# Innovative Demonstrations for Energy Adaptability
# QS-21 Wireless Pneumatic Thermostat Demonstration

## *Final Report*

***April 7, 2015***


## Objective of IDEAS Demonstration

Demonstrate ability of Wireless Pneumatic Thermostats to improve the control of heating in New York City Schools. By replacing existing legacy thermostats with Wireless Pneumatic Thermostats, the following benefits would be realized:

- Ability to implement setpoint setback during occupied hours – reduce unnecessary heating when zones are not occupied
- Ability to monitor operation of terminal units at each zone to detect and diagnose faults which may cause energy waste or discomfort to occupants

## Overview of Demonstration

All 69 legacy pneumatic thermostats at QS-21 were replaced with Wireless Pneumatic Thermostats in the summer of 2014. Since QS-21 only had heating and no cooling, data collection started only when heating season started in November 2014.

The Wireless Pneumatic Thermostats controlled the hot water valves which control space heating. Energy savings would be realized via improved control of heating setpoints which would lower hot water consumption. Since QS-21 does not have hot water usage meters installed, it was not possible to directly measure the hot water savings. Instead, savings will be manifested through reduced consumption of fuel oil by the boilers vs. prior years (adjusted by degree days for year-on-year comparison).

## Interim Findings

We compared the current heating season fuel oil consumption vs. prior year, and adjusted for heating degree days. QS-21 realized a reduction of 20% in fuel oil consumption (Figure I), which we attribute to the WPT savings strategies since no other material changes occurred to affect fuel consumption.

*Figure I – Measure Fuel Savings at QS-21*

| 2013-2014 Heating Season | | | 2014-2015 Heating Season | | | Difference | |
|---|---|---|---|---|---|---|---|
| Month | Fuel Consumption (gal) | Heating deg days | Month | Fuel Consumption (gal) | Heating deg days | Unadjusted | Adjusted for deg-days |
| Nov-13 | 3,913 | 577 | Nov-14 | 2,443 | 579 | -38% | -38% |
| Dec-13 | 4,449 | 826 | Dec-14 | 3,310 | 752 | -26% | -23% |
| Jan-14 | 7,169 | 1,123 | Jan-15 | 5,860 | 1,086 | -18% | -18% |
| Feb-14 | 6,334 | 938 | Feb-15 | 5,912 | 1,136 | -7% | -8% |
| **Total** | **21,865** | **3,464** | **Feb-15** | **17,525** | **3,553** | **-20%** | **-20%** |

We were able to observe the behavior of the thermostats to see whether they were able to execute the setpoint setback and fault detection functions. We took one week of data from January 5th through 9th (a relative cold period in NYC – see Figure II for weather data).

All of the thermostats were programmed for occupied and unoccupied schedules. Typical zone schedule is:

Occupied:

- 7am to 4pm on weekdays
- 70 deg F setpoint

Unoccupied:

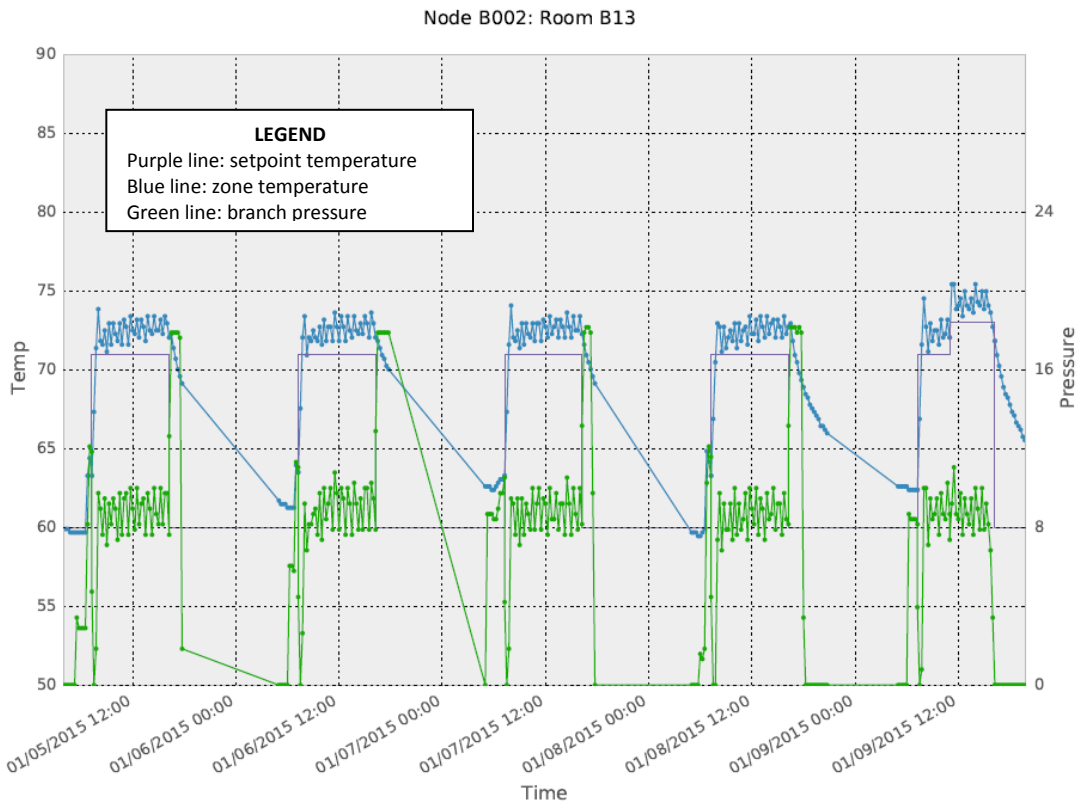
- 4pm to 6am and weekends
- 60 deg F setpoint

