

Building America Stakeholder Meeting

Austin, Texas February 29 to March 2, 2012

Hydronic Controls Retrofits for Low-Rise Multi-Family Buildings

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ARIES Collaborative

Advanced Residential Integrated Energy Solutions

Research Objective

- Determine the impact of control strategies that use apartment temperatures for central boiler control on energy consumption, comfort and cost.
- Compare energy performance, comfort and cost to individual radiator valve controls in each apartment.

Background

- Most multi-family boiler systems have:
 - No zone/apartment level control, or
 - Non-electric thermostats on radiator valves
- Central boiler system resets hot water based on outdoor temperature
- Problem:
 - apartments are often too hot or too cold.
 - Occupants often open windows to “control” temperature

Concept

- New wireless temperature sensors offer the potential to cost-effectively retrofit poorly-controlled heating systems to reduce energy use
- More intelligent boiler plant “reset” control strategies may be more cost effective than full scale retrofits that put zone controls in each apartment.

Test Site - Project Participants

- The ARIES Collaborative, a Department of Energy Building America research team
 - The Levy Partnership, Inc.
 - CDH Energy Corp.
- Homeowners' Rehab Inc., a non-profit housing developer in Cambridge, MA.
- Massachusetts Low Income Multi-Family Retrofit Program (LEAN), a utility program providing funding for the retrofit
- EnerSpective, Inc., assessing the project for the utility program

Test Site

- 42-unit complex of three, three-story masonry buildings in Cambridge, MA
- Each building has two or three 87% eff space heating boilers (+one boiler for DHW)



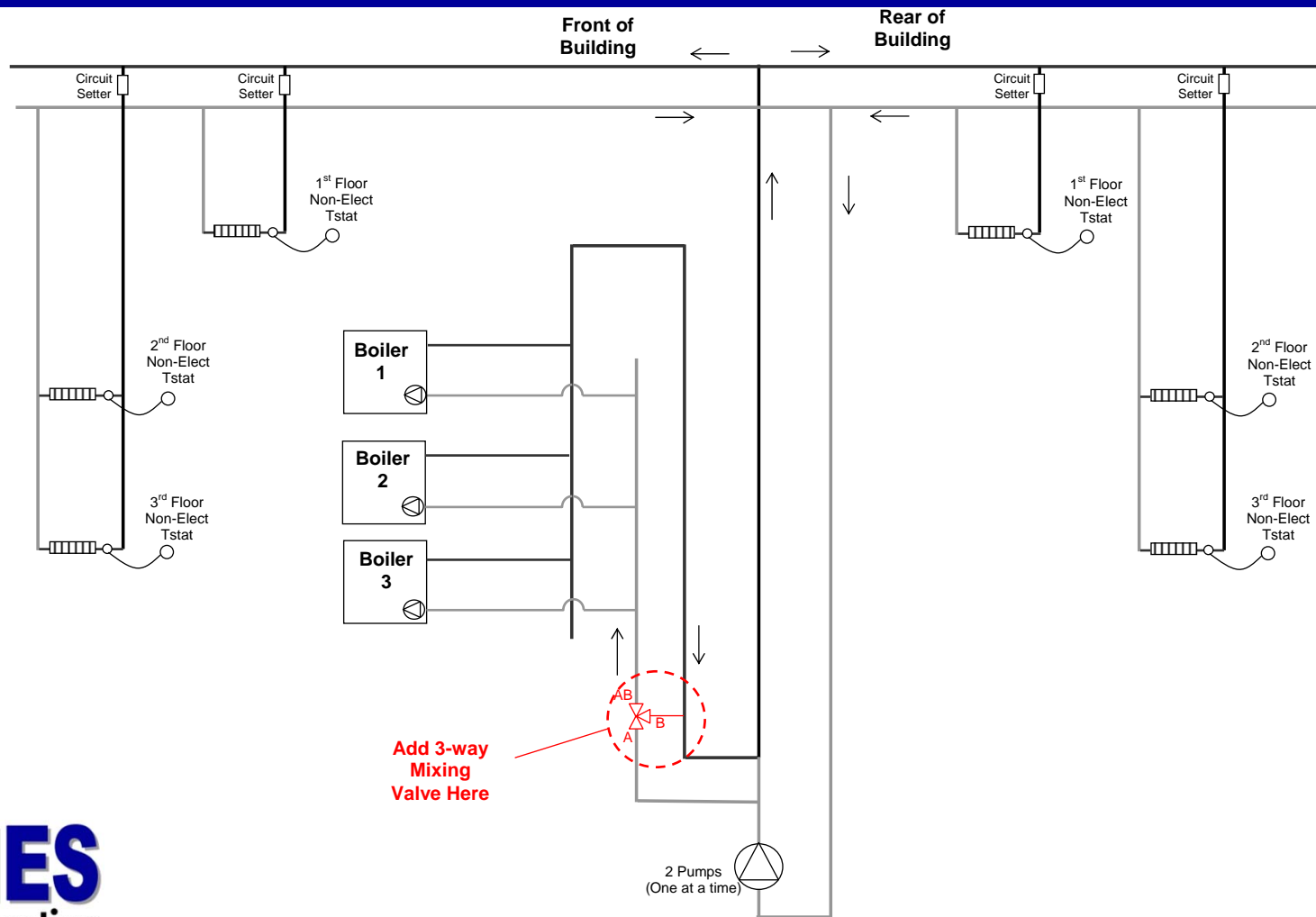
Technical Approach

- **PHASE I:** Replace boiler controls with wireless system that supplies heat based on both apartment and outdoor temperatures. Rigorously quantify the effectiveness of this strategy.
- **PHASE II:** Install radiator zone valves to provide local control.

