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Using Wireless Solutions to Lower Costs in HVAC Performance

Michael R. Brambley, Ph.D.
Energy and Environment Directorate
Battelle Pacific Northwest Division
Richland, Washington
michael.brambley@pnl.gov

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Why HVAC System Operating Efficiency is a Concern

- Systems run during unoccupied hours—nights, weekends, holidays
- Poor economizer operation
- Outdoor-air ventilation during morning warm-up or cool-down
- Incorrect “optimal” start and stop of HVAC systems
- Excessive equipment cycling
- Leaky valves
- Exhaust fans running continuously 24/7
- Faulty sensors
- High supply-air static pressure—excess air flow to zones, cold drafts, noise from diffusers, increased energy use
- Higher energy consumption and costs than necessary

Example HVAC Applications of Wireless Technology

- Four example applications of wireless technology for improving and maintaining the efficiency of heating, ventilating and air-conditioning systems.
  - Whole-building energy-use monitoring and fault detection
  - In-building condition monitoring
  - Wireless control systems
  - Remote monitoring and diagnostic system for packaged air conditioners and heat pumps

Whole-Building Energy-Use Monitoring - Energy Expert

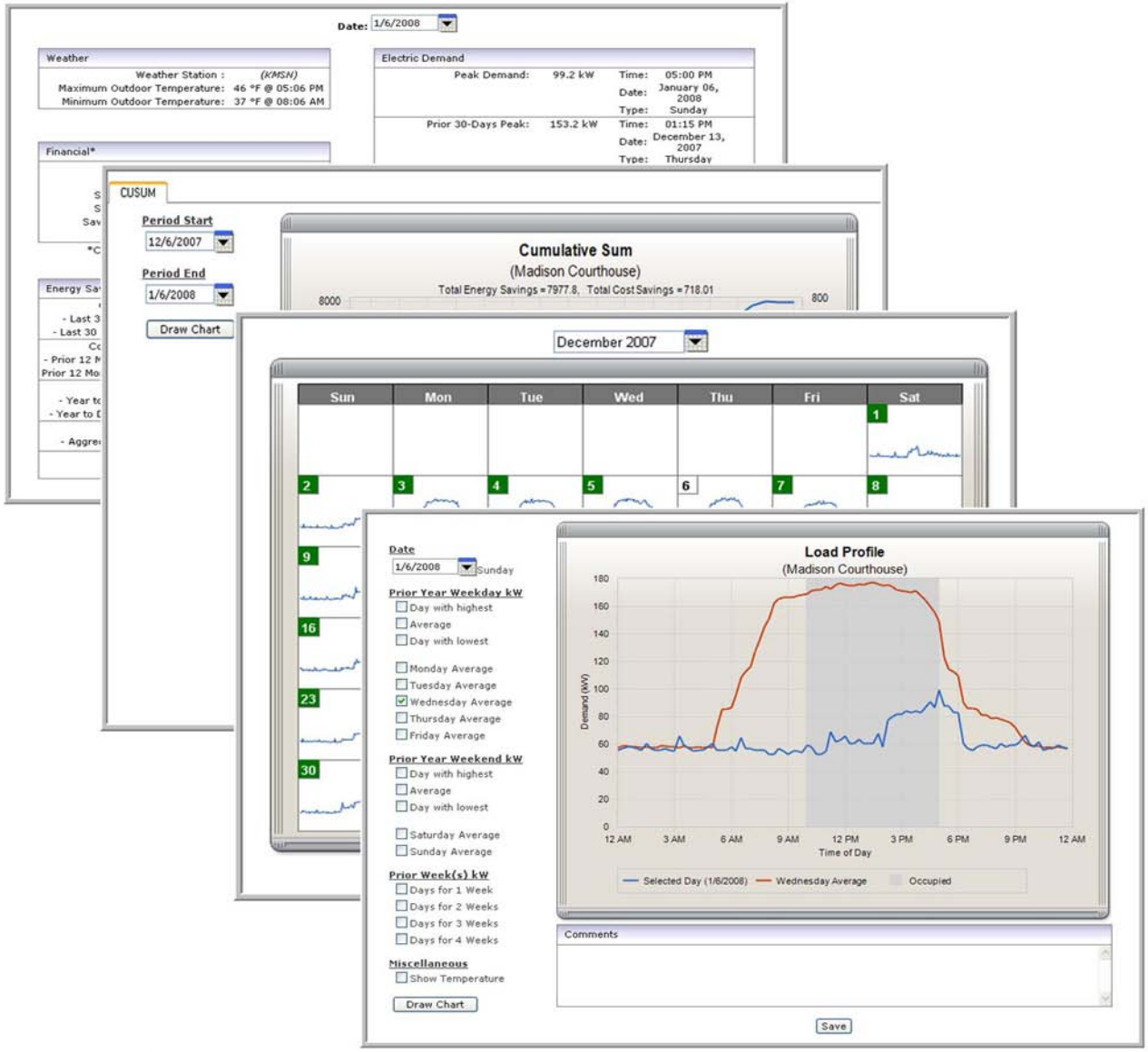
- *Energy Expert* is a commercially available energy-consumption tracking tool that uses a PNNL computational engine for tracking and detecting anomalies in whole-building and major system energy consumption

- Automatically constructs reference models of whole-building & major system energy use
  - controls for weather
  - controls for daily & weekly occupancy differences (schedules)
  - controls for other independent variables
- Detects by comparing actual to expected energy use
- Measures energy savings and energy waste

Whole-Building Energy-Use Monitoring - Energy Expert

Graphic courtesy of NorthWrite, Inc.

