Battelle
The Business of Innovation

Transforming the Practices of Building Operation and Maintenance Professionals: A Washington State Pilot Program

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Scaling Up: Building Tomorrow's Solutions

Background

- State of Washington, Antitrust Division, investigated several energy companies concerning activity occurring during the 2000-2001 energy crisis
- Washington State Attorney General's Office decided to use a portion of recovered funds for R&D projects that would bring immediate benefit to the rate payers
- Battelle was selected for the commercial buildings work

Focus of the Work

- Battelle's work focuses in three areas:
  - **Large commercial buildings**
    - **Provide "re-tuning" training to HVAC service providers**
    - **Help them to continue to provide the services beyond the project**
  - Small commercial buildings
    - Deploy a low-cost smart monitoring and diagnostic system developed by PNNL in partnership with the U.S. DOE and NorthWrite Inc.
    - Train HVAC service providers in the installation and use of this technology to provide a new service for delivering energy savings to their customers
  - Small business and educational outreach
    - Target technicians currently working in the industry for near-term impact and
    - Introduce new curricula to technical schools in the State to train technicians of the future in this field

Large Commercial Buildings – Focus of the Presentation

- Approach
  - Recruit 5 to 10 companies that provide HVAC services to commercial buildings to deliver re-tuning services and to help recruit customers
  - Each of the selected service providers are required to recruit at least 6 buildings for re-tuning
  - Use 10 to 20 of the buildings as training grounds for hands-on training of the HVAC service providers on how to perform re-tuning
- Goal
  - Educate companies that large buildings can be re-tuned economically to save electricity
  - Teach the proper techniques and skills to perform re-tuning, and
  - Show that service providers can provide re-tuning as a service for a fee

Definitions (ours)

- HVAC Retro Commissioning
- HVAC Re-tuning
- HVAC Re-commissioning
- HVAC Continuous Commissioning
- All processes above in part relate to setting up control systems to some known design configurations, verifying set points and adding control algorithms

Purpose of Re-Tuning

- Improve the building's energy efficiency through low-cost and no-cost operational improvements (mostly control changes)
- Identify opportunities to further increase the building's energy efficiency
- Identify problems requiring physical repair
- Catch the big energy saving opportunities

What is Re-Tuning?

- 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

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Initial Information to Collect

- Overall building geometry
  - Approximate gross square feet
  - Number of floors
  - General building shape
- Type of HVAC system(s)
- Approximate number of zones
- Approximate number of each major type of equipment
  - Boilers
  - Chillers
  - Air handlers
- Type of building automation system (manufacturer, model, version)

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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