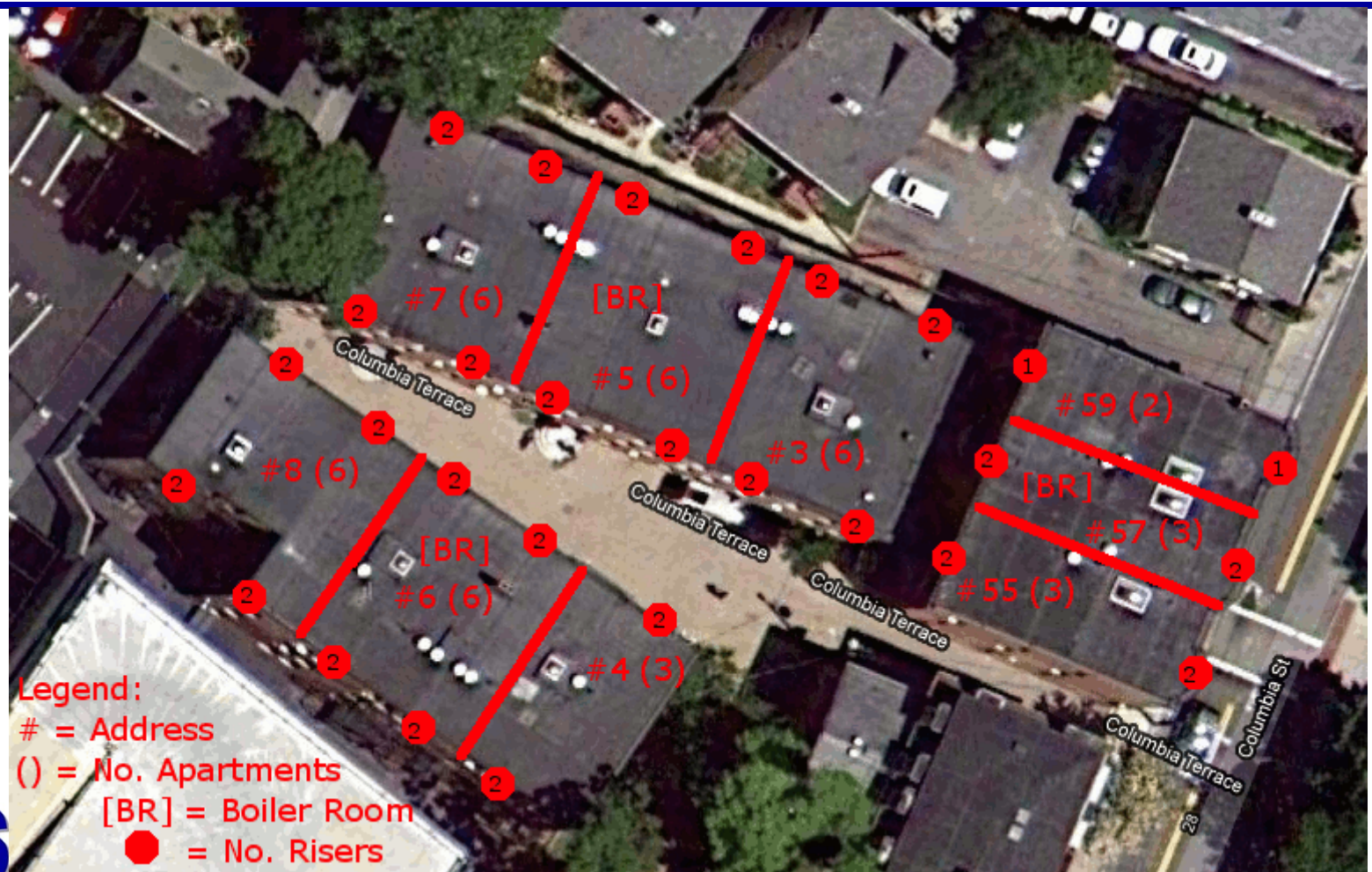
PHASE I: Indoor Temperature Based Boiler Control

- Wireless temperature sensors in apartments - data used to adjust building supply water temperature
- Web-enabled. Off-site server stores data and makes it available on a website
- Adaptive and intelligent reset and night setback approaches
- Where required, maintain boiler return water temperatures above 140°F with new 3-way mixing valve
- Goals:
 - Reduce spacing heating energy by 15% to 20%
 - Maintain space temperatures closer to the required set points (reduce overheating)