Whole-Building Energy-Use Monitoring - Energy Expert

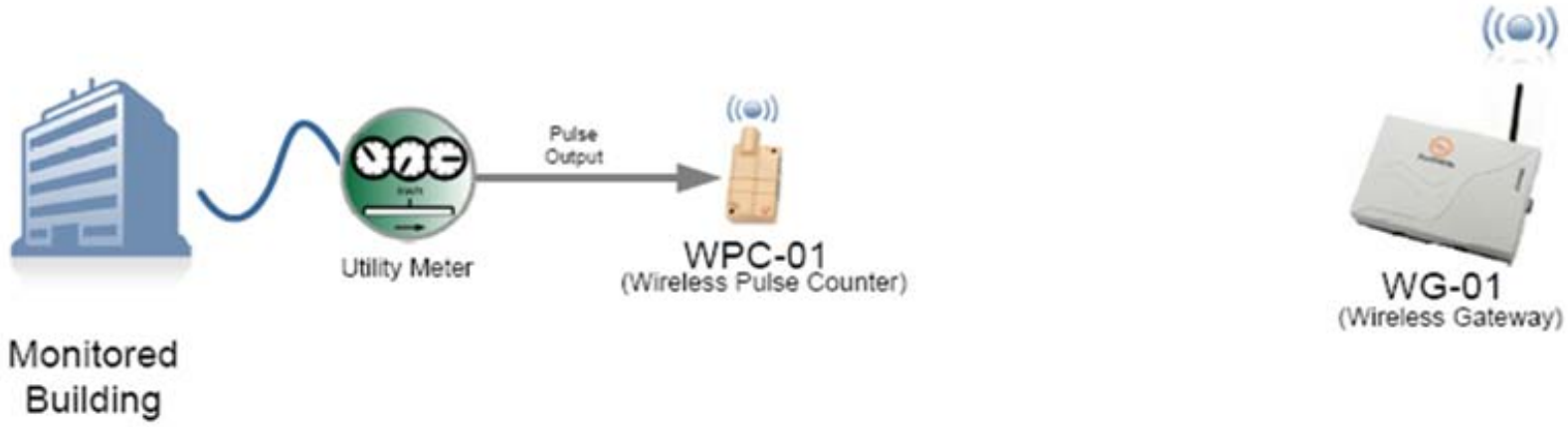


Graphic courtesy of NorthWrite, Inc.

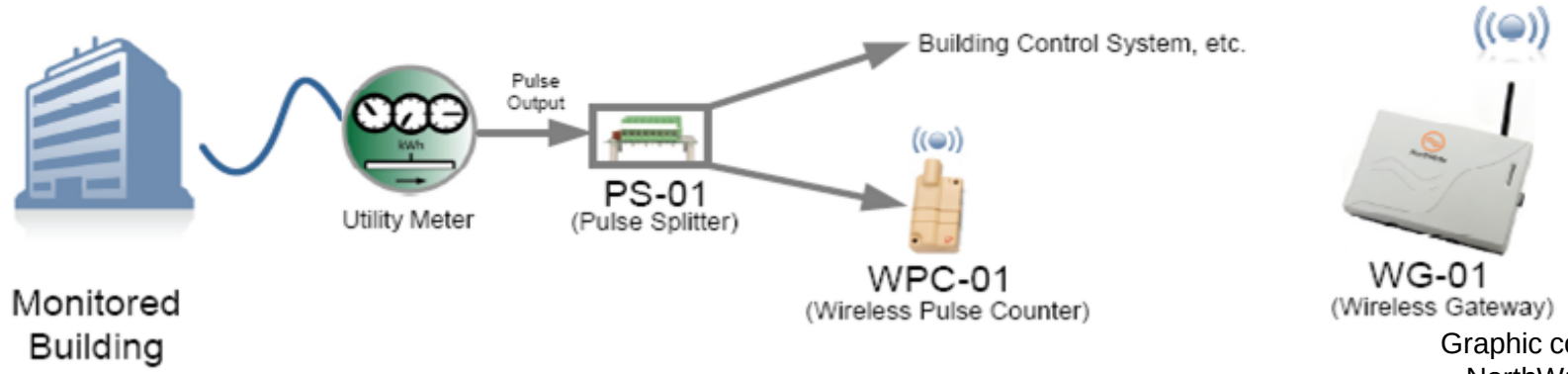
Whole-Building Energy-Use Monitoring

Three Typical Cases of Wireless Monitoring for Energy Expert

Case 1: Utility Provides Pulse Output



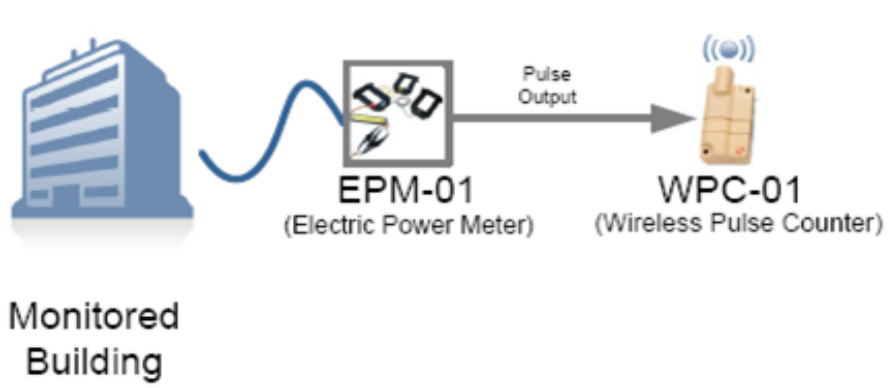
Case 2: Pulse Output Already In Use—Install Pulse Splitter and Share



Graphic courtesy of NorthWrite, Inc.