Steps for Trend Data Collection

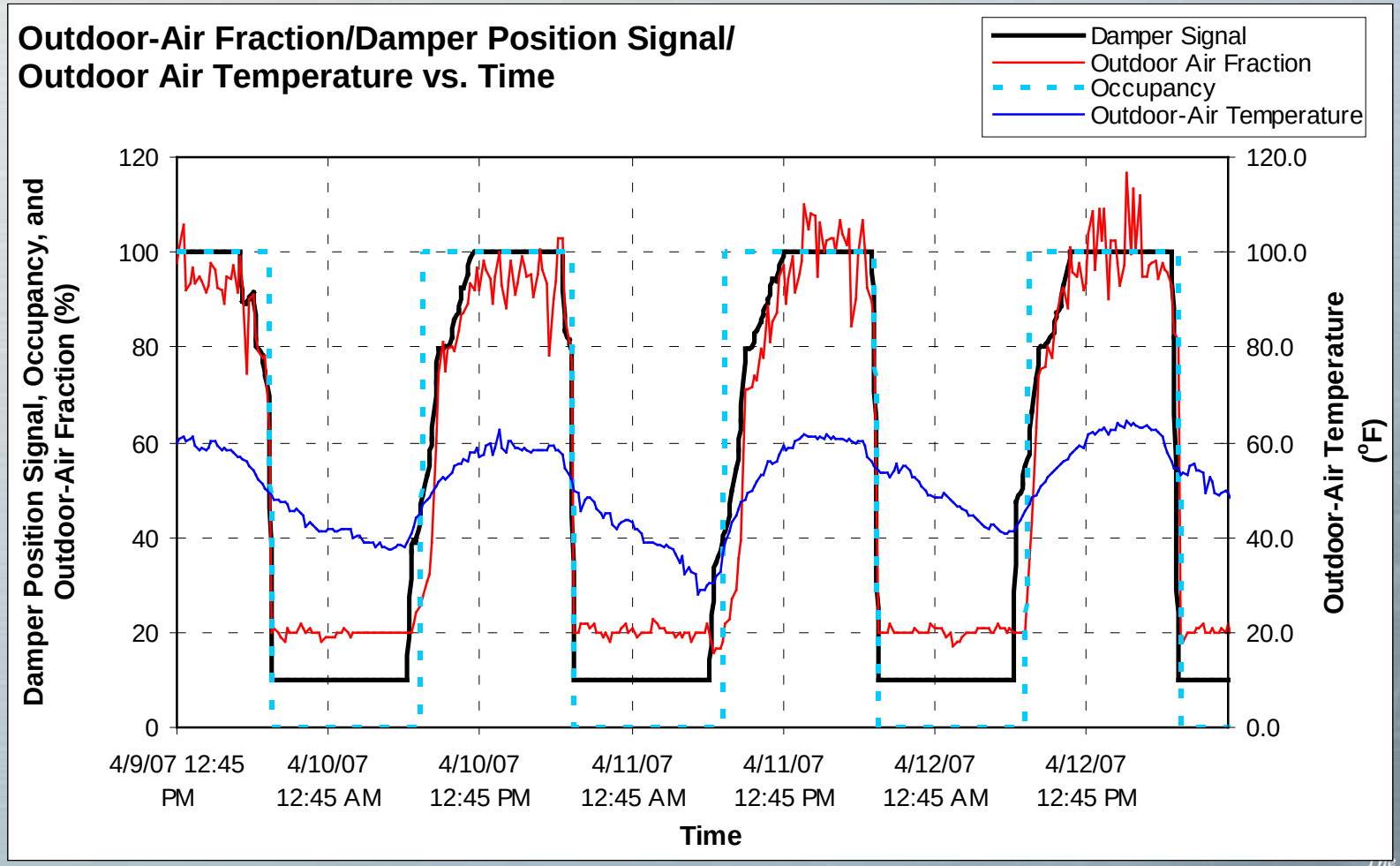
- Develop a monitoring plan – develop forms to guide service providers through this. Plan includes the points to trend and for each point:
  - Planned trend start time
  - Planned trend end time
  - Length of measurement period (2 weeks recommended)
  - Time interval between logged measurements (30 minutes or less recommended)
  - Measurement units (e.g., °F for temperature)
- Implement trend logs in control system

Analyze Trend Log Data – Major Steps

- Download trend log data files from BAS
- Format data files for compatibility with the spreadsheet analysis tool
- Open data files in spreadsheet analysis tool and automatically generate graphs
- Review graphs to identify operational issues
- Record operational issues for reference during re-tuning