System Configuration

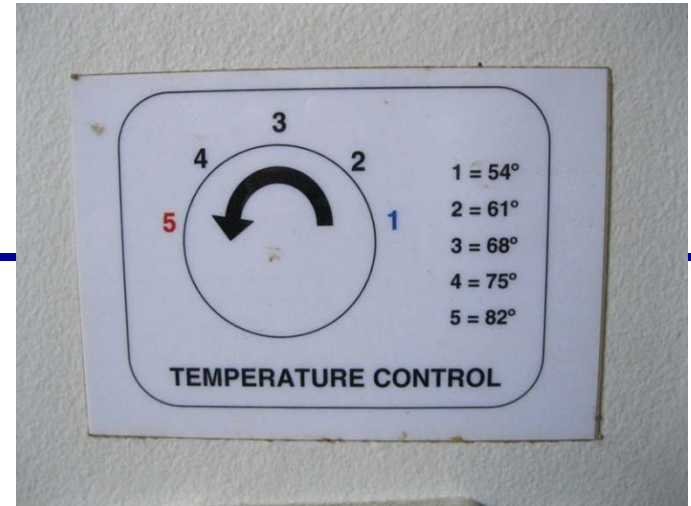


Apt Complex Layout



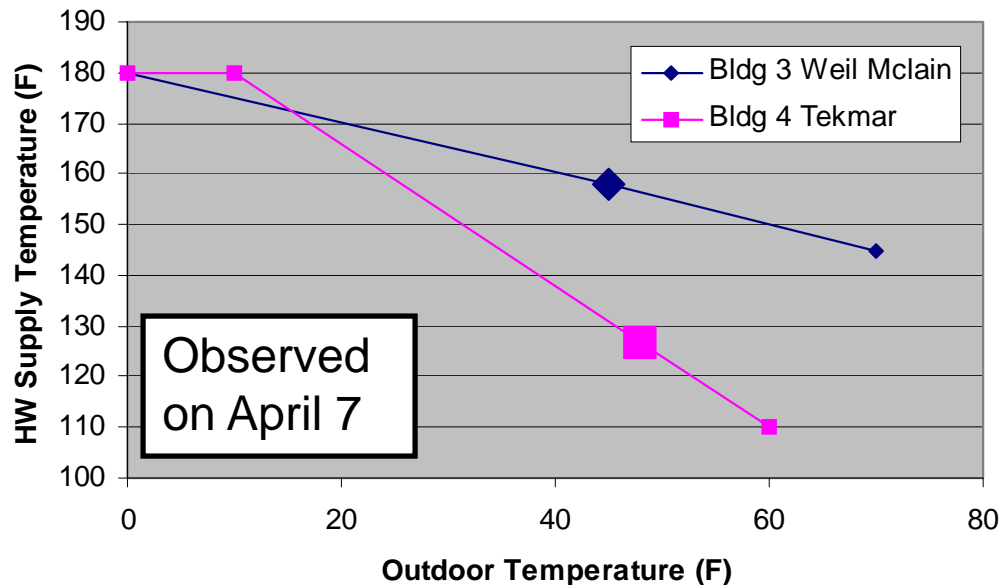
Current Zone Controls

- Each apartment has 1-2 non-electric, remote “thermostats” to regulate baseboard water flow
- Valve calibration is unknown
- Many have failed in open position (resulting in overheating)
- Residents typically disregard municipally mandated set points (68°F day, 64°F night)



Boiler Controls

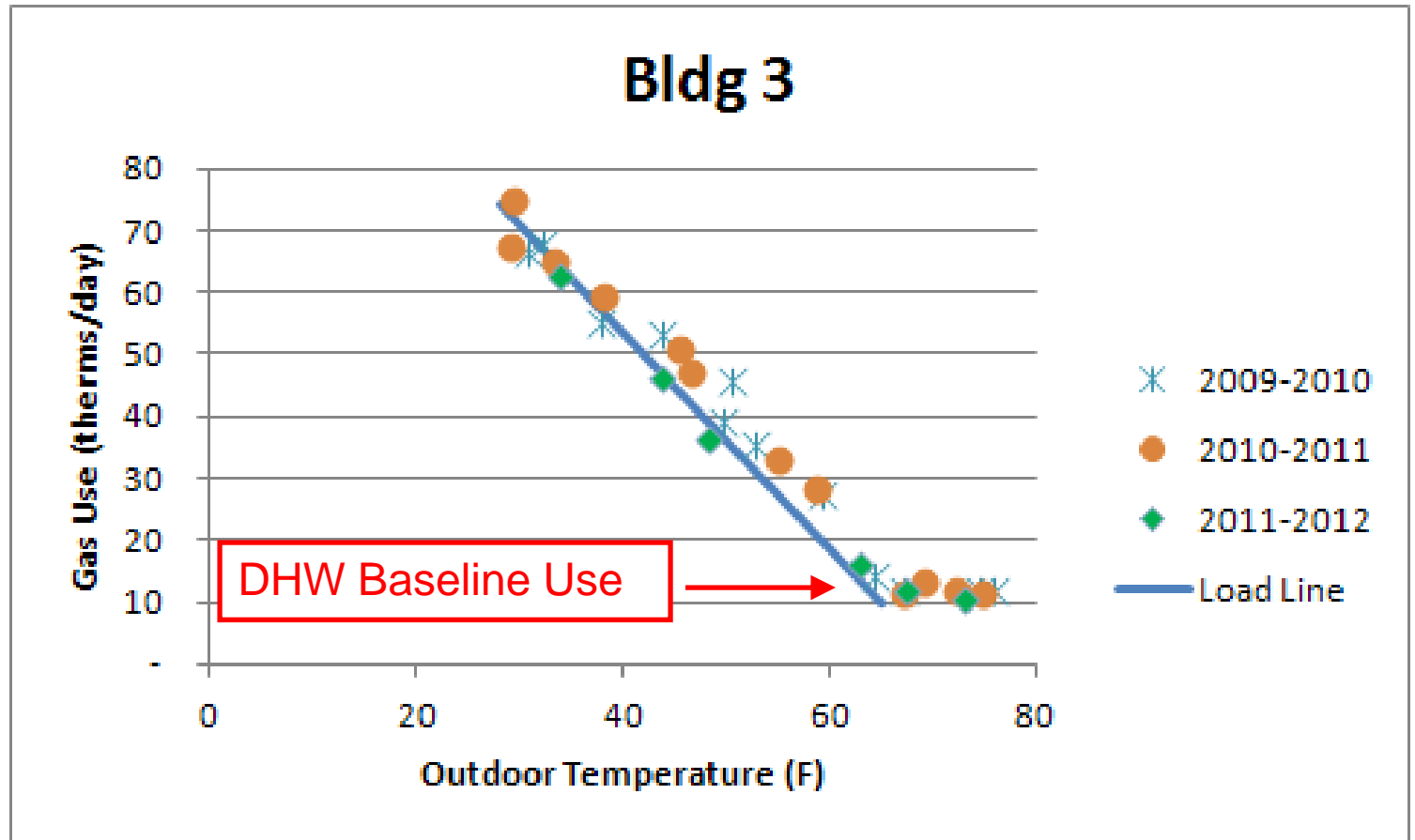
- Both Buildings have Outdoor Reset control
- Supply T about 30°F higher in Bldg 3 on April 7, 2011



Adjusted Test Plan

- BUILDING 3: Wireless, Web-enabled system (Intech 21)
 - Full functionality
 - Web-based data collection
- BUILDING 4: Updated Baseline system (Tekmar)
 - Standard controls, boiler protection valve
 - Data collection capabilities

Baseline Performance



Data Collection (Intech 21)

- Web-enabled control will be used to collect data at 15-minute intervals:
 - Apartment temperatures
 - Outdoor temperature
 - Hot water supply temperature
 - Hot water return temperature
 - Hot water return temp (entering boilers)
 - Cumulative boiler run time (each boiler)
 - Mixing valve position
 - Cumulative runtime of hot water pump
- Also...
 - Comfort will be gauged by heat complaint reports, surveys and observations of open windows
 - Monthly gas consumption from fuel bills