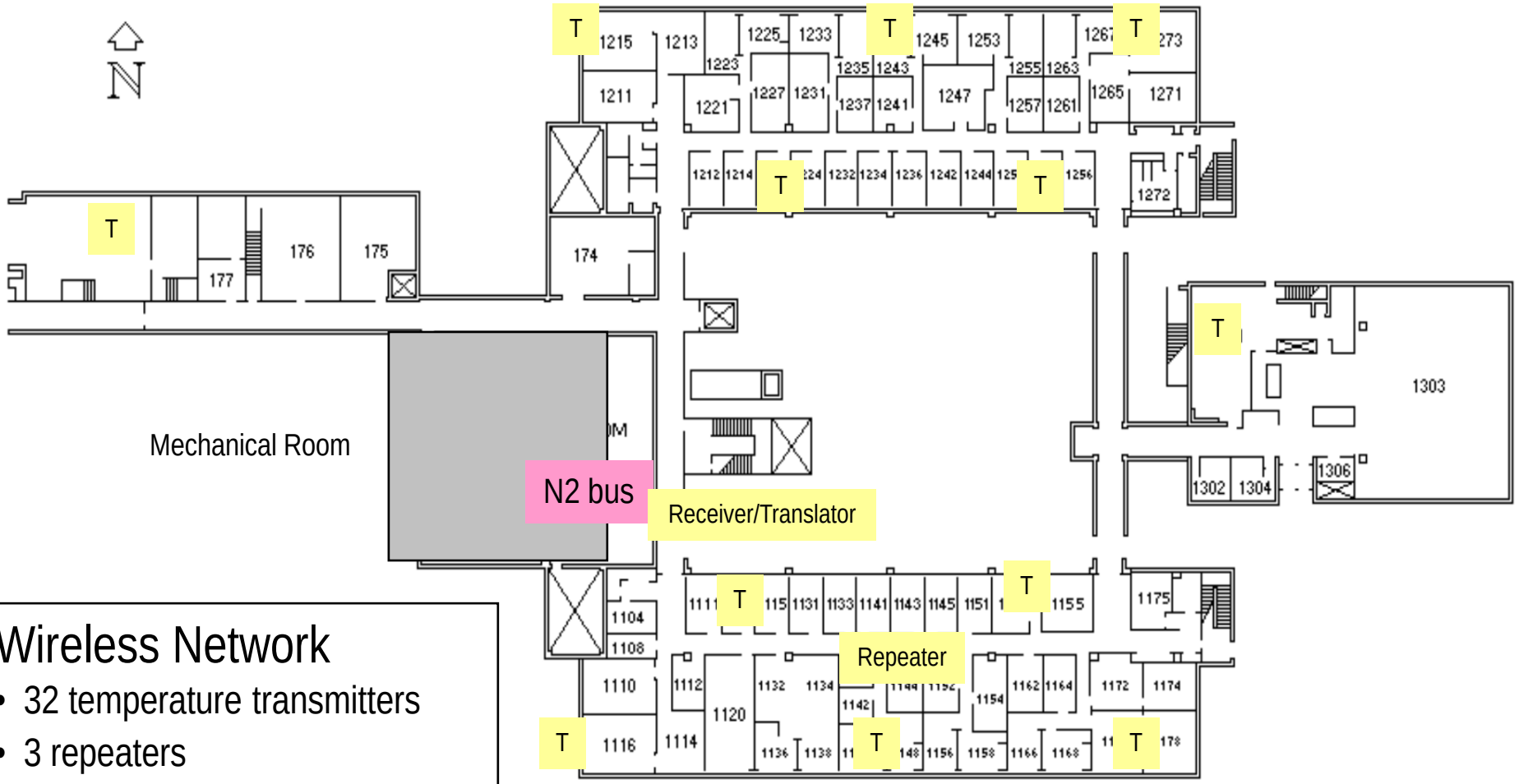
Whole-Building Energy-Use Monitoring

Case 3: No Meter is Available (or Submetered Load)



Graphic courtesy of NorthWrite, Inc.

In-Building Condition Monitoring



Wireless Network

- 32 temperature transmitters
- 3 repeaters
- 1 receiver/translator

In-Building Condition Monitoring Wireless Sensor Network Technology

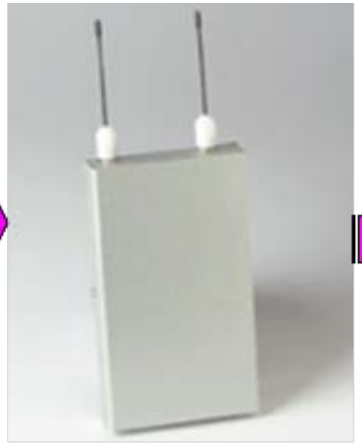
Temperature sensors with transmitters
battery-powered

Repeater

Receiver

Translator
from wireless to a BAS

BAS



- **900 MHz**
- **FHSS**
- **Range: 2500 ft.**
- **Battery life: 3 yr**
- **Sensor: RTD**

- **Line powered**
- **Range: 4 miles**

- **Up to 100 transmitters**

Impacts

- Greater occupant satisfaction – fewer space heaters
- Ability to diagnose hot and cold spots
- Operators implemented supply temperature reset