Note: that the building boilers and pneumatic compressors were shutdown between 6pm and 4am on weekdays. During this shutdown period, the entire system is off and the Wireless Pneumatic Thermostats did not provide any control. For the purpose of this demonstration, we focused on the time periods where the Wireless Pneumatic Thermostat control is active.

*Figure II – Outside Temperature Data for January 2015*


Of the 69 thermostats installed, 52 units controlled temperature per the scheduled setpoints i.e. completely normal function. For these units, the space temperatures showed a reduction during unoccupied periods – a clear indication of lower heat consumption. Figure III shows a typical plot of the data captured from one Wireless Pneumatic Thermostat which indicate correct function: the setpoints follow the programmed schedule, and the zone temperatures follow the setpoints. The branch pressure is also operating normally to control the hot water valve to regulate the space temperature.

*Figure III – Typical Wireless Pneumatic Thermostat Zone showing proper control*




For the remaining 17 zones, the Wireless Pneumatic Thermostats detected likely equipment faults which prevented them from controlling the zone temperature properly:

- Two zones had insufficient heating:
    - Despite a low branch pressure output from the Wireless Pneumatic Thermostat (i.e. hot water valve fully open), the space temperature was unable to reach the setpoint (see Figure IV for typical case).
    - This may be due to the heating valve stuck in a closed or partially closed position, and may need to be repaired or replaced.

- Fourteen zones had too much heating:
    - Despite a high branch pressure output from the Wireless Pneumatic Thermostat which is fully closing the hot water valve, the space temperature is above the setpoint (see Figure V for typical case).
    - This may be due to the heating valve stuck in an open position, and may need to be repaired or replaced.

- One zone had low/no supply air pressure:
    - Without supply air pressure, the Wireless Pneumatic Thermostat is unable to operate properly.
    - This may be due to a broken or leaking pneumatic line supplying the air pressure, and would need to be repaired or replaced.

Figure VI shows a summary of which zones exhibited which behavior. The data also shows that 11 zones had pneumatic calibration which were slightly off, which resulted in a 1-2 degree temperature offset from the setpoint. This may be the result of slightly different valve spring constants at that zone, or slight deviation during the calibration process. In any case, Cypress Envirosystems recommends that the Wireless Pneumatic Thermostats for these zones be recalibrated to tighten the temperature control (a process which only takes two minute per zone).

