, CO

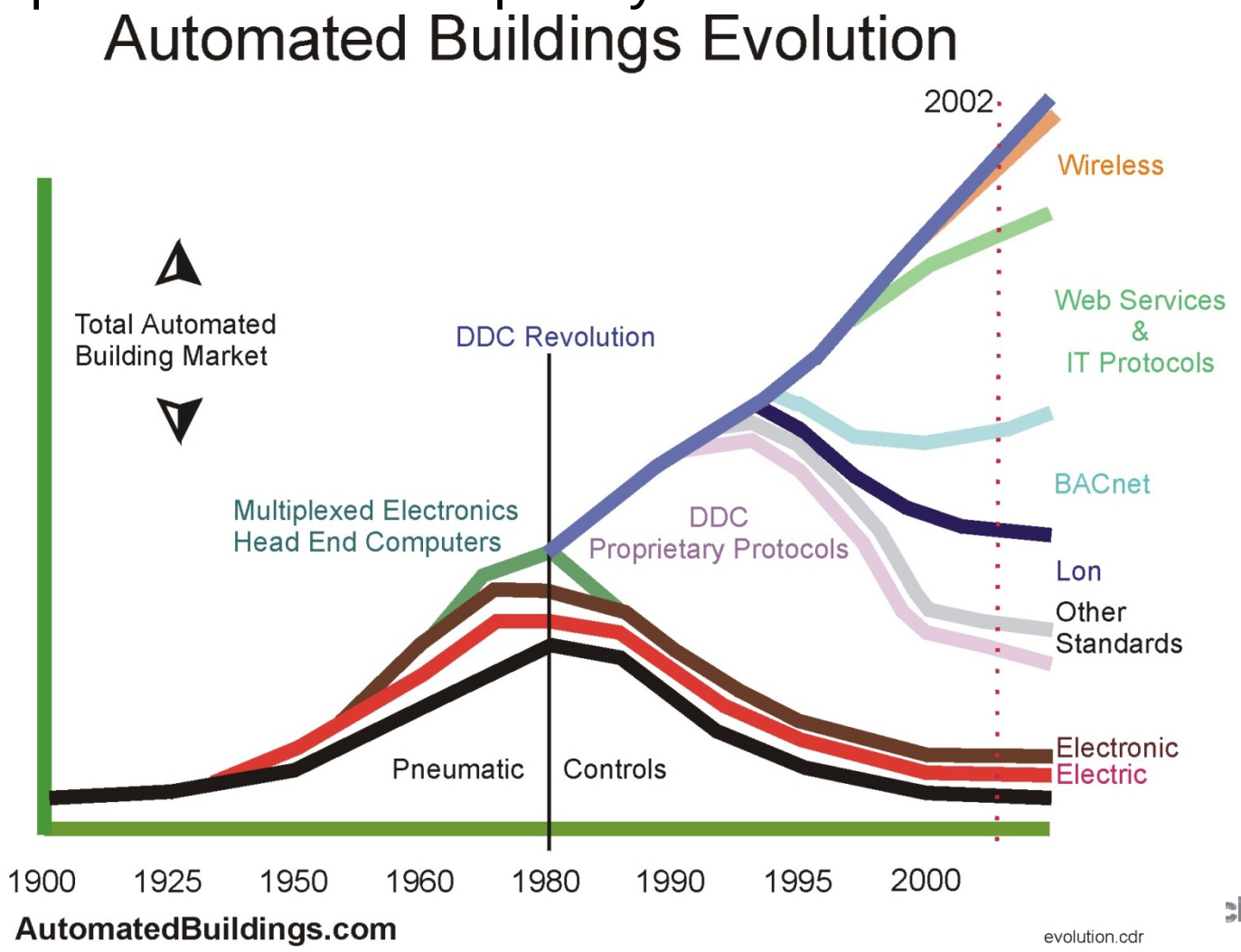
Pacific Northwest
NATIONAL LABORATORY

Outline

- Introduction to Building Automation Systems (BAS)
- How to Enhance Operational Efficiency of Buildings Using BAS?
- How to Make Buildings More Demand Responsive Using BAS?
- Closing Remarks

Evolution and Status of Building Automation Systems

- In the past two decades BAS have increased capabilities and complexity



evolution.cdr

Is There a Need to Enhance Building Operations?

- Buildings are not properly commissioned, operated nor maintained
  - even though capabilities of BAS continue to increase
  - typical installations include minimum number of sensors
  - lack of skilled operators and training
- Improper operations lead to inefficiencies and reduced lifetime of the equipment
- Enhanced building operations lead to:
  - enhanced equipment performance
  - better comfort
  - improved equipment availability, and
  - fewer complaints from building occupants

Enhancing Building Operations Through Re-tuning

What is Re-tuning?

- Re-tuning is one approach to improve operational efficiency through low-cost and no-cost operational improvements (mostly control changes)
- Re-tuning is a systematic process to identify and correct building operational problems that lead to energy waste
- Implemented primarily through the building control system at no cost other than the labor required to perform the re-tuning process
- May include small, low-cost repairs, such as replacing faulty sensors
- Includes identifying other opportunities for improving energy efficiency that require investment
- Might be thought of as a scaled-down retro-commissioning focused on identifying and correcting operational problems