Wireless Control Systems

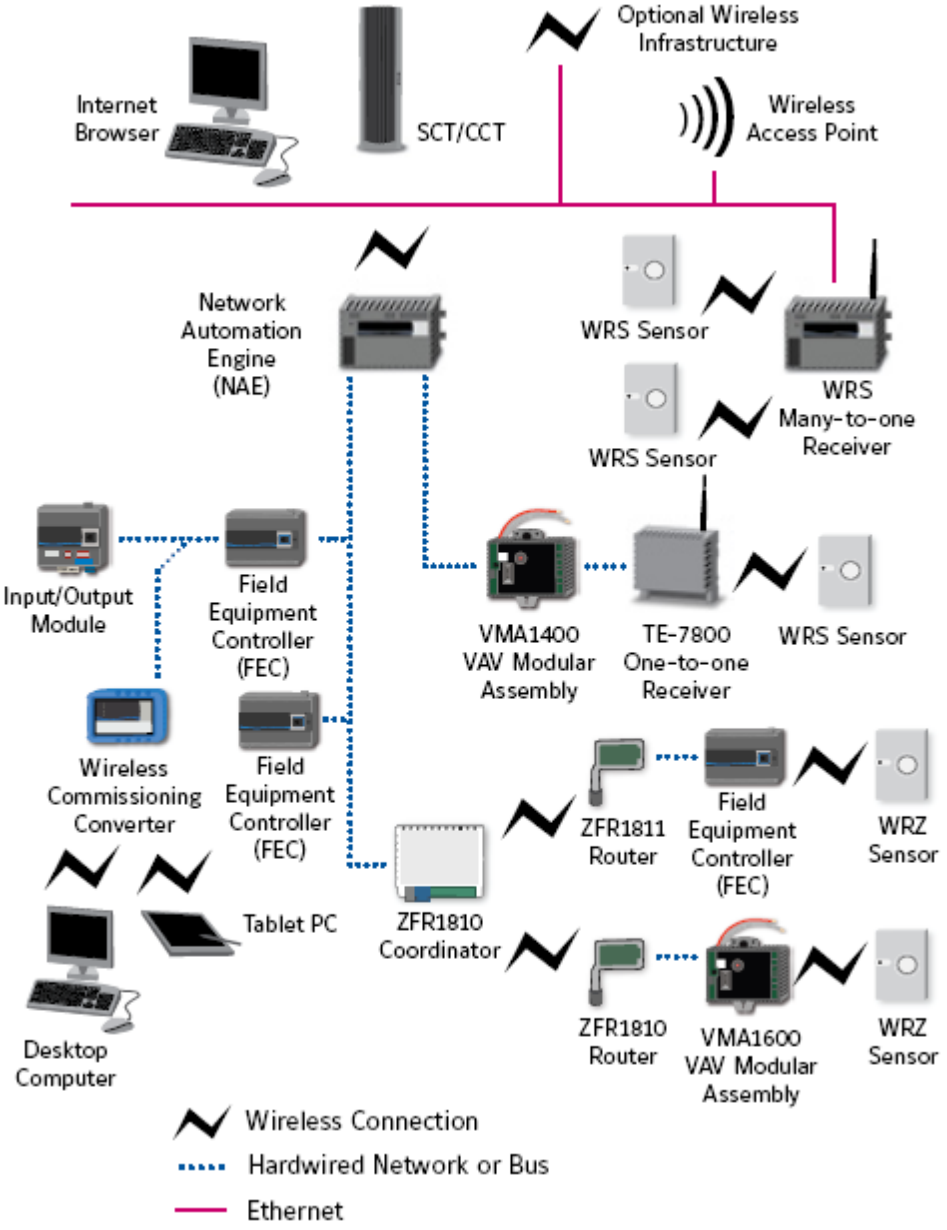
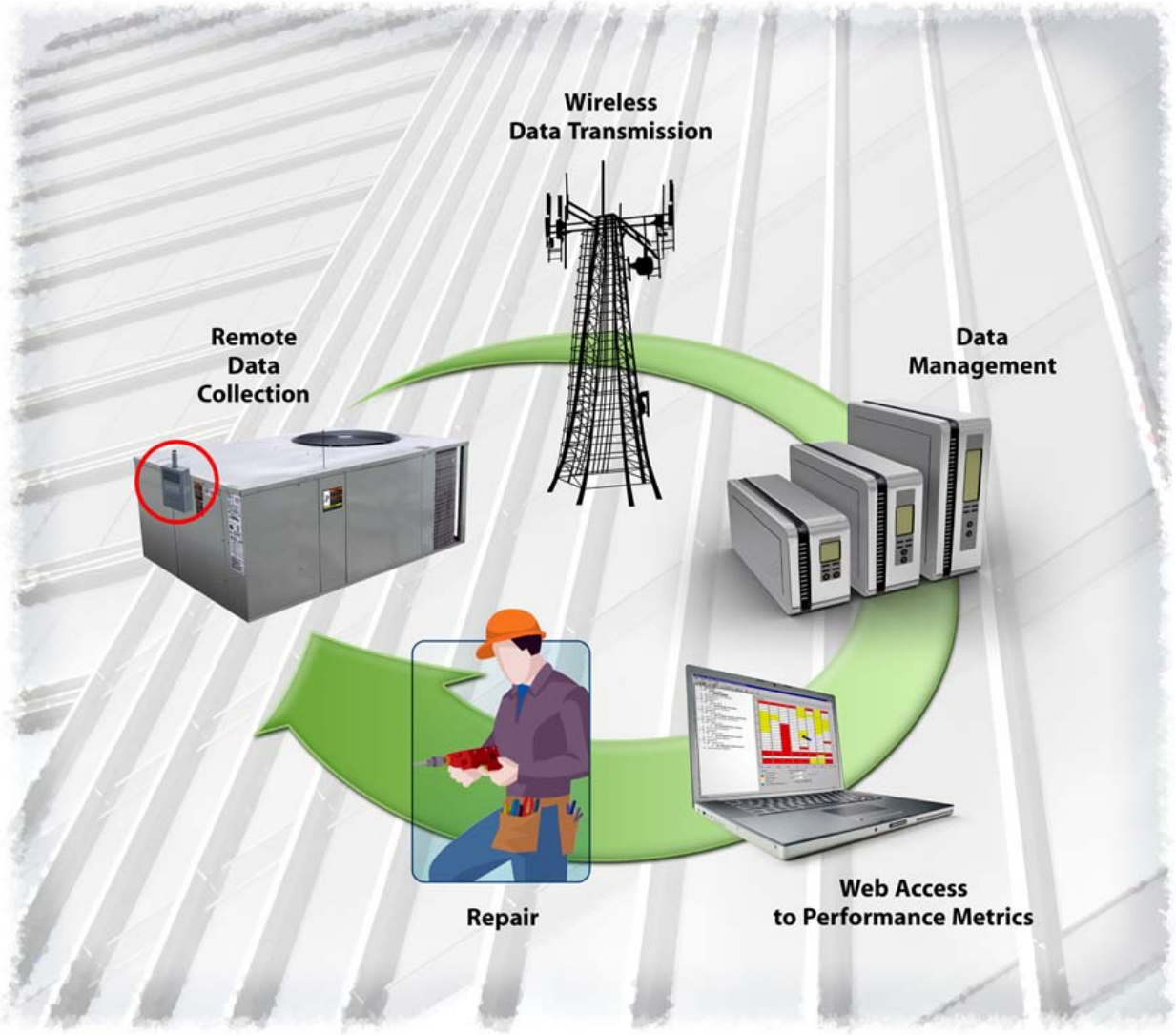


Diagram courtesy of Johnson Controls, Inc.