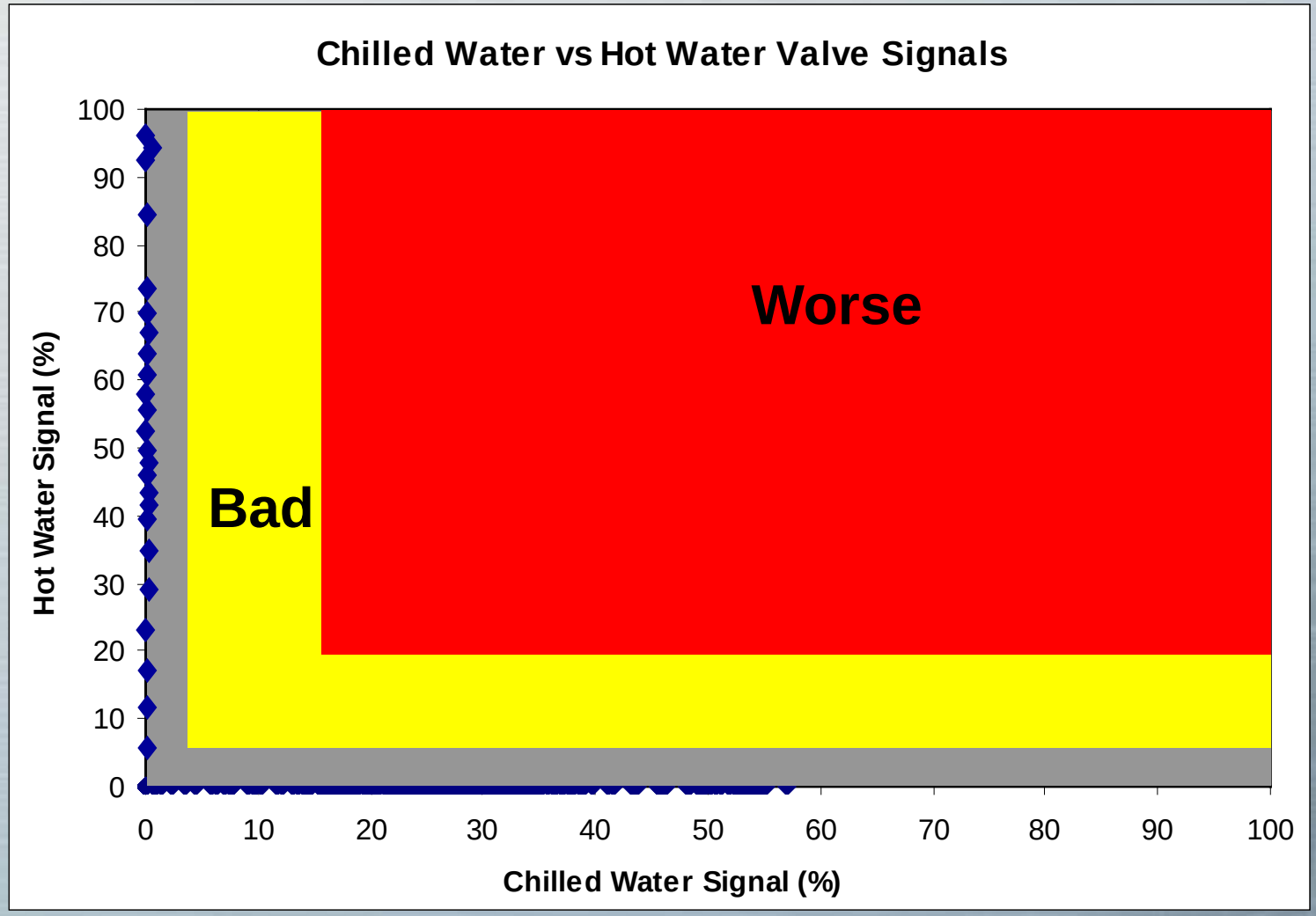
Minimum Outdoor-Air Operations: Example use of Graphs

- 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



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Building Walk Down: Purpose

- Get to know the building better
- Develop a general impression of:
  - Overall building condition
  - Overall building design
  - HVAC system design
- Collect some basic data on the building systems at a level of detail greater than the initial data collection

Building Walk Down: Major Steps

- Review electrical and mechanical prints
- Walk the outside of the building
- Walk the inside of the building
- Walk down the roof
- Walk down the air handlers
- Walk down the plant area
- Review the DDC system (BAS) front end

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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

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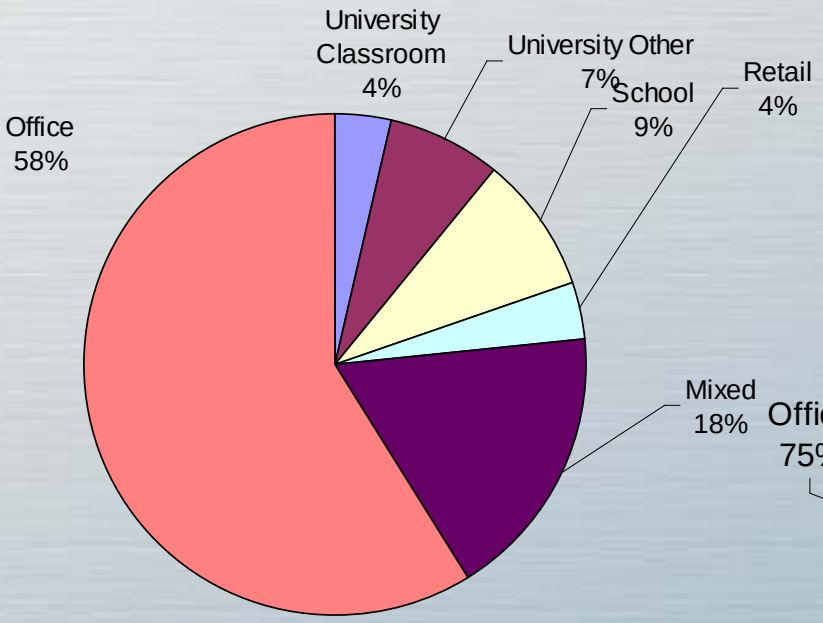
- **Post-Re-Tuning: Reporting re-tuning findings**
- **Savings Analysis: Determining and reporting the impacts**