Six Primary Steps of Re-Tuning

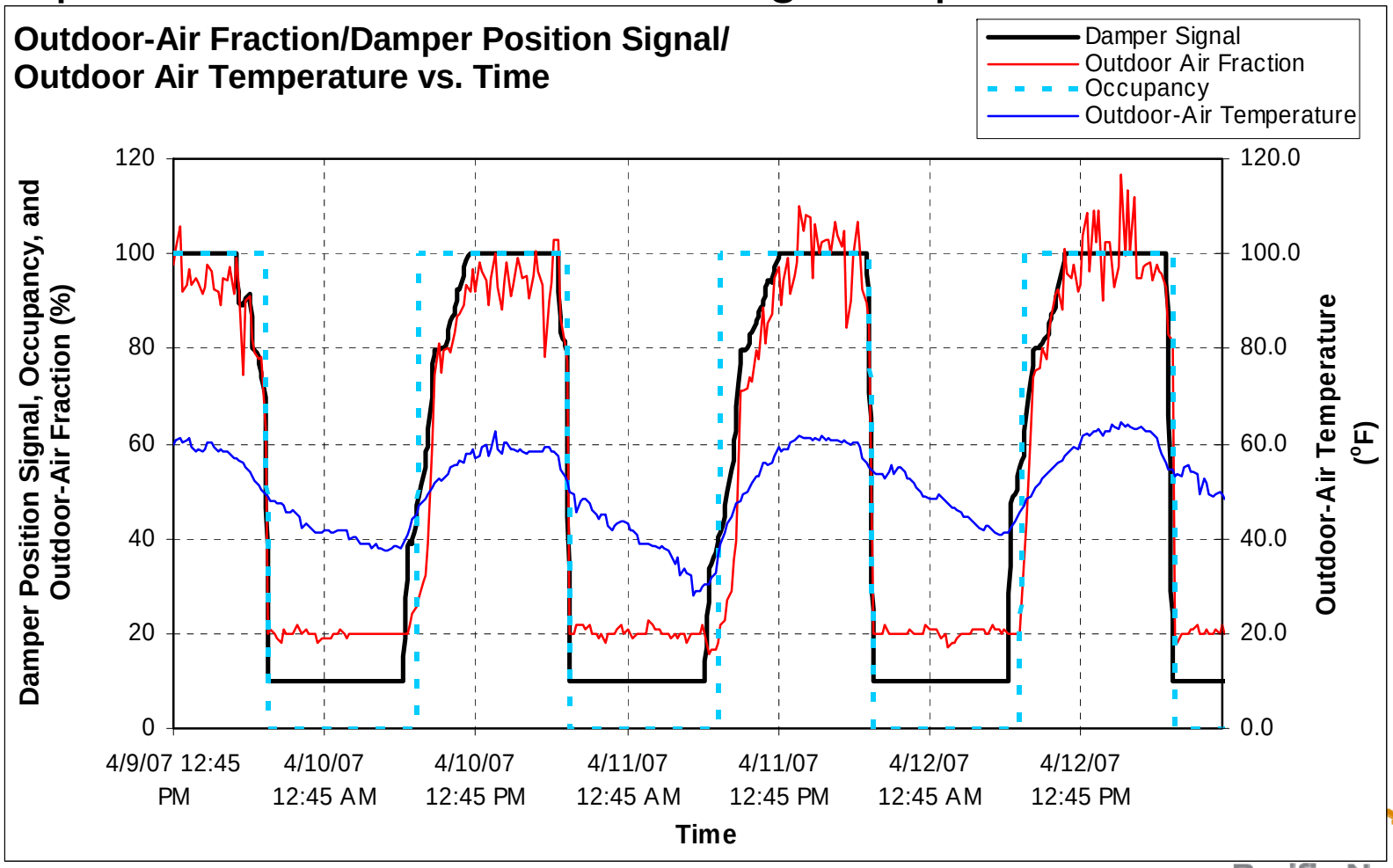
- Collecting initial building information: Basic building information
- **Pre-Re-Tuning Phase: Trend-data collection and analysis**
- Building Walk Down: Getting to know the building
- Re-Tuning: Identifying and correcting operations problems
- Post Re-Tuning: Reporting re-tuning findings
- Savings Analysis: Determining and reporting the impacts

Trend-Data Collection & Analysis: Purpose

- Detect potential operational problems even before visiting the building
- Identify problems that require time histories to detect – incorrect schedules, no use of setback during unoccupied modes, poor economizer operation

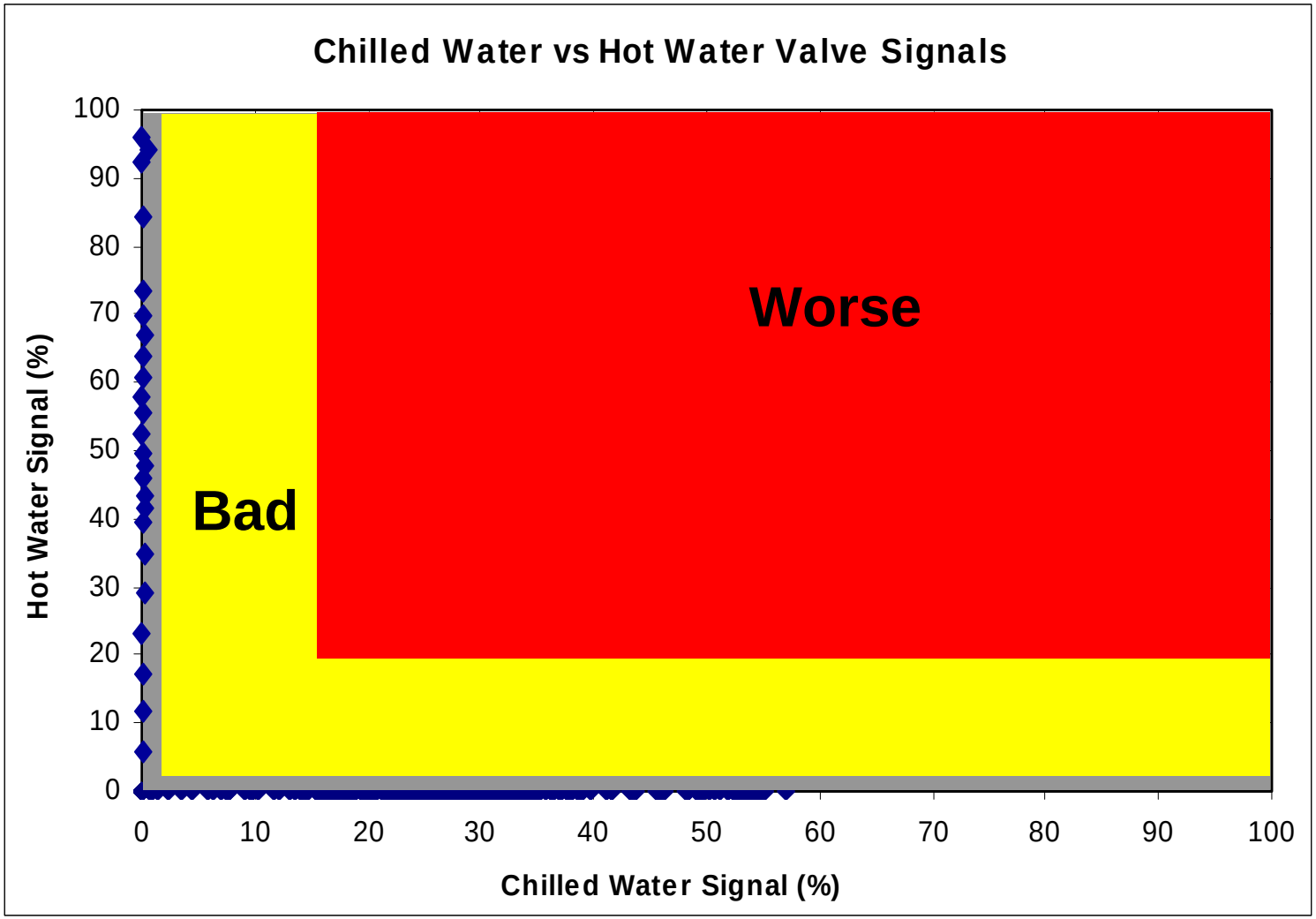
Minimum Outdoor-Air Operations: Example use of Graphs