Smart Monitoring and Diagnostic System (SMDS) for Packaged Air Conditioners and Heat Pumps

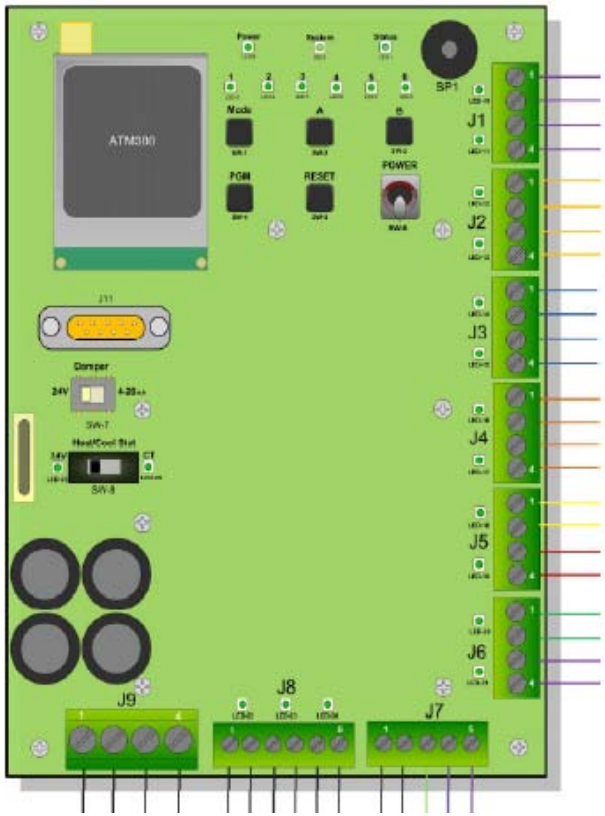


Diagnostics Provided

- Packaged HVAC Unit Air-Side Fault Detection and Diagnostics
- Packaged HVAC Unit Efficiency Monitor and Diagnostics
- Optional: Packaged Unit Refrigerant-Side Fault Detection and Diagnostics