*Figure IV – Typical zone with insufficient heating*

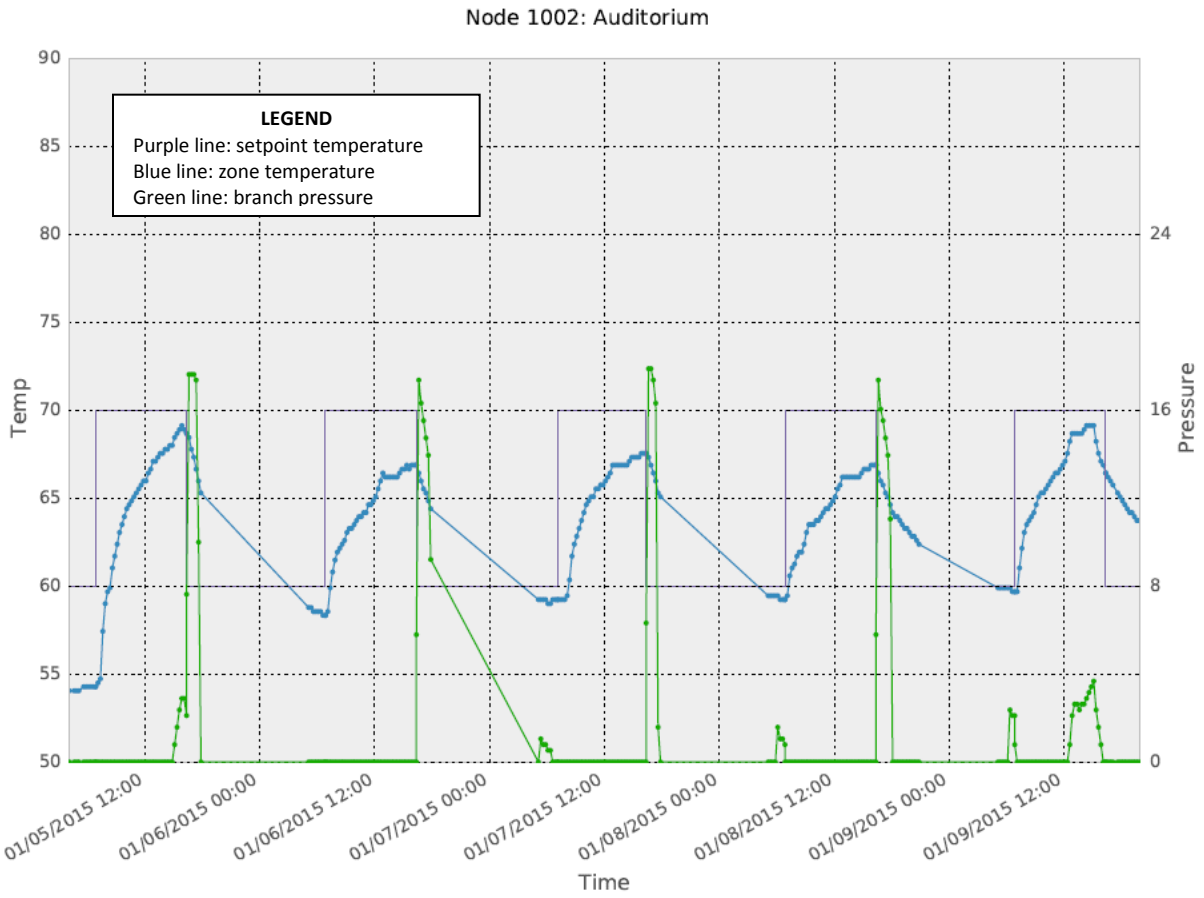


*Figure V – Typical zone with too much heating*

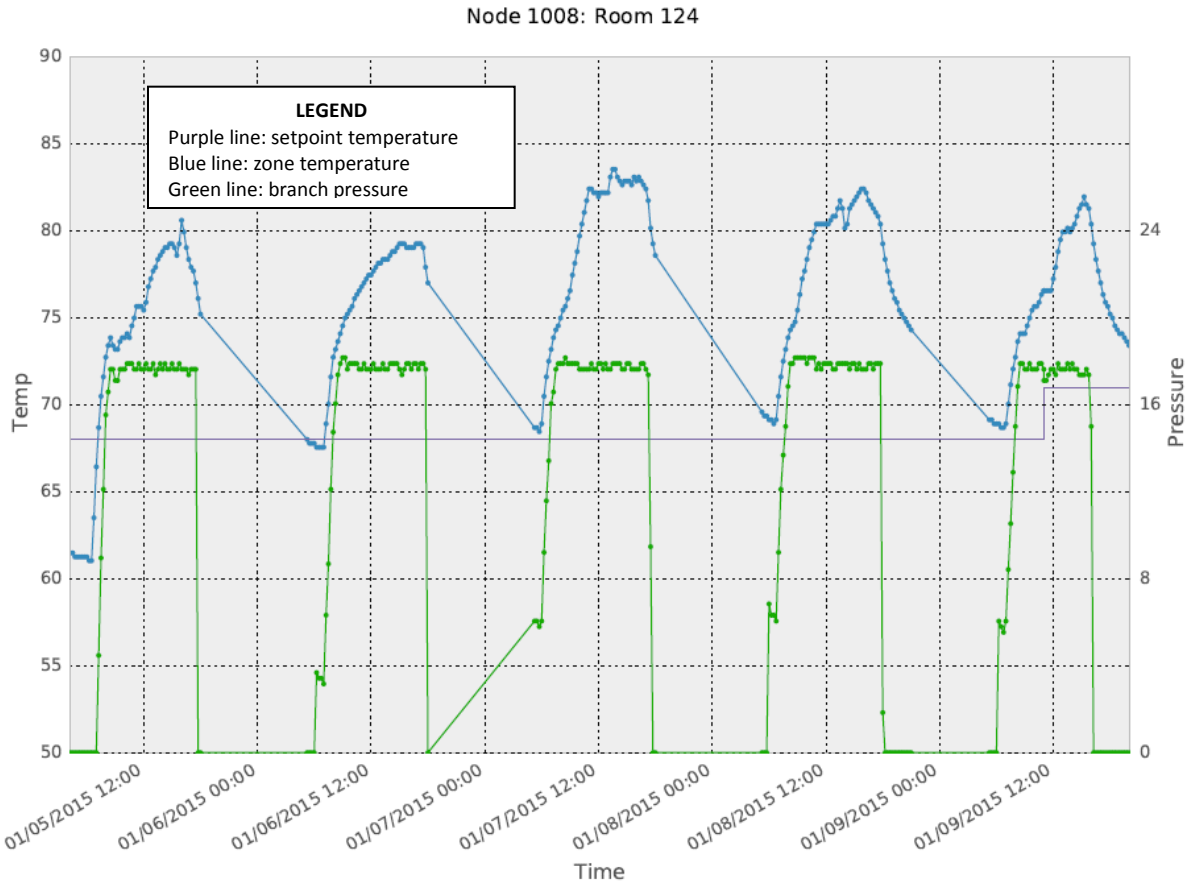


*Figure VI – Summary of performance by zone*

| NodeID | Node Name | Normal Function | Not enough heat | Too much heat | Supply Pressure Issue | Calibration Adj. Recommended |
|---|---|---|---|---|---|---|
| 1001 | Lobby | | | | | 1 |
| 1002 | Auditorium | | | | | |
| 1003 | Room 128 | | | | | |
| 1004 | Room 125 | | | | | |
| 1005 | Principal | | | | | 1 |
| 1006 | Room 123 | | | | | 1 |
| 1007 | Room 126 | | | | | |
| 1008 | Room 124 | | | | | |
| 1009 | Room 117A | | | | | |
| 100A | Room 117B | | | | | 1 |
| 100B | Room 115 | | | | | |
| 100C | Room 113 | | | | | |
| 100D | Room 112 | | | | | |
| 100E | Room 111 | | | | | |
| 100F | Room 110 | | | | | |
| 1011 | Room 109 | | | | | |
| 1012 | Room 108 | | | | | |
| 1013 | Room 107 | | | | | |
| 1014 | Room 106 | | | | | |
| 1015 | Room 142A | | | | | |
| 1016 | Room 142B | | | | | |
| 1017 | Cafeteria-A | | | | | |
| 1018 | Cafeteria-B | | | | | |
| 1019 | Cafeteria-C | | | | | 1 |
| 101A | Cafeteria-D | | | | | 1 |
| 101B | Kitchen | | | | | 1 |
| 101C | Gym-A | | | | | |
| 101D | Gym-B | | | | | |
| 101E | Stage-Left | | | | | |
| 101F | Stage-Right | | | | | |
| 1021 | PTA Room | | | | | |
| 2001 | Room 228 | | | | | |
| 2002 | Room 225 | | | | | |
| 2003 | Room 226 | | | | | |
| 2004 | Room 221 | | | | | |
| 2005 | Room 224 | | | | | |
| 2006 | Room 219 | | | | | 1 |
| 2007 | Room 215 | | | | | |
| 2008 | Room 213 | | | | | |