- Outdoor-air fraction, outdoor-air temperature and damper position vs. time: For building occupied 12 h/d



Outdoor-Air Lockouts for Heating & Cooling: Another Example use of Graphs

- Air handler heating vs. cooling valve positions



Pacific Northwest NATIONAL LABORATORY

Using the knowledge learned from trend-data analysis and building walk through to start the re-tune process

Major Focus Areas in Re-Tuning

- Occupancy scheduling
- Discharge-air temperature control
- Discharge-air static pressure control
- Air-handling unit (AHU) heating & cooling
- AHU outside/fresh air makeup
- AHU economizer operation
- Zone conditioning
- Meter profiles
- Central plant

Highlights of Re-Tuning

- Every set point adjustment made will have an impact of some sort on the utility meter
- Can save energy and keep occupants comfortable
- It takes time to tune a building
- There are no magic set points that work all the time
- Always monitor the utility meters (gas & electric) to see what affect you have had
- Look at the big picture when making adjustments
- Watch the meter profiles weekly
- Learn and know the building's personality

Six Primary Steps of Re-Tuning

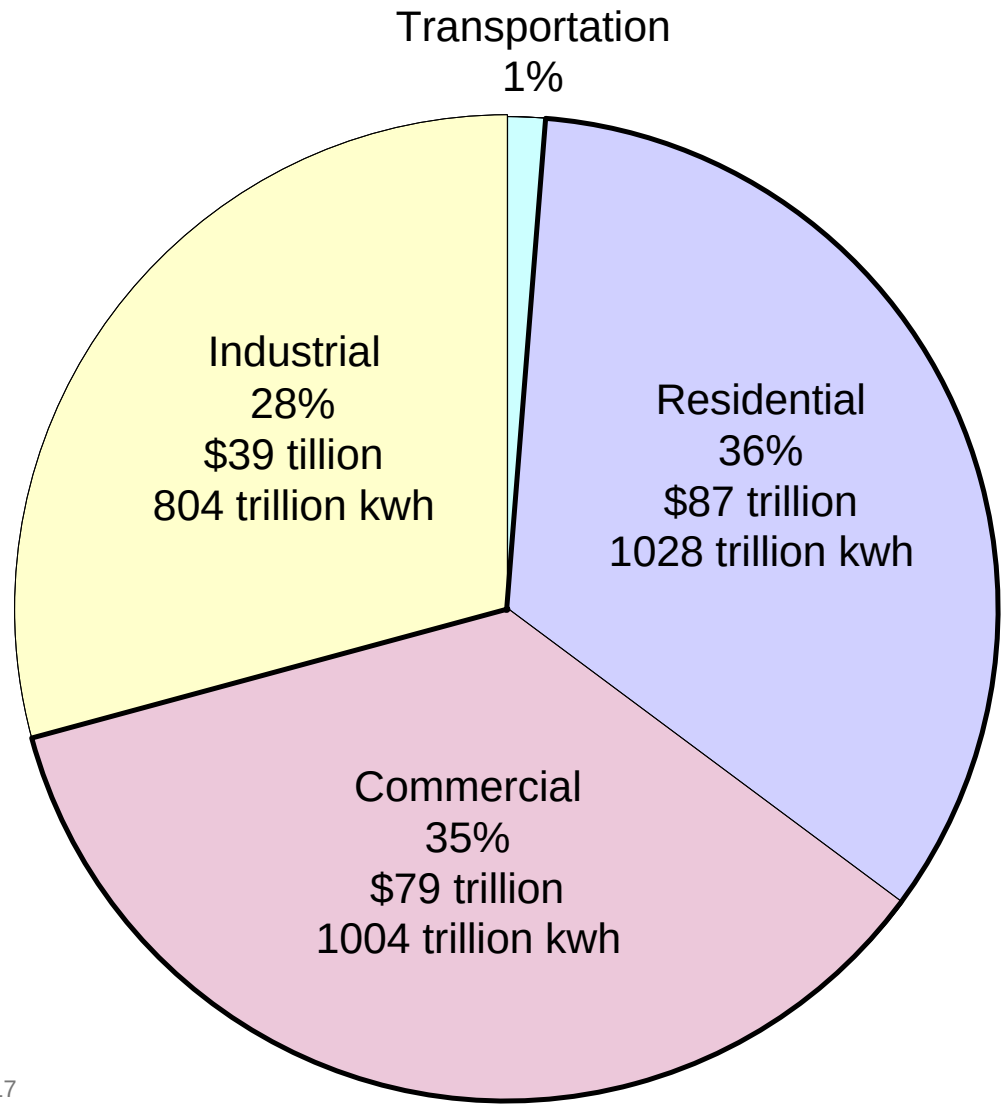
- Collecting initial building information: Basic building information
- Pre-Re-Tuning Phase: Trend-data collection and analysis
- Building Walk Down: Getting to know the building
- Re-Tuning: Identifying and correcting operations problems
- **Post-Re-Tuning: Reporting re-tuning findings**
- **Savings Analysis: Determining and reporting the impacts**

Re-Tuning Implementation Issues

- Many simple operational changes take a long time before they are implemented
- Stumbling block appears to be the perception by building operations staff that they lack clear authority to implement minor operational changes
- In many cases, the building operator takes directions from someone who is not present in the building on a day-to-day basis
- There is some reluctance by building operational staff to make changes because of a perception that changes can lead to complaints