SMDS Hardware

SMDS Circuit Board and Sensors



Thermistors
- outdoor air
- return air

Thermistors & humidity sensors
- mixed air
- supply air

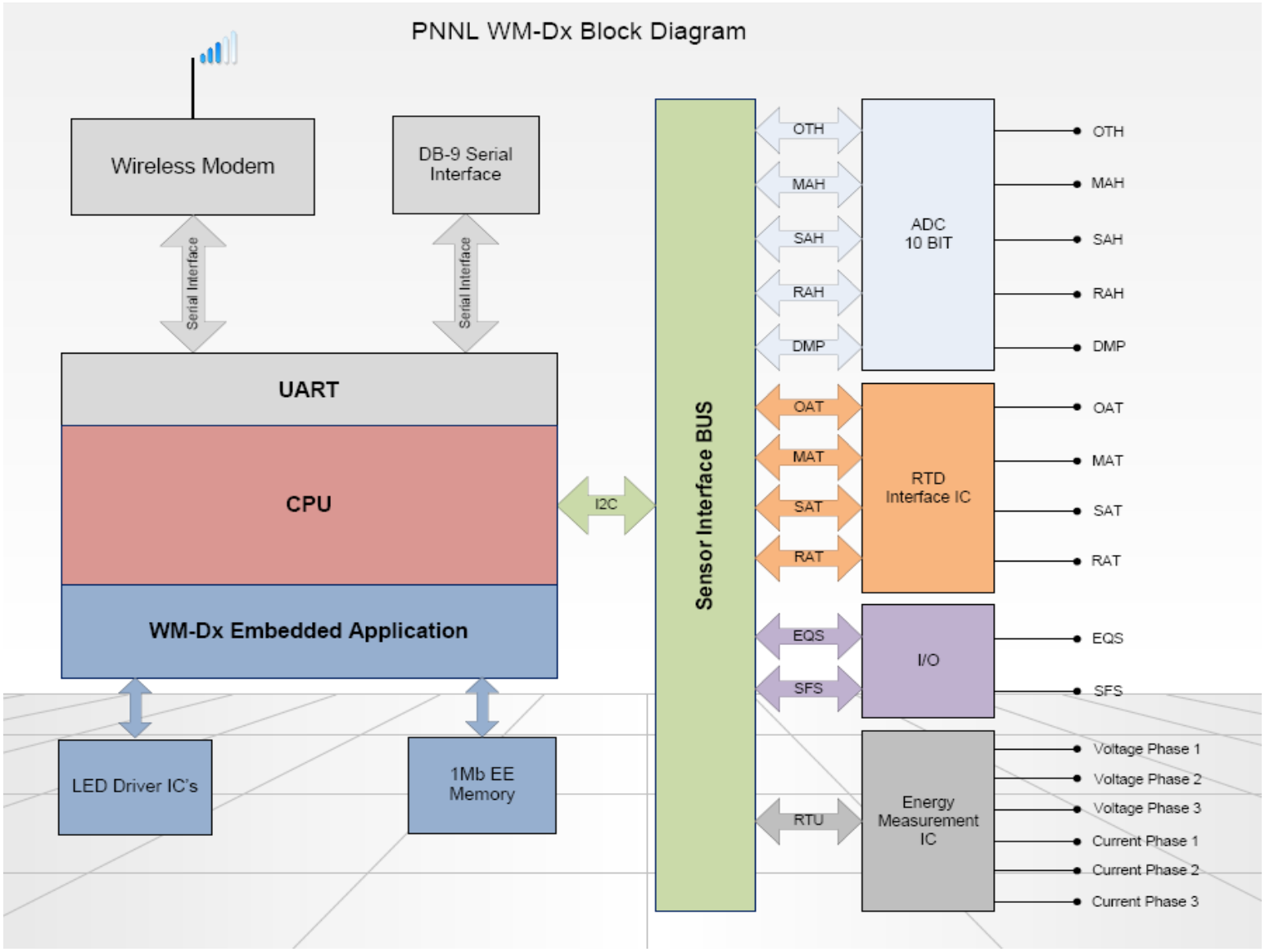
Current switch
- supply fan status

Direct connections
- heating/cooling status
- damper signal

Voltage taps and ground
- direct connections

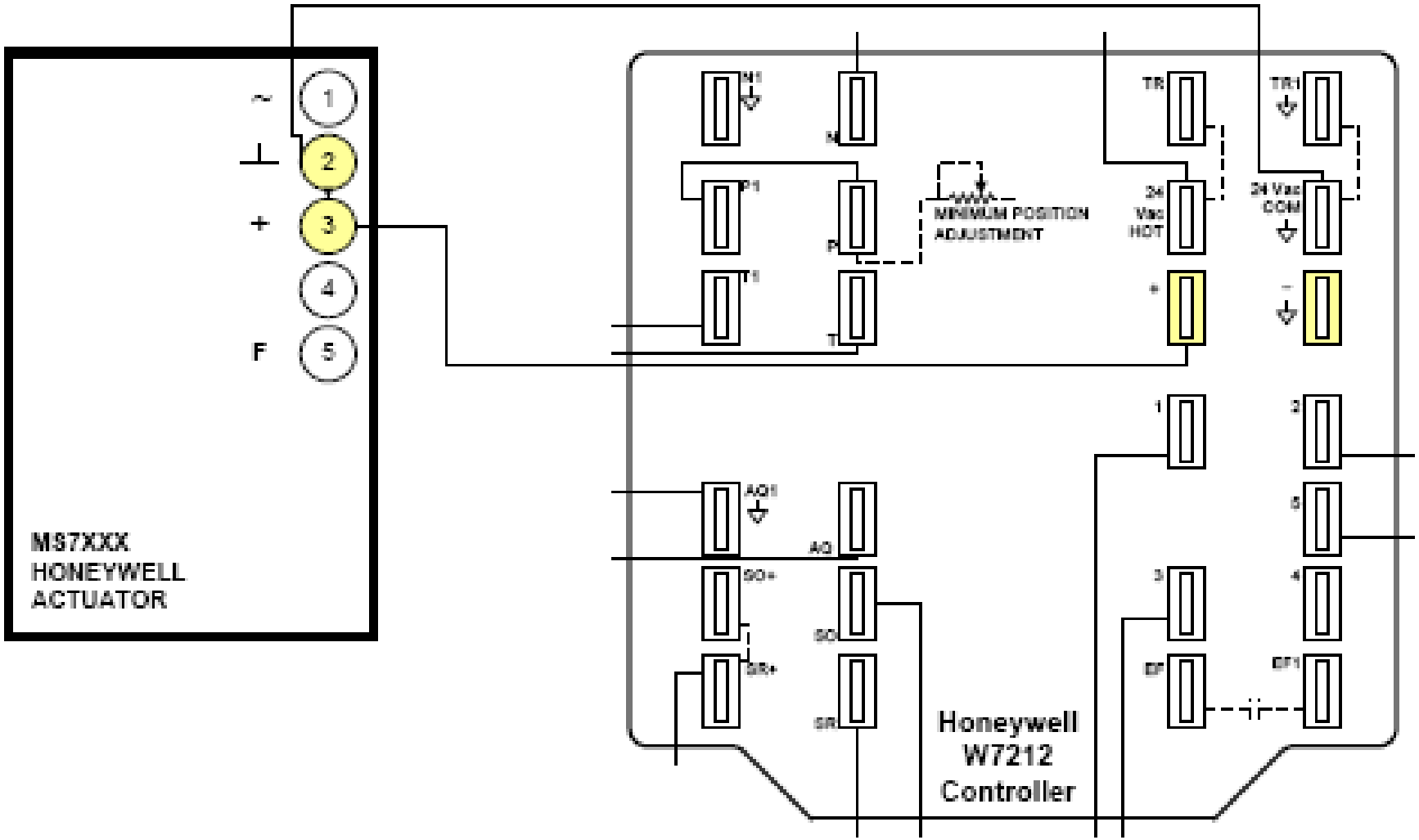
Current transformers

SMDS Major Components



Temperature and Humidity Sensors Installation

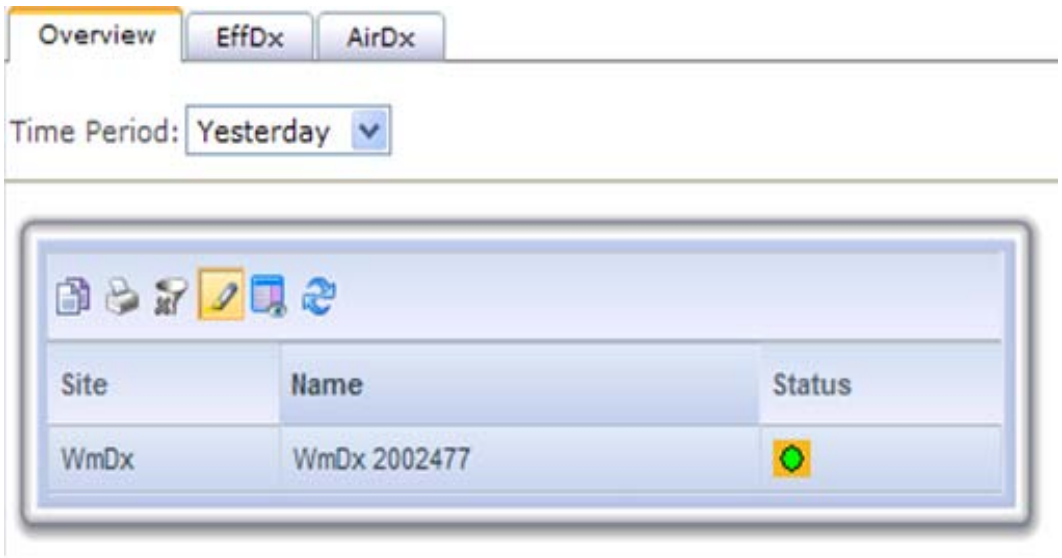
Damper Position Signal Example

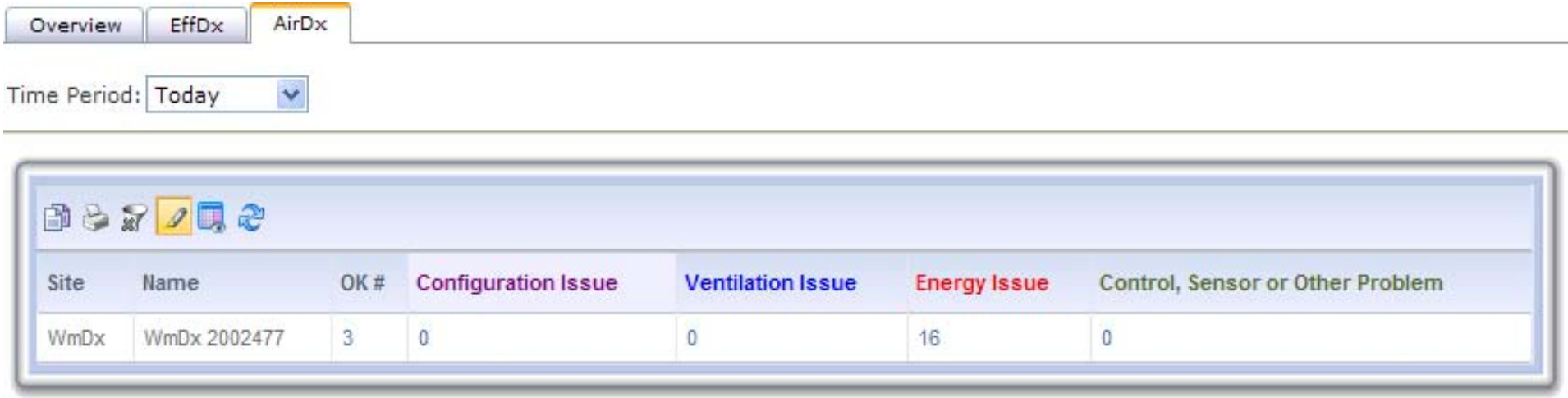


Diagnostic Algorithms

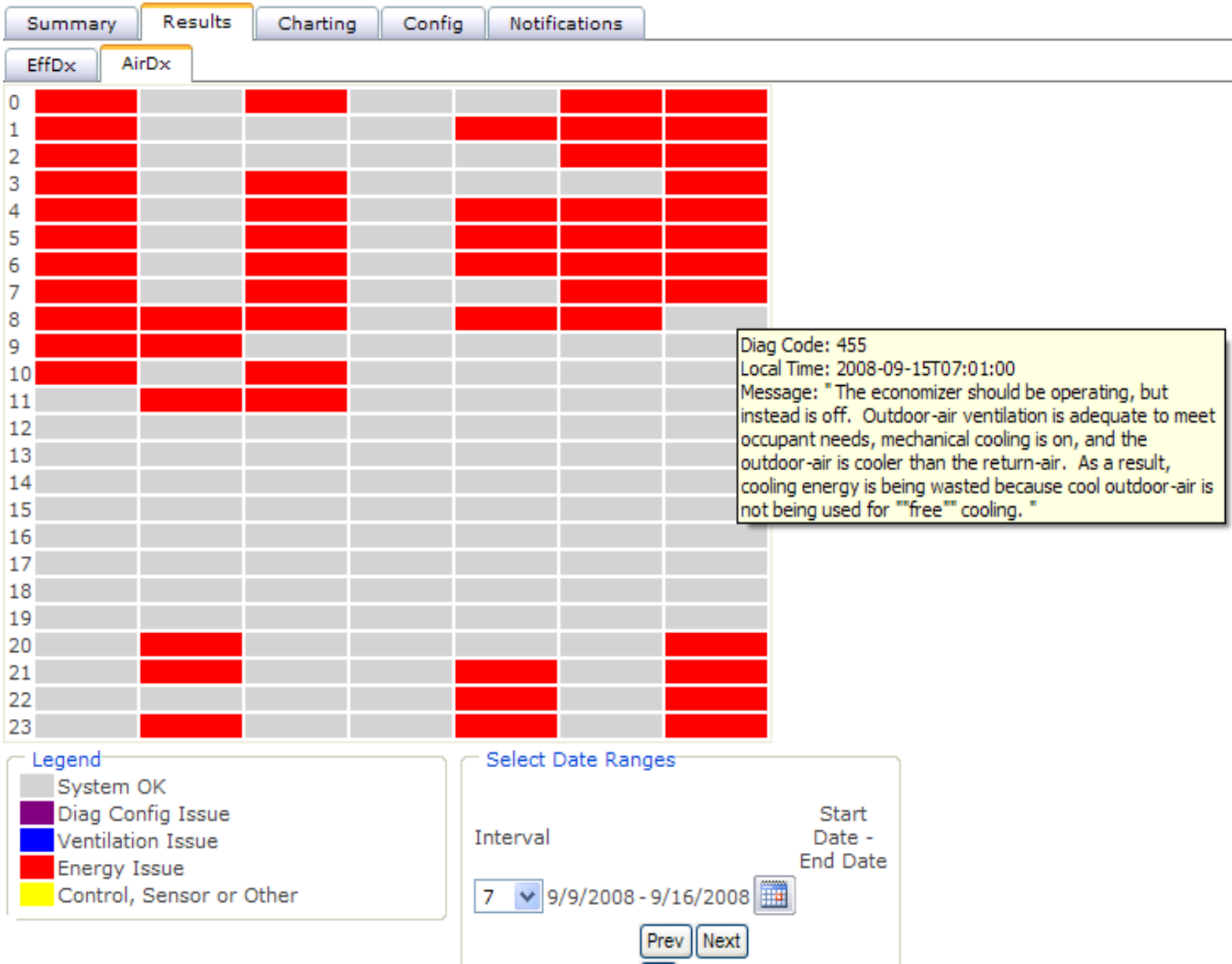
- Outdoor-Air Ventilation and Economizer Operation
  - Algorithms from Outdoor-Air Economizer Diagnostician (OAE) module of the Whole-Building Diagnostician (WBD)
  - Tested on many units with results published
  - http://www.buildingsystemsprogram.pnl.gov/fdd/wbd/index.stm for details and list of publications
- Efficiency Monitor/Diagnostician
  - Based on RTU power use and change in enthalpy of air across the cooling coil.
  - Rated air flow rate is used to calculate COP—looking for changes in cooling efficiency rather than accurate absolute value
- Refrigerant-side Diagnostics
  - Based on troubleshooting rules from Carrier Corporation. 1992. *General Training Air Conditioning II – Module Troubleshooting*.

