NASA Ames Saves Energy and Reduces Project Costs with Non-Invasive Retrofit Technologies

The Wireless Pneumatic Thermostat Enables Energy Efficiency Strategies, Ongoing Commissioning and Improved Operational Control

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NASA Ames Reduced Project Cost by Over 80% with Non-Invasive Retrofit Technologies

• Legacy Pneumatic Thermostats
  ➢ Waste energy
  ➢ High maintenance costs
  ➢ Uncomfortable occupants
  ➢ No visibility

• Project Scope
  ➢ 14 buildings
  ➢ 1,370 pneumatic thermostats
  ➢ Integration with campus BAS
  ➢ Diagnostics for ongoing commissioning

• Traditional DDC Retrofit
  ➢ Cost over $4.1 million
  ➢ Asbestos exposure/abatement
  ➢ Occupants significantly disrupted
  ➢ Project time: 12-18 months

• WPT Non-Invasive Retrofit
  ➢ Cost under $850 thousand
  ➢ No asbestos exposure/abatement
  ➢ Occupants not disrupted
  ➢ Project time: 3 months

OPTIONS

Before

After
70% of Buildings in North America Still Have Pneumatic Thermostats

- **Waste energy, more maintenance, unhappy occupants…**
  - No Night Setback, No Zone Control, No Optimal Start/Stop,
    No Occupancy Override, No Demand Response…

- **High Cost to Retrofit**
  - Market rate of $2,000 - $3,000 per zone
    for traditional DDC retrofit

- **Disruptive to Occupants**
  - Open walls and ceiling to run wires
    and change actuators
  - Exposure to Asbestos

*Retrofitting Existing Buildings is a PAIN IN THE NECK!!*
The Wireless Pneumatic Thermostat Enables DDC Zone Control in 20 Minutes without Disrupting Occupants

- Invasive DDC retrofit
  - Opening walls and running wire drive up costs
  - Asbestos disturbance
  - Many hours or days per thermostat
  - Occupants impacted

- Non-Invasive WPT retrofit
  - Leaving walls intact and not running wire keep costs low
  - No asbestos disturbance
  - 20 minutes per thermostat
  - Occupants not impacted

WPT Provides DDC Zone Control without Disruption

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
<th>Step 5</th>
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</thead>
<tbody>
<tr>
<td>Identify pneumatic thermostat type</td>
<td>Remove thermostat and backplate</td>
<td>Install WPT backplate to wall</td>
<td>Attach pneumatic pipes to WPT</td>
<td>Hang on wall and integrate with BAS</td>
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</table>
WPTs in 14 buildings at NASA Ames Integrated with Siemens Apogee Automation System

WPT System Communicates via BACnet/IP to 3rd party Building Automation Systems (e.g. Johnson, Honeywell)

Notes:

- Wireless Pneumatic Thermostat (WPT) System

BACnet interface compatible with:

<table>
<thead>
<tr>
<th>VENDOR</th>
<th>BAS</th>
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<tbody>
<tr>
<td>Alerton</td>
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<tr>
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<tr>
<td>Honeywell</td>
<td>Excel, Tridium</td>
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<td>Metasys</td>
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<td>Siemens</td>
<td>Apogee</td>
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<tr>
<td>TAC (by Schneider Electric)</td>
<td>Andover Continuum</td>
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<td>Trane Tracer Summit BCU</td>
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<td>Delta Controls</td>
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</table>
WPT Enables the Same Energy and Maintenance Benefits as Traditional DDC

Estimated Savings Potential
$635/year (per 1000 sq-ft)
Upfront Retrofit Cost: $600 (per 1000 sq-ft)
Payback Period: 11 months

Energy Savings
18-30% reduction in HVAC use
2500 kWh per year / 1000 sq-ft
$235/year @ $0.10/kWh

Maintenance Savings
3-6 hours/year per 1000 sq-ft
$400/year @ $80/hour

Temp Setpoint Policy
Retro Commissioning
Night/Weekend Setback & Occupancy Override
Duct Static Pressure & Supply Air Temp Reset
Deadband Temp Policy

Automatic Calibration
Faster Trouble-Shooting/On-going Commissioning
Reduced Tenant Complaints/Calls

10-15%
1200 kWh/yr
$115/yr
Source: Case Study
5-10%
600 kWh
$60/yr
Source: DOE2 eQUEST Modeling
2-4%
300 kWh
$30/yr
Source: Trane Application Note
3-5%
400 kWh
$30/yr
Source: Cypress Modeling

Note: All calculations based on 300,000 sq-ft retrofit project, $0.10 per kWh electricity rate, and $80 per hour maintenance labor rate.
The WPT’s Diagnostic Data Enable Ongoing Commissioning to Improve Maintenance Costs and Save Energy

### Diagnostic Data

<table>
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<tr>
<th>Alarm</th>
<th>Possible Faults</th>
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<tr>
<td>None</td>
<td>• None</td>
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<tr>
<td>Faulty Reset Velocity</td>
<td>• Faulty Reset Velocity Controller</td>
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<tr>
<td>Controller</td>
<td>• Stuck damper</td>
</tr>
<tr>
<td></td>
<td>• Broken spring</td>
</tr>
<tr>
<td></td>
<td>• Undersized cooling capacity design</td>
</tr>
<tr>
<td>Electric reheat and AC on</td>
<td>• Faulty Reset Velocity Controller</td>
</tr>
<tr>
<td>VAV Box Fault</td>
<td>• Electric reheat and AC on</td>
</tr>
<tr>
<td>Adjacent Zone Overcooling</td>
<td>• VAV Box Fault</td>
</tr>
<tr>
<td></td>
<td>• Adjacent Zone Overcooling</td>
</tr>
</tbody>
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### Graphs

- **Setpoint Temp**
- **Room Temp**
- **Branch Pressure**
Before and After Utility Data from the County of Santa Clara Quantify WPT Benefits

Realized Benefits and Payback Period

- Payback period: 16 months
- Energy savings: $42,000/year
  - 350,000 kWh per year at $0.12/kWh
- Demand Response: $7,500/year
  - 10,700 kWh per year at $0.70/kWh
- Maintenance Cost Savings: $156,000/year
  - Reduced over 50% due to diagnostic data

Actual Year-Over-Year Utility Data

1 Graph is based on actual PG&E billing data and reflects average kWh/day. The range shown is 15,000 to 20,897 kWh/day.

Non-Invasive Retrofit Technologies Save Energy and Improve Operations in Many Applications in Various Types of Facilities

<table>
<thead>
<tr>
<th>Typical Problems</th>
<th>Non-Invasive Solutions</th>
<th>Sample of Installations</th>
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<tbody>
<tr>
<td>Pneumatic Thermostats</td>
<td>WIRELESS PNEUMATIC THERMOSTAT</td>
<td>Government</td>
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<td>“Go from Pneumatic to DDC in minutes”</td>
<td>• Architect of the Capitol</td>
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<td>• VA Hospitals</td>
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<td>Leaking Steam Traps</td>
<td>WIRELESS STEAM TRAP MONITOR</td>
<td>Healthcare</td>
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Corporate
- Google
- Genentech
- InBev
- Texas Instruments
- Wells Fargo
- Fairmont Hotel

Commercial Real Estate
- Cushman & Wakefield
- Vornado
- Equity Office
- Shorenstein