Test in Various Modes

- Control Modes:
 1. Existing conditions (baseline outdoor reset)
 2. Indoor temperature-based control
 3. Control with night-time setback
- Spend several weeks in each mode
- Directly compare energy performance and comfort impacts after normalizing for weather

Analysis Approach

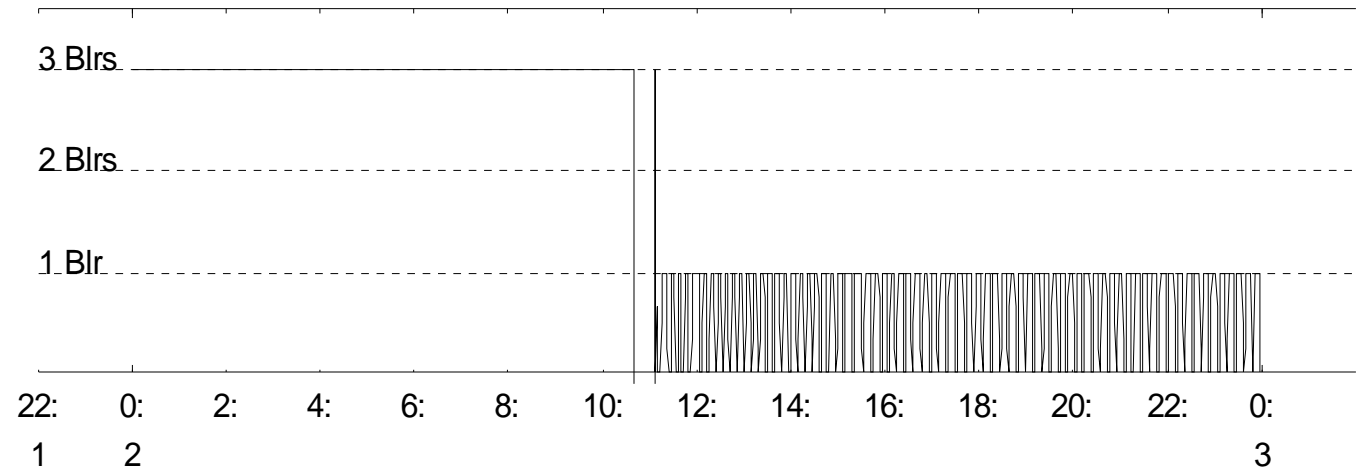
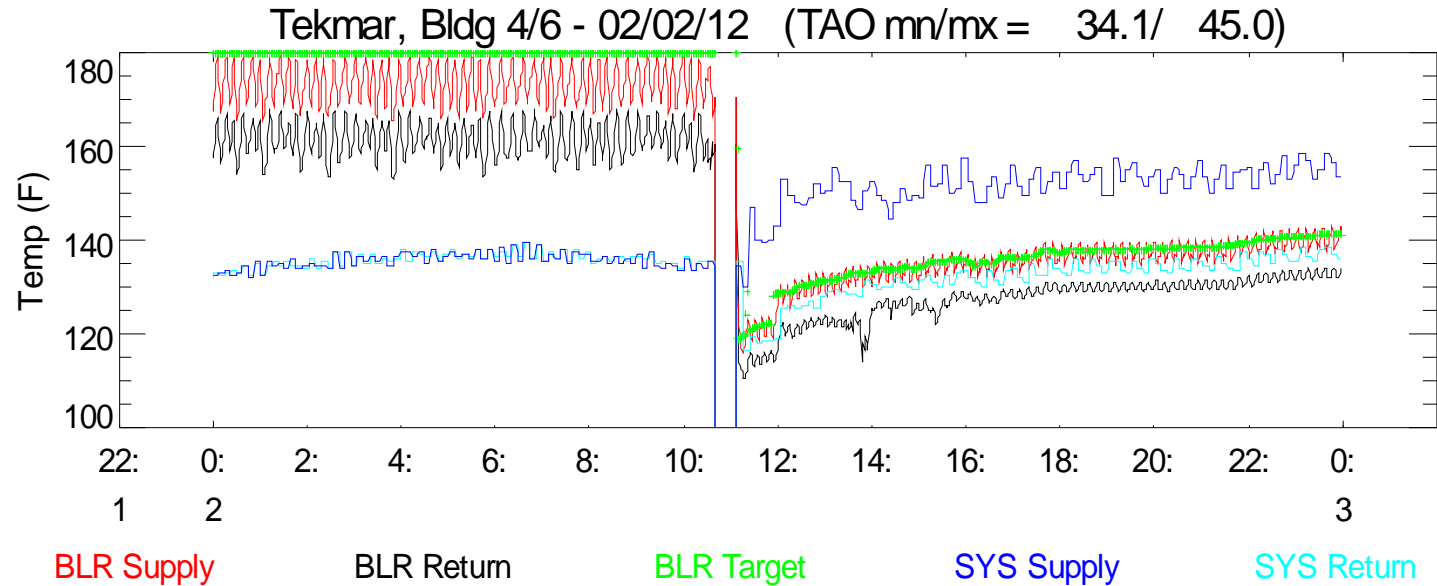
- Daily load line analysis relating total boiler runtime to outdoor temperature for each day
- Compare resulting linear trends for different performance periods / control modes to discern impacts
 - Multi-linear regression analysis with dummy variables to determine if the differences are statistically significant
 - Relate monthly runtimes to billed gas use to discern impact on fuel use

First Results (Tekmar)