Leveraging BAS to Make Buildings More Demand Responsive

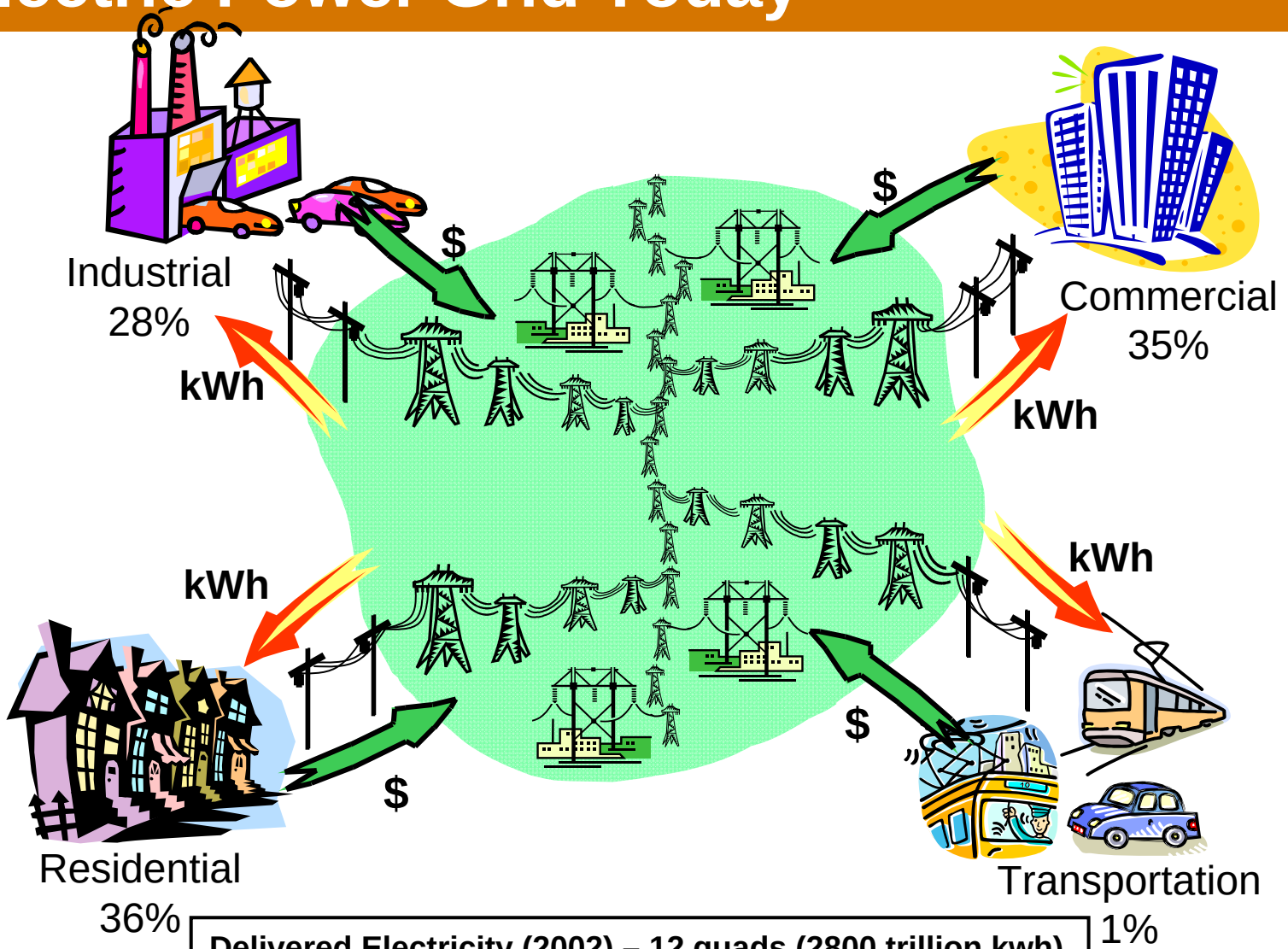
Importance of Electricity to Buildings and Buildings to the Electric Power Grid



Buildings account for:

- 71% of electricity use
- 2032 trillion kwh (8.5 $quads_e$) per year
- $166 trillion dollars annually

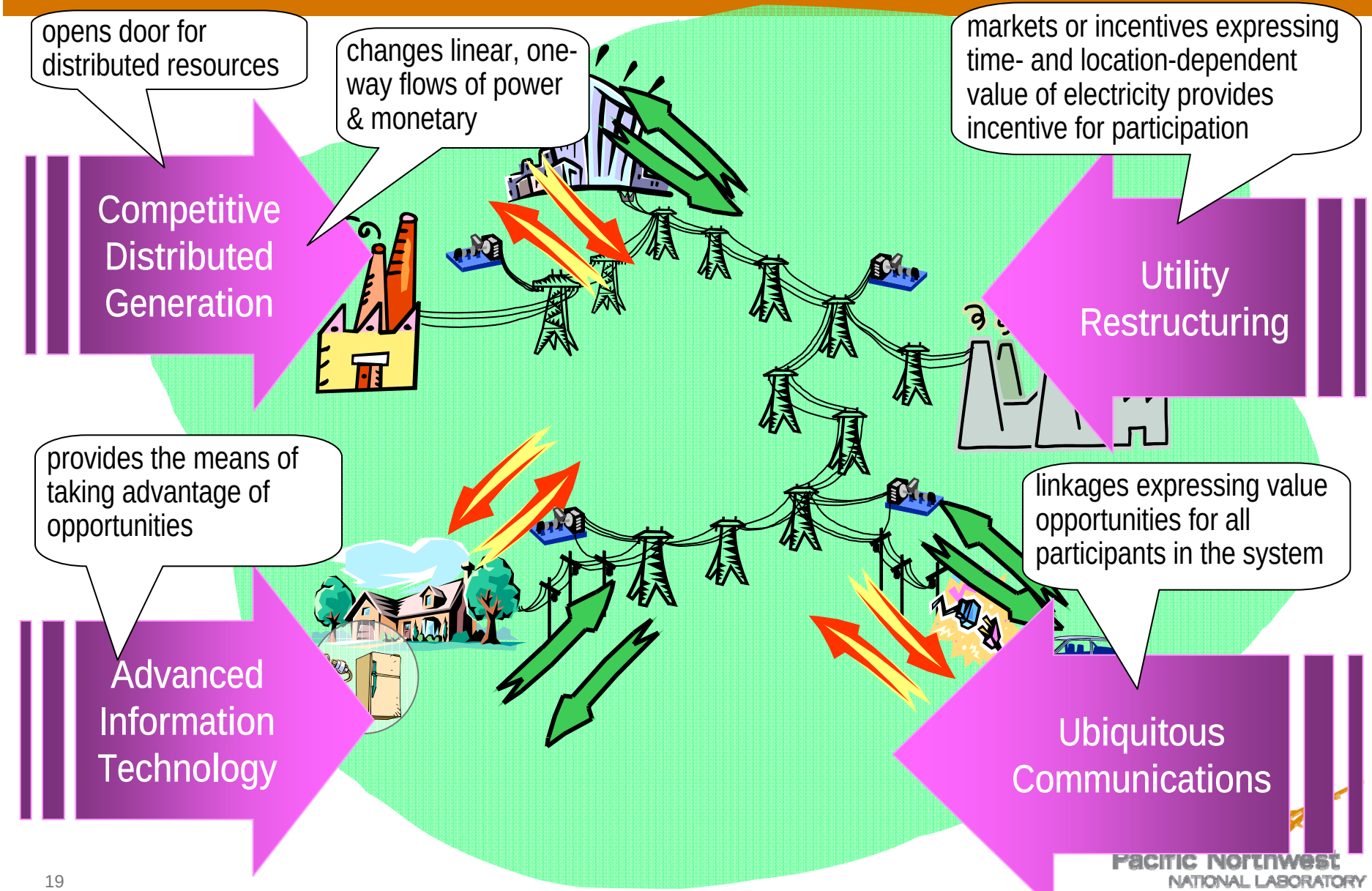
Electric Power Grid Today



Delivered Electricity (2002) – 12 quads (2800 trillion kwh)
Primary Energy Consumption (2002) – 37 quads