| 2009 | Room 212 | | | | | |
| 200A | Room 211 | | | | | |
| 200B | Room 210 | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 200C | Room 209 | | | | | | |
| 200D | Room 208 | | | | | | |
| 200E | Room 207 | | | | | | |
| 200F | Room 206 | | | | | | 1 |
| 3001 | Room 328 | | | | | | |
| 3002 | Room 325 | | | | | | |
| 3003 | Room 321 | | | | | | |
| 3004 | Room 326 | | | | | | 1 |
| 3005 | Room 319 | | | | | | |
| 3006 | Room 324 | | | | | | |
| 3007 | Room 315 | | | | | | |
| 3008 | Room 313 | | | | | | |
| 3009 | Room 312 | | | | | | |
| 300A | Room 311 | | | | | | |
| 300B | Room 310 | | | | | | |
| 300C | Room 308 | | | | | | |
| 300D | Room 309 | | | | | | |
| 300E | Room 305 | | | | | | |
| 300F | Room 304 | | | | | | |
| 3011 | Room 300 | | | | | | 1 |
| B001 | Room B12 | | | | | | |
| B002 | Room B13 | | | | | | |
| B003 | Room B11 | | | | | | |
| B004 | Room B10 | | | | | | |
| B005 | Room B9 | | | | | | |
| B006 | Room B8 | | | | | | |
| B007 | Room B2 | | | | | | |
| **Total** | **69** | **52** | **2** | **14** | **1** | | **11** |

## Conclusions

The Wireless Pneumatic Thermostat deployment at QS-21 appear to be delivering the two benefits that were intended. The setpoint setbacks are reducing the heating load and resulted in tangible fuel oil savings of 20%. The fault detection discovered potential equipment failures which are likely causing energy waste (i.e. heating valves stuck open) which will deliver additional energy savings when corrected.

# Appendix

Complete data plots for all
Wireless Pneumatic Thermostat Zones
For January 5 to 9, 2015