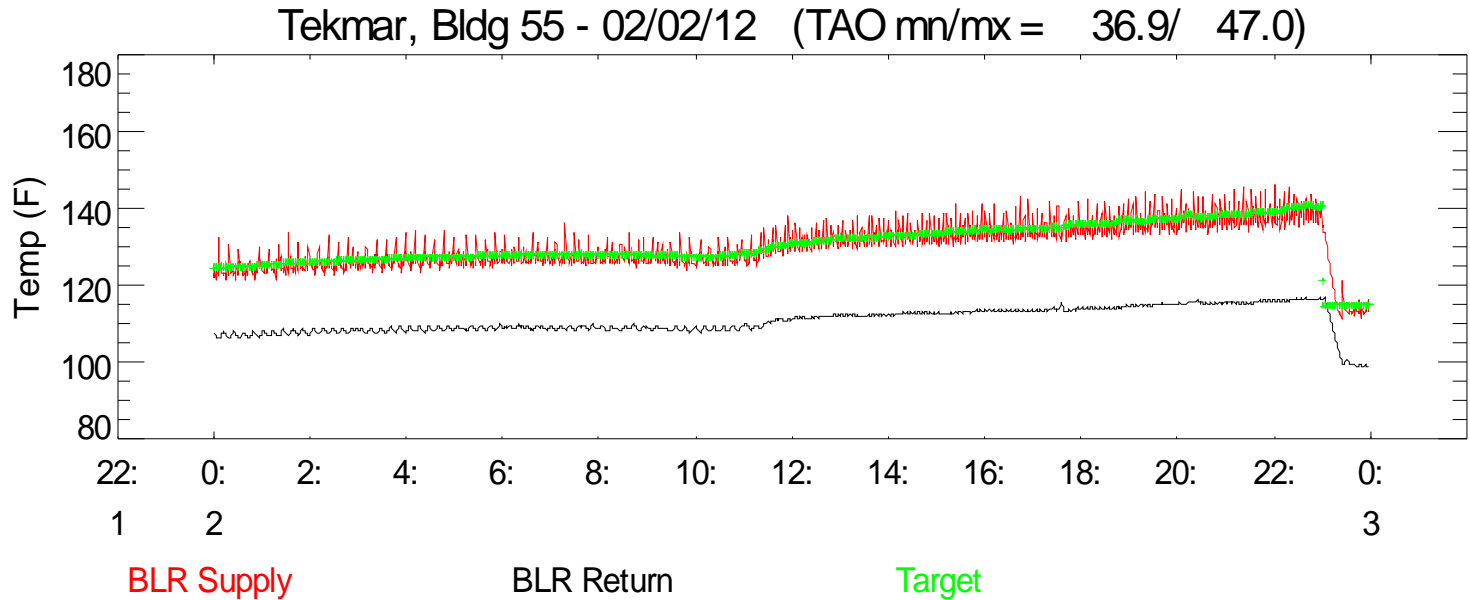
- Collected (1-min) Data on (Baseline) Tekmar Performance in Building 4 and Building 55
 - Tried to incorporate mixing valve control in Bldg 4
- Understanding details of baseline controls
- Assessing impact of night setback

BLDG 4 Disabling Mixing Valve Control

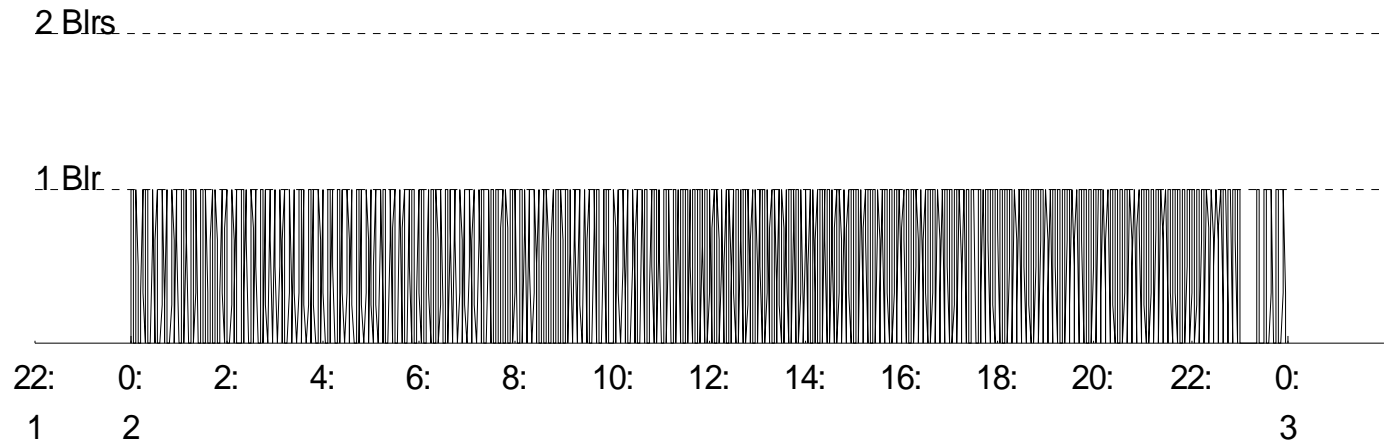
Boiler
Controller
(Tekmar 274)
is set to lead
on Feb 2