Pacific Northwest
NATIONAL LABORATORY

Electric Power Grid of the Future



How will Buildings Participate in the Electric Grid of the Future?

- Receive electricity prices or other gird emergency signal from the grid in real time
- Receive electricity prices for electricity buy back from the grid in real time
- Adjust building loads in real time to optimize tradeoffs among:
  - building services (indoor temperature, lighting levels, ventilation,…)
  - use of on-site dispatchable distributed generation
  - cost of electricity purchases
  - sales of excess electricity back to the grid
  - minimize total cost of energy services to the site

Leveraging Existing BAS

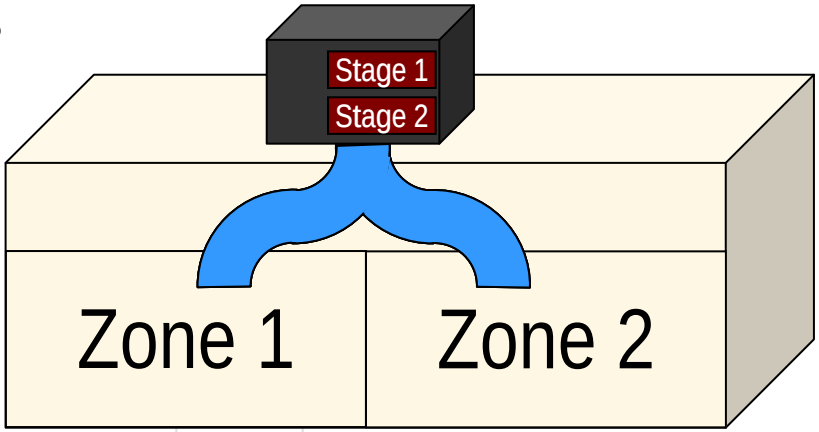
- BAS can be leveraged with little or no capital investment to make commercial buildings more demand responsive
- Challenge is to identify loads that are elastic to price or other “grid signals”
- BAS are the key to successfully integrate building with the “Grid of the Future”
- Automation is key to make buildings more demand responsive
- Another key for success is to provide the ability for the customer to override demand response either locally or globally

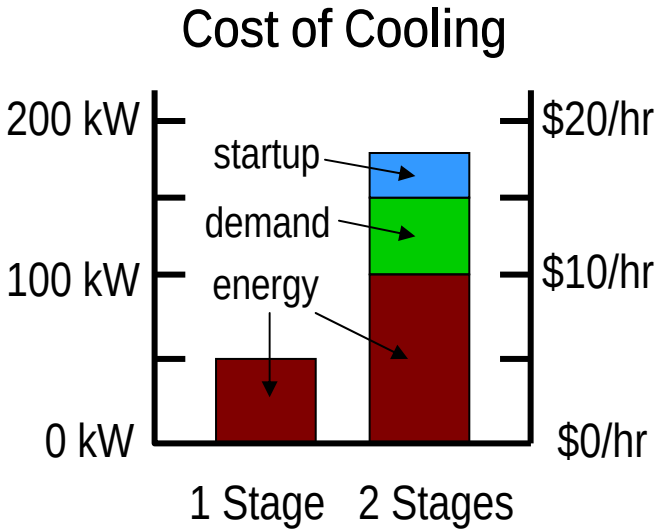
Example of Automated Demand Response Using BAS in Commercial Buildings