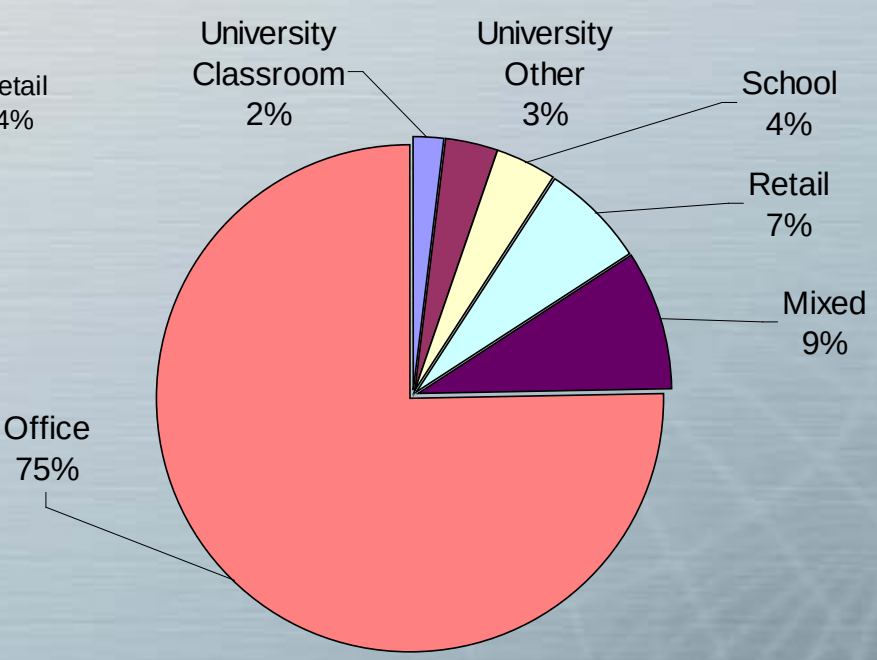
Progress Large Commercial Buildings

- Selection of Service Providers (complete)
  - Recruited 8 service providers
  - Positive reaction from all service providers
  - Service providers are excited to learn the re-tuning process and apply it to the selected buildings
- Selection of Regions and Buildings (completed)
  - Seattle-Metro, Tacoma, Olympia, Vancouver, Spokane, Blaine and Tri-Cities
  - Total 56 buildings – over 10M square feet

Distribution of Building Type by Number and Square Footage



Building Type by Percentage of Buildings (Total 56)



Building Type by Percentage of Floor Area (Total 10,247,387)

Preliminary Findings – Large Commercial Buildings

- 25 of 56 buildings have been re-tuned
- Battelle's re-tuning approach has found a number of "no-cost" and "low-cost" operational changes that could result in significant savings (>5% of the total consumption) in almost all buildings used for field training

List of Common Problems

Type	Problem	Number of Buildings
Controls	Systems running longer hours than needed	6
	Improper economizer operations	6
	Outdoor-air is not reset to zero during morning warm-up or cooling	5
	Optimal start/stop not working or not present	4
	Tight Dead-band (1^{o}F), causing excessive cycling between heating and cooling modes	3
	Building unoccupied during summer months, but all systems running during that period	3

List of Common Problems (cont.)