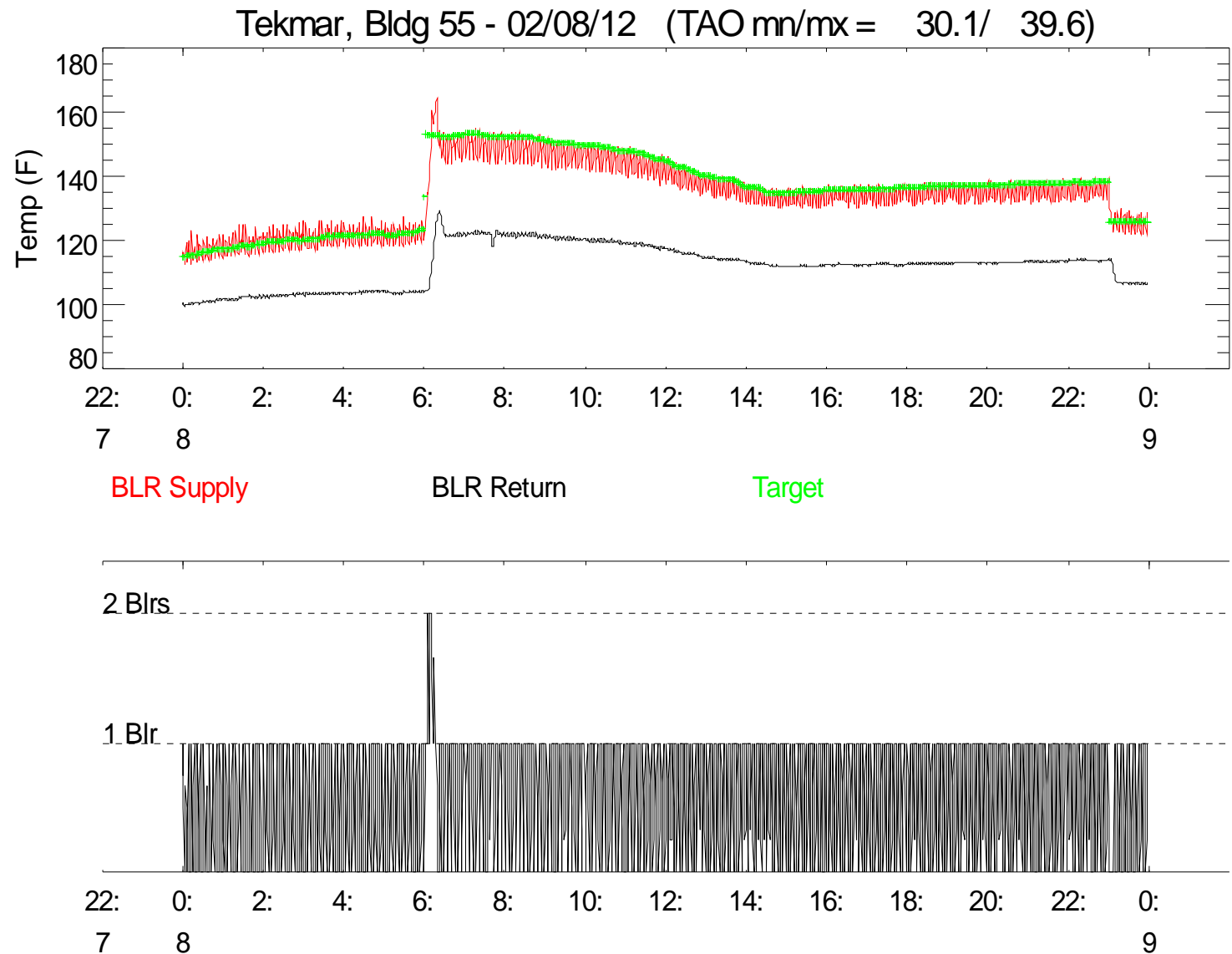
BLDG 55 Start of Night Setback



Start of Night-time Setback on Feb 2



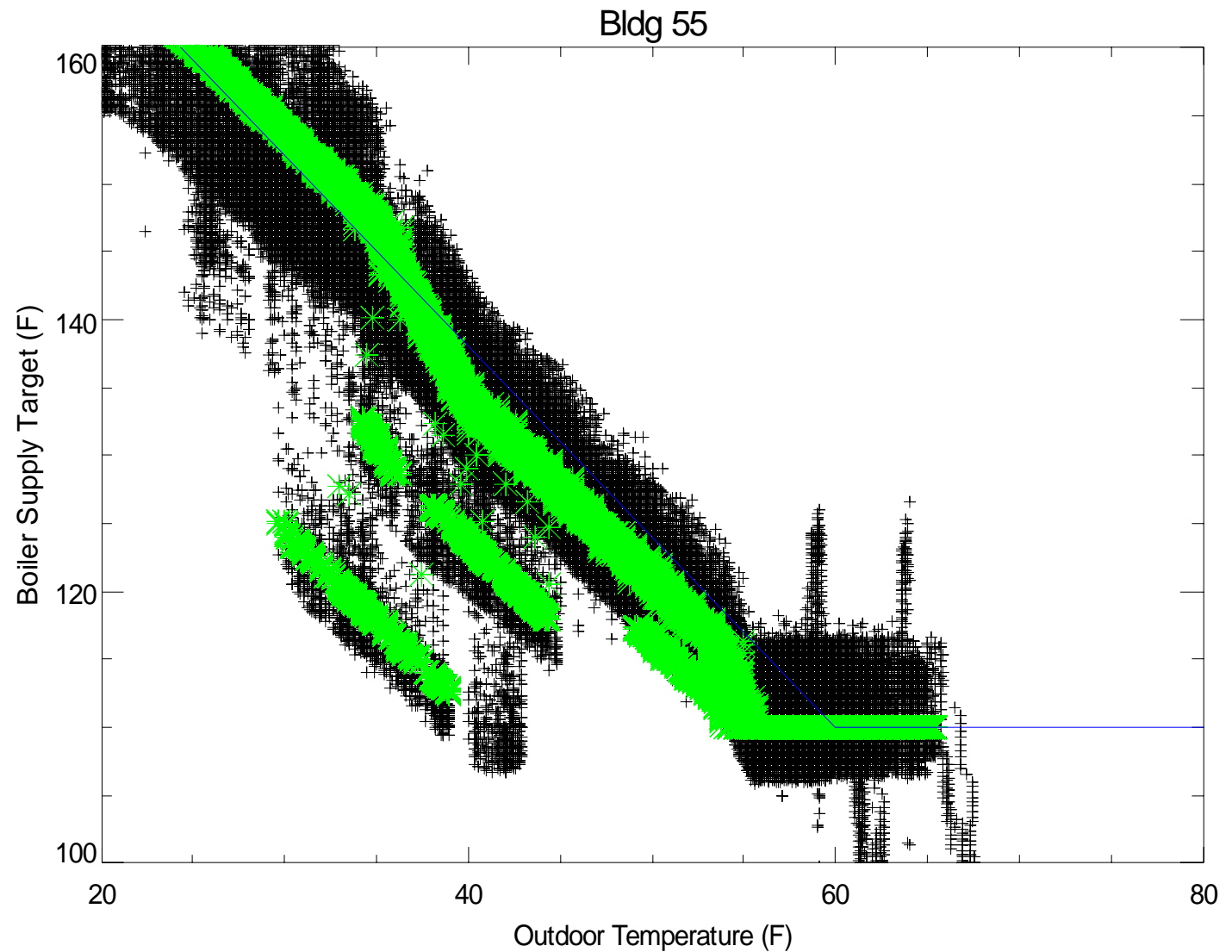
Night-time
Setback made
less
Aggressive on
Feb 8