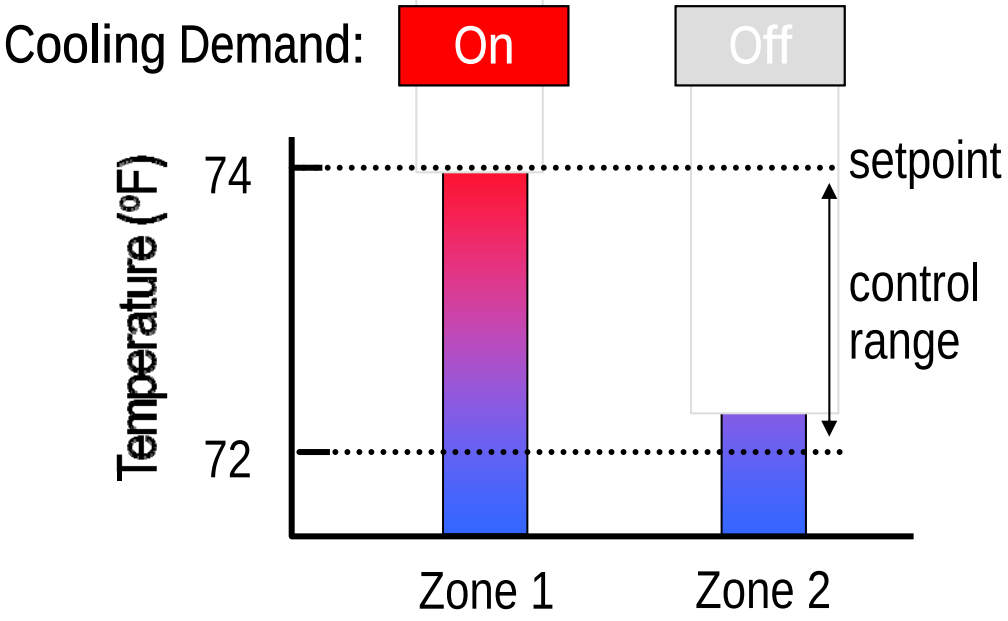
Pacific Northwest
NATIONAL LABORATORY

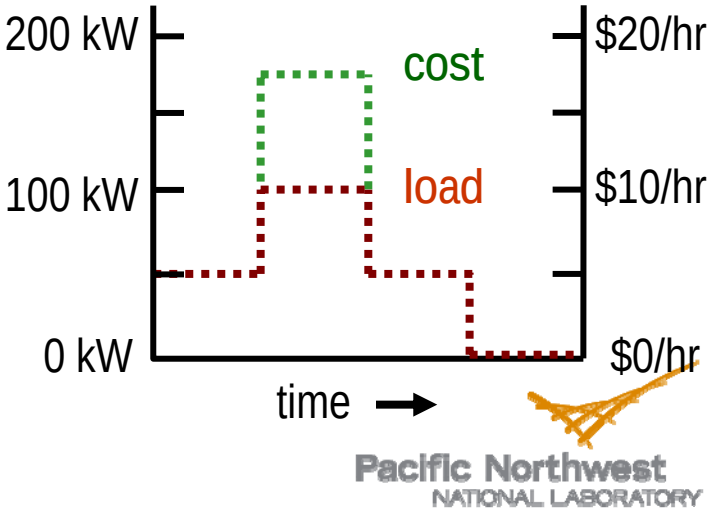
Traditional Control — Satisfies Absolute Demand Regardless of Cost or Grid Conditions

Commercial Buildings



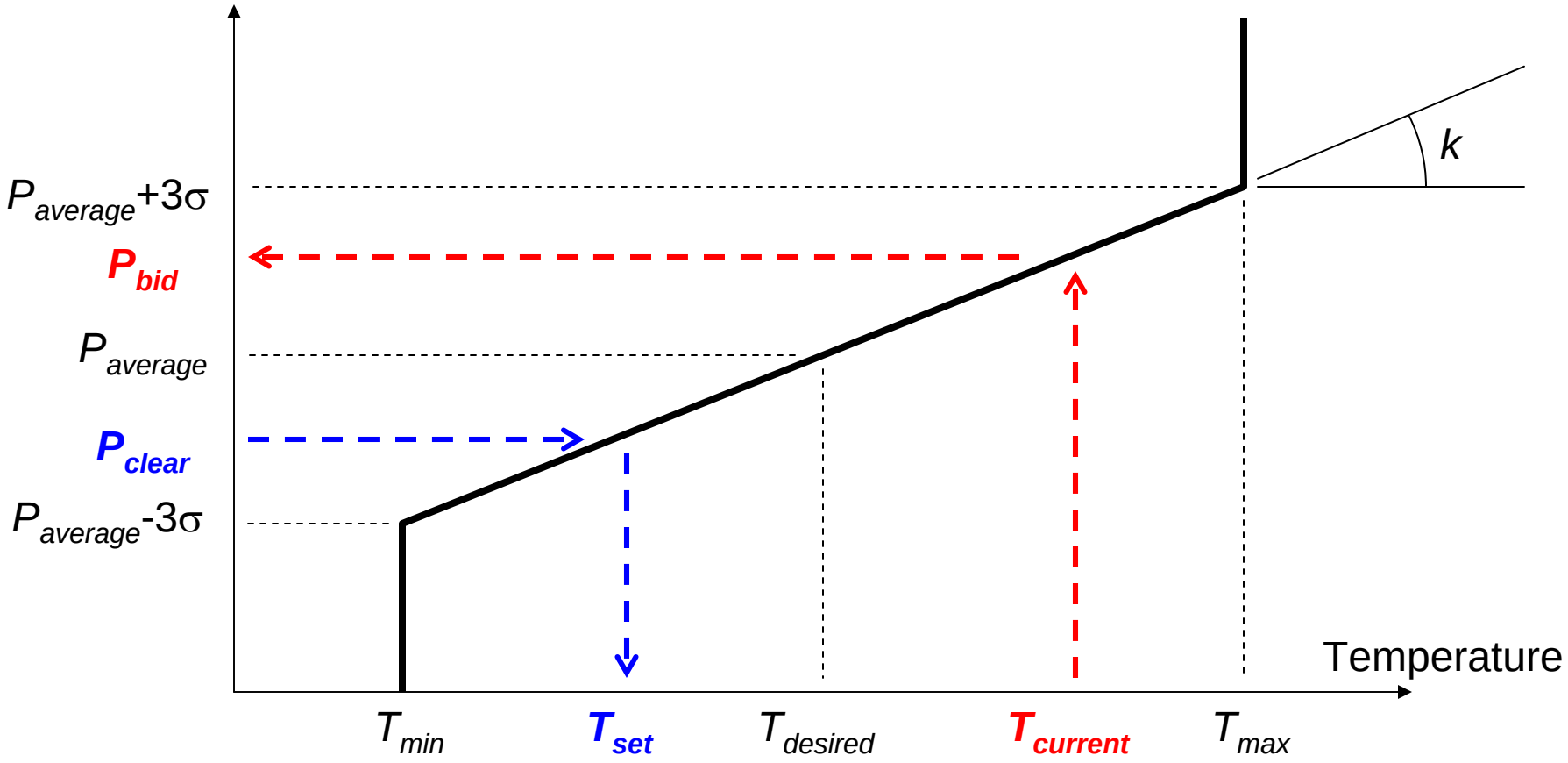






Pacific Northwest NATIONAL LABORATORY

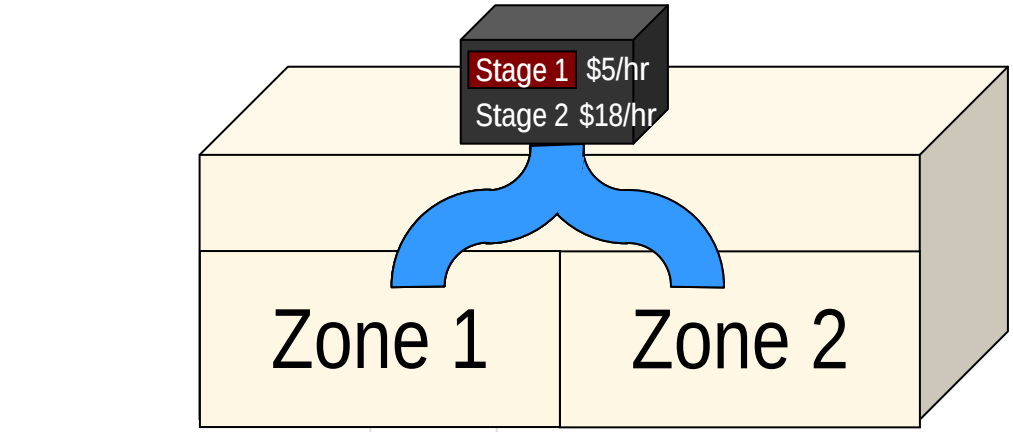
Price Based Controls for Thermostatic Devices