HVAC Systems	No chilled water or hot water reset	6
	Leaky valves	3
	Static pressure too high	2
	Exhaust fans on 24 x 7	2
	No static pressure reset	2
Building	Un-insulated chilled/hot water pipes or missing attic insulation	4
	Missing door/window seals	3
	Faulty sensors	2
Lighting	Some areas over lit	4
	Lack of occupancy sensors in common areas	3

Issues – Large Commercial Buildings

- One of the objectives of the large commercial buildings task is to document savings
  - Re-tuning approach has identified a number of “no-cost” and “low-cost” savings opportunities
- Many of the changes are taking a long time to implement
- 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

Measuring Impacts and Successes

- Widespread acceptance of these technologies will depend on electric energy savings and cost-effectiveness of the proposed solutions
  - We will determine electric energy savings impacts based on
    - reported problems and solutions
    - utility data (monthly kWh, weather data, and other important data) and submetered RTU electricity data
- Effectiveness of the service companies in providing the re-tuning is important to ensure that the benefits from this program continue beyond the initial demonstration
  - We will develop metrics to evaluate each technician's performance
  - Number of companies and technicians using the methods and installing the new technologies after participating in the program
- The long-term success of the program will depend on the rate and degree of market penetration of these technologies

Additional Easy to Remember URLs

- 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)

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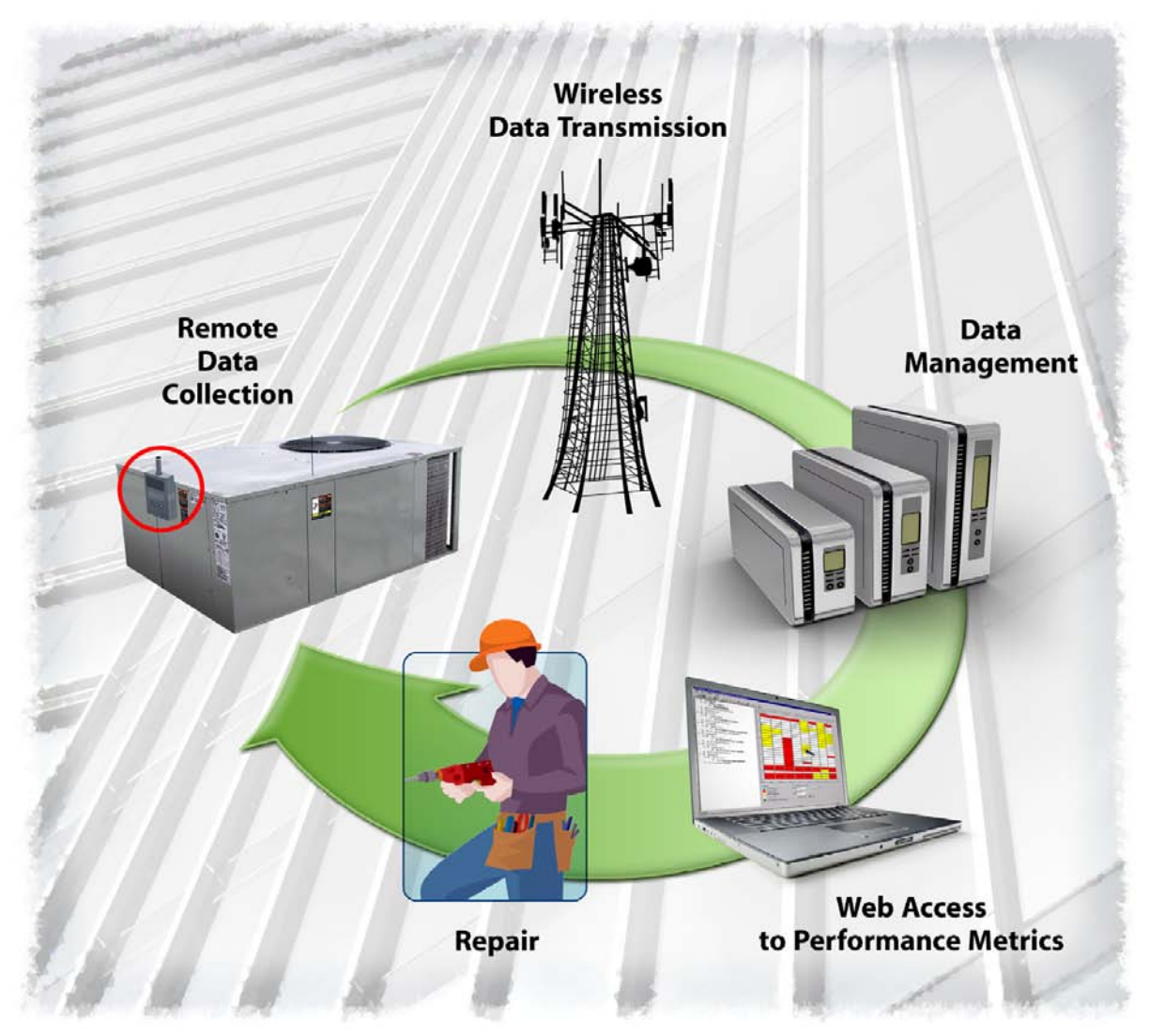
Backup Slides