BLDG 55 Night Setback

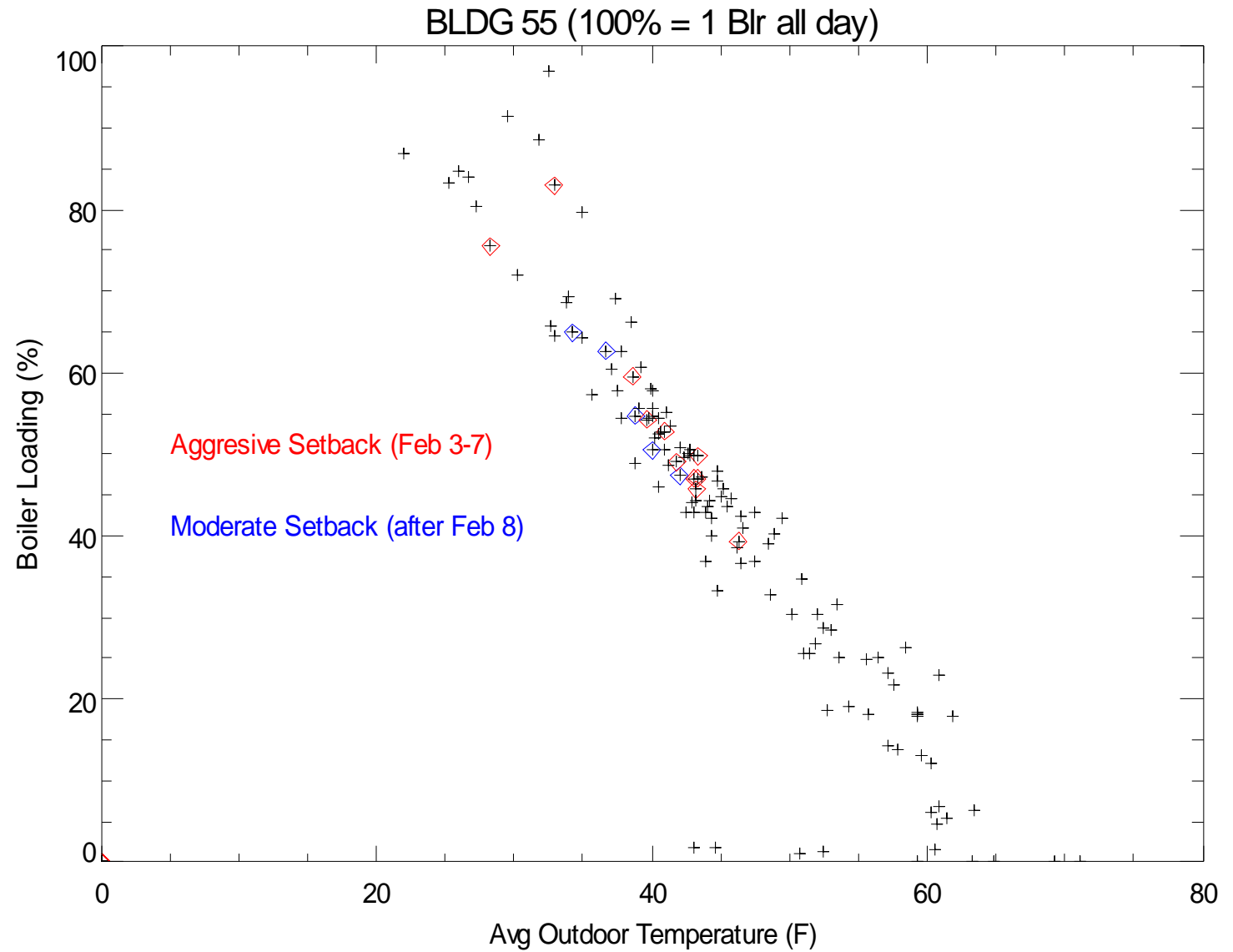
Outdoor Air
Reset
Schedules
(with various
levels of
Setback)

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BLDG 55 Night Setback

Impact of
Setback on
Boiler Runtime



First Results (Intech 21)

- Collected (15-min) Data on Building 3 since October 2011
 - Measuring indoor temperatures
 - Controller functions not fully enabled
- Test plan
 - Mixing valve control enabled (Feb 8)
 - Just started outdoor air reset (Feb 22)
 - Enable indoor air control features in March

Summary

- Testing program has just started
 - Gathering data to quantify control changes
- Looking at various control issues in multiple buildings
 - Understanding baseline operation... and mixing valve control
 - Impact with and without night setback
 - Various forms of reset control