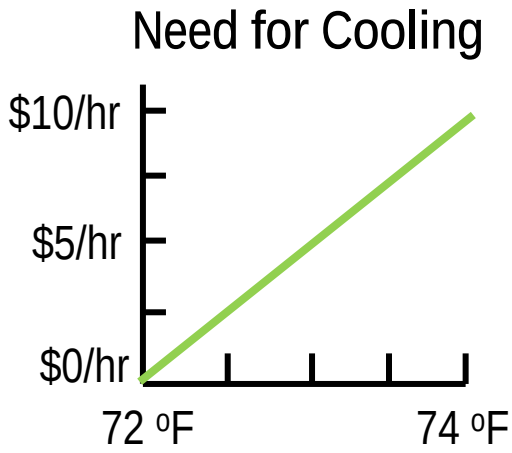


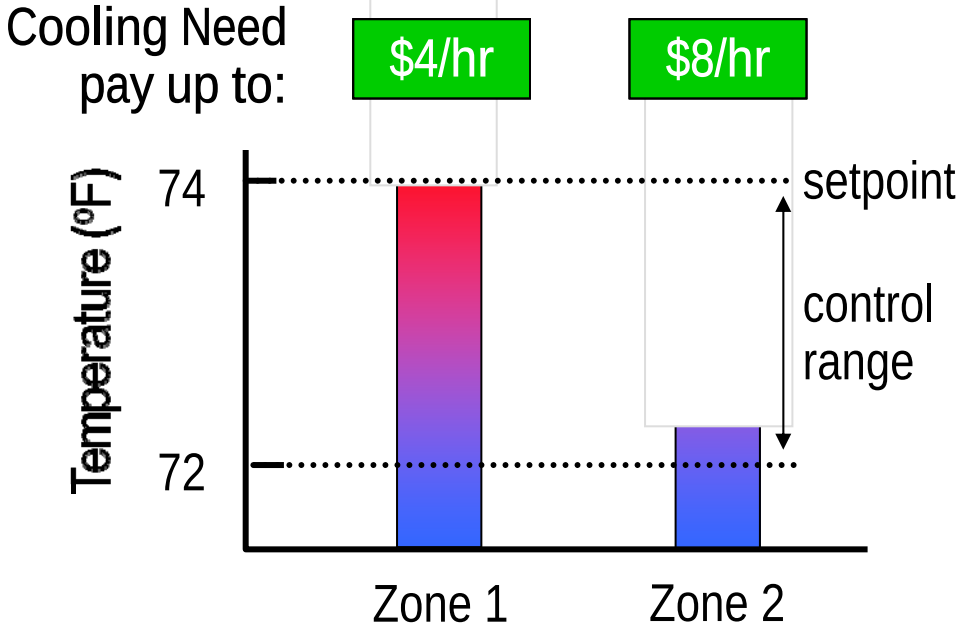
Small *k*: low comfort, high demand response

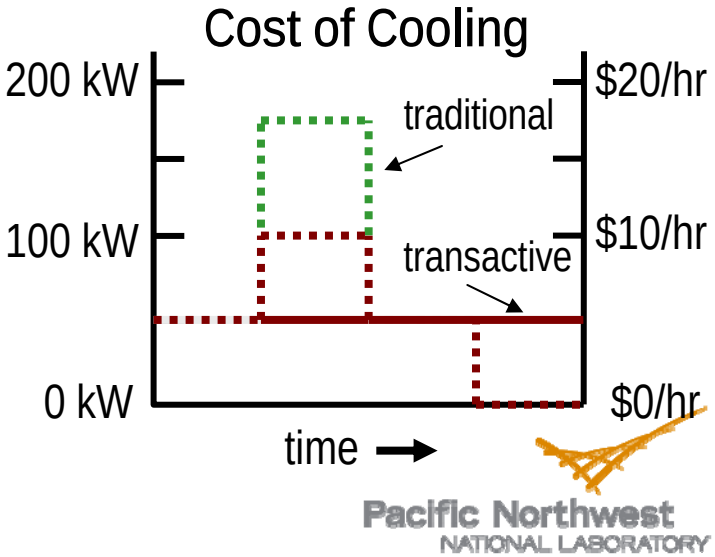
Large *k*: high comfort, low demand response

Transaction-Based Control — Relative Need Expressed as Willingness to Pay; Control System Minimizes Cost