Air-Side User Interface

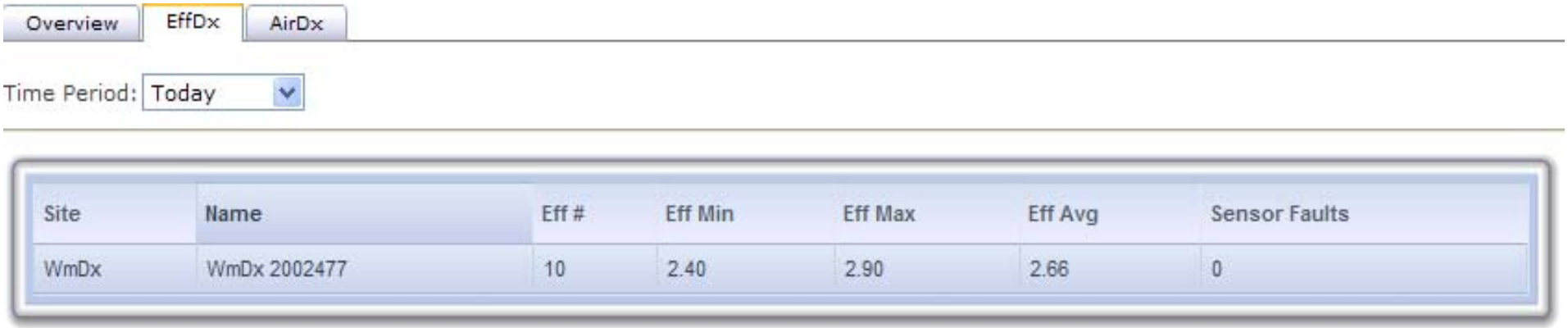




Air-Side User Interface – Graphic Hourly Results



Efficiency Monitoring/Diagnostics User Interface



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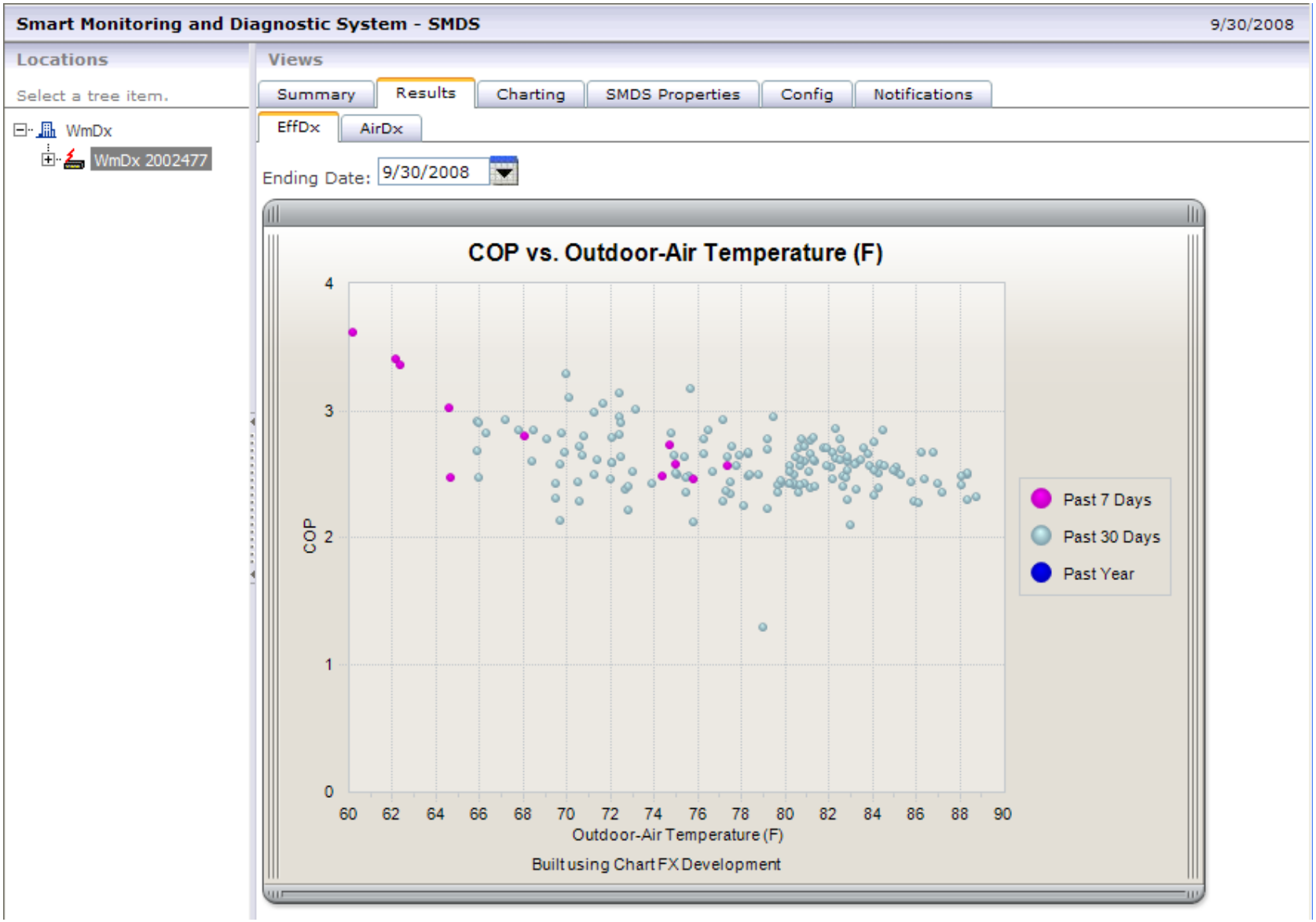

SMDS Potential Benefits

- Enable RTU maintenance based on actual operating condition of units (condition-based maintenance) rather than periodic preventive maintenance only or neglect.
- Enable rapid response to urgent service needs.
- Target technician time on units that need it most during a service call.
- Inform owners and service providers on degradation in unit efficiency to inform service decisions.
- Energy and cost savings to owners.
- More satisfied building occupants.
- Higher-level service offering for HVAC contractors.

SMDS Status

- Field testing on approximately 150 rooftop air conditioners and heat pumps in Washington State.
- Six HVAC contractors participating—east and west sides of Cascades.
- Collecting data for:
  - Time required for installation
  - Diagnostic performance
  - User perceptions
  - Service actions taken
  - Energy impacts
  - Impressions of users
- Installations in Fall 2008 and Spring 2009.
- Project completion in Fall 2010.
- Exploring development of lower-cost SMDS.

Thank you!