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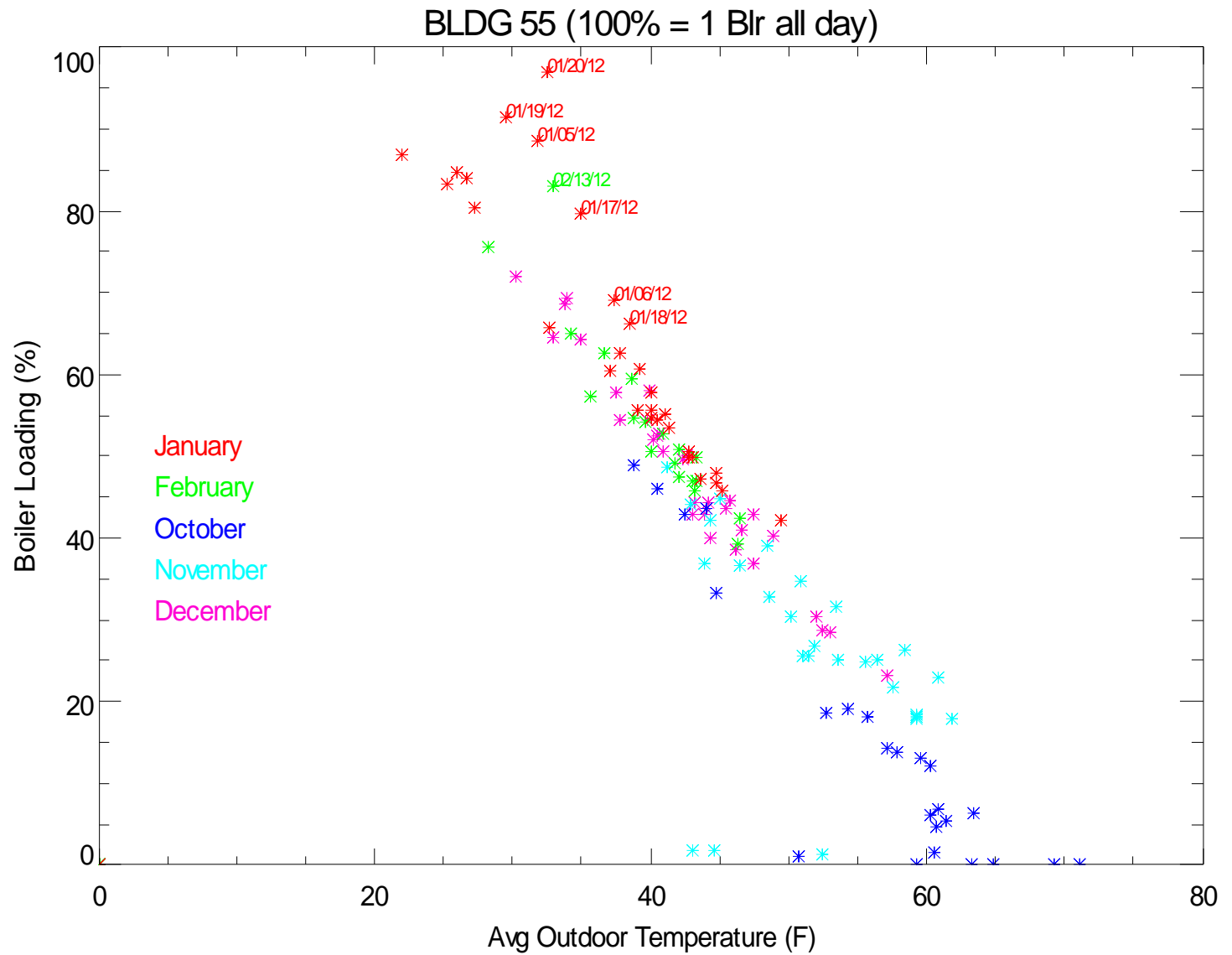
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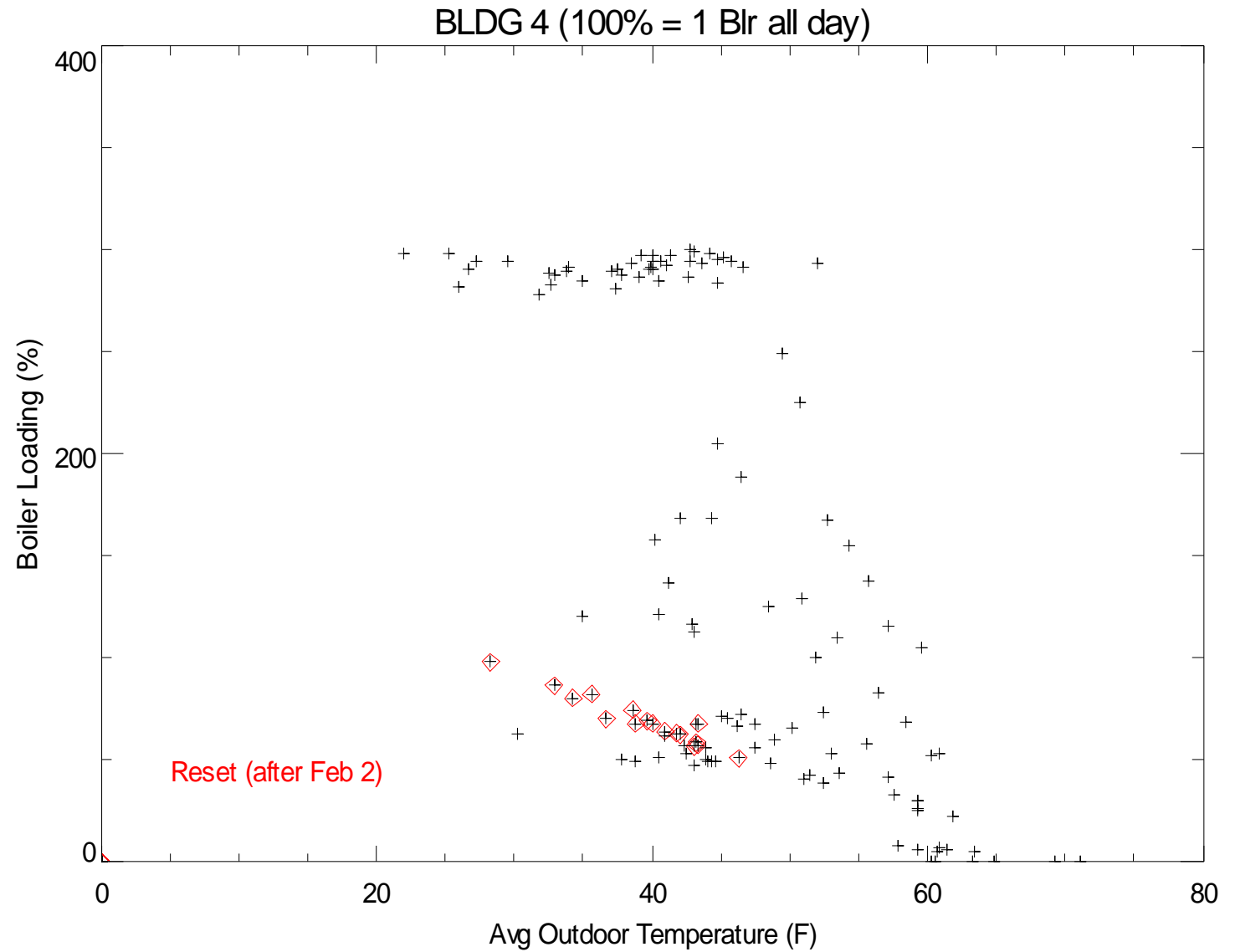
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