Small Commercial Buildings

- Approach
  - Recruit 5 to 10 companies that provide roof-top unit (RTU) maintenance services
  - Work with service providers to deploy the technology in 5 to 15 buildings with a total of 30 to 40 roof-top units, while providing hands-on training on the technology to technicians
  - Train the service technicians on the use of the technology
  - Companies will then deploy the technology on 110 to 145 more RTUs (in 30 to 40 more buildings)

- Goal
  - Introduce a new technology that has potential to transform the condition of RTUs across the commercial buildings sector
  - Educate companies that cost-effective solutions for continuous monitoring and diagnostics can save electricity and money,
  - Teach companies and their technicians how to provide the service,
  - Show that this service can be provided successfully for a fee

Smart Monitoring and Diagnostic System



Outreach to Business and Educational Institutions

- Approach
  - Train HVAC service technicians in the methods and technologies tested and demonstrated in this project and in the general principles and practices of good energy management
  - Educate secondary and post-secondary students who have or may choose career paths related to the HVAC servicing or building energy management fields
  - Publicize the results of the project to other HVAC service provides who are not part of the training and to customers to encourage widespread adoption of these energy-saving methods

- Goal
  - To ensure lasting impact of the project on electricity savings in Washington, far beyond the time period over which the project is performed

Improving Efficiency of Washington Commercial Buildings - Windows Internet Explorer

http://buildingefficiency.labworks.org/

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Saving Electricity in the Pacific Northwest

Improving the Efficiency of Commercial Buildings

Commercial buildings in Washington are the state's fastest growing electricity-consuming sector, fueled by a decade of economic growth. The sector consumes about 36 percent of the entire state's electric energy at a cost of about $1.7 billion annually. Many experts estimate that between 10 and 30 percent of that electric energy is wasted because of inefficient operations, costing rate payers millions annually.


Large Commercial Buildings

Battelle's Pacific Northwest Division has initiated a multi-year project to help improve electric energy efficiency of commercial buildings throughout the state. Battelle will focus on changing the way heating, ventilation and air-conditioning (HVAC) systems in large and small commercial buildings are operated, serviced and maintained. Funding for the project comes from the Washington State Attorney General's Office as a result of a settlement concerning alleged illegal manipulation of electricity prices during the West Coast energy crisis of 2000-2001. A blue-ribbon panel of industry experts and legislators chose Battelle to receive funds made available to programs that benefit Washington residents and businesses.


Small Commercial Buildings


Outreach & Training

Battelle will be using innovative methods and technologies for capturing electricity savings that were developed, tested and proven during the West Coast power crisis of 2000-2001. These innovations typically reduce power use of HVAC systems by up to 20 percent and potentially

Internet 100%

Post-Re-Tuning: Calculating Energy Savings – Overview of Approach

- Calculated as the difference between the actual energy use in the post-re-tuning 12 months and the energy use that would have occurred during the same 12 months if the building had not been re-tuned.

$$E_{savings,j} = E_{base,j} - E_{actual,j}$$

$E_{savings,j}$ = energy savings for a specific building (j)

$E_{actual,j}$ = actual measured energy use of the building during the 12 months after re-tuning

$E_{base,j}$ = energy consumption of the building during the 12 months after re-tuning if it had not been re-tuned

Facility Manager Feedback

"The greatest benefit from this program has been the change in how the HVAC technician views the operation of the building. As a group our facilities staff is looking for ways to save energy and meet the needs of the tenants. They are "coming around" to the idea that the two demands, energy efficiency and tenant comfort, are not at odds with each other. This is a great step forward in operating our buildings more efficiently. As you know it is the human factor that has the most impact on building operations."

Resource Conservation Manager – Washington General Administration

"The opportunities look very good with *little cost* and effort ~ Steve and Ron [are] doing a great job with the field training, pointing out opportunities to save energy and operate the building more efficiently."

Chief Engineer – CB Richard Ellis (Group Health)