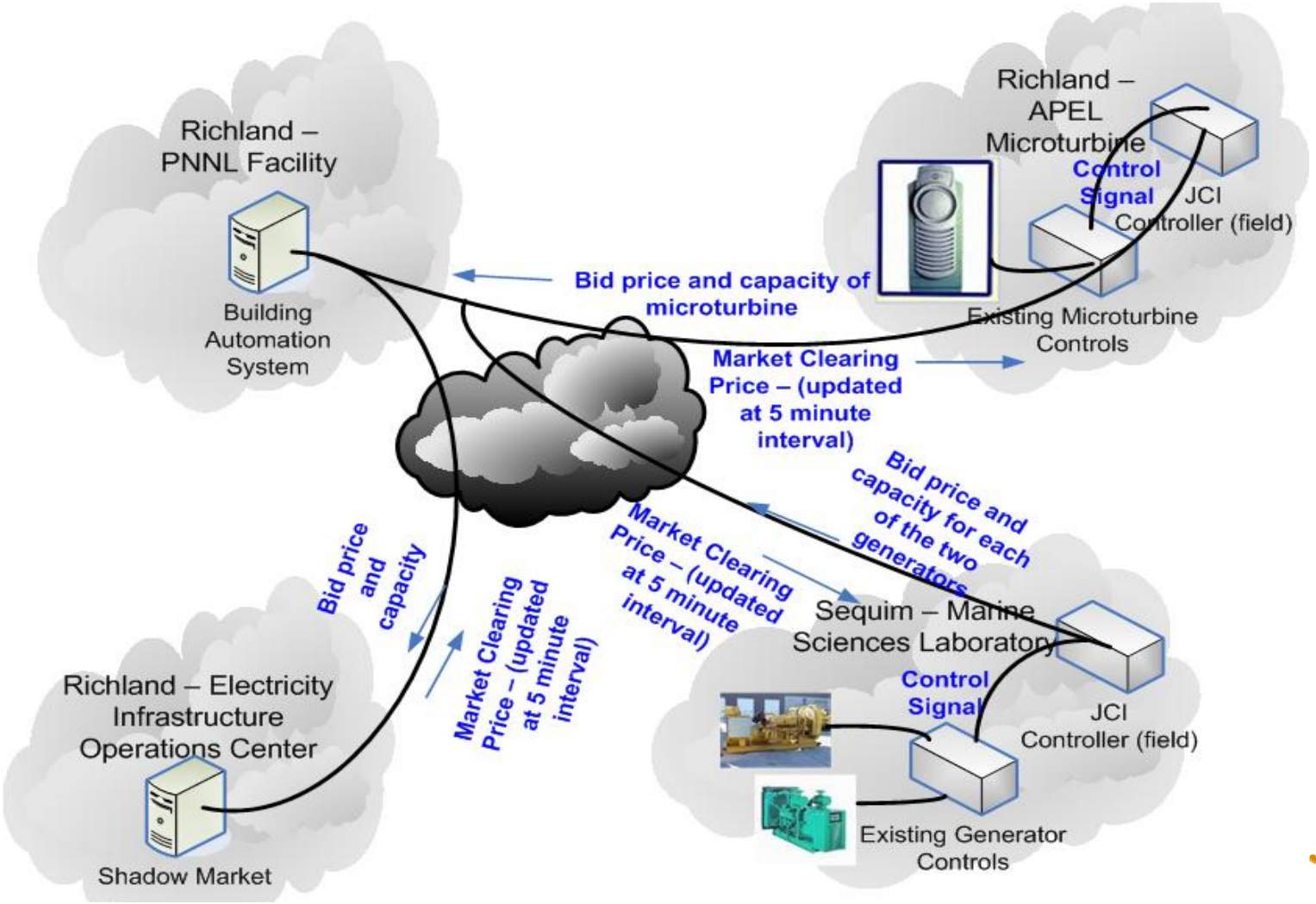






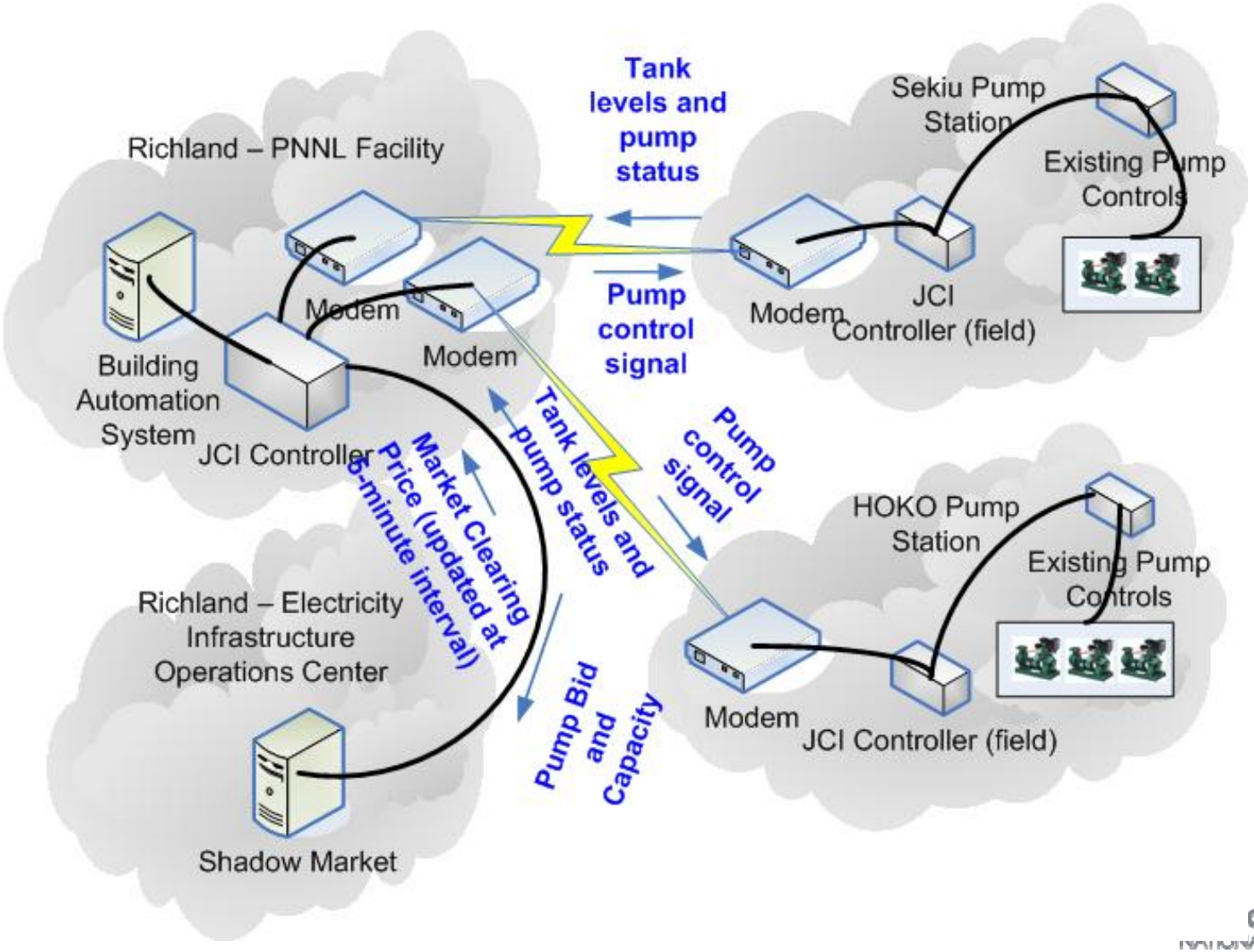
Pacific Northwest NATIONAL LABORATORY

Leveraging BAS to Bid Distributed Generation Assets Into Market



Pacific Northwest NATIONAL LABORATORY

Another Example: Pumps Bidding Into the Market



Summary

- Although capabilities of BAS have increased significantly over the past two decades, buildings still continue to operate inefficiently
- Lack of properly trained and skilled building operators appears to be one of the reasons for our inability to leverage BAS
- BAS, if used properly, can enhance building operations and also make buildings more demand responsive
- New technology and techniques are under development that will expand capabilities for using BAS to interact successfully with the changing electric power grid.

Additional Information

- http://energy-buildings.org (Main page)
- http://retuning.org (Large Commercial Buildings)
- http://largebuildings.org (Large Commercial Buildings)
- http://smallbuildings.org (Small Commercial Buildings)
- http://buildingenergyeducation.org (Outreach activities)
- http://gridwise.pnl.gov (smart grid activities)
- http://eioc.pnl.gov (other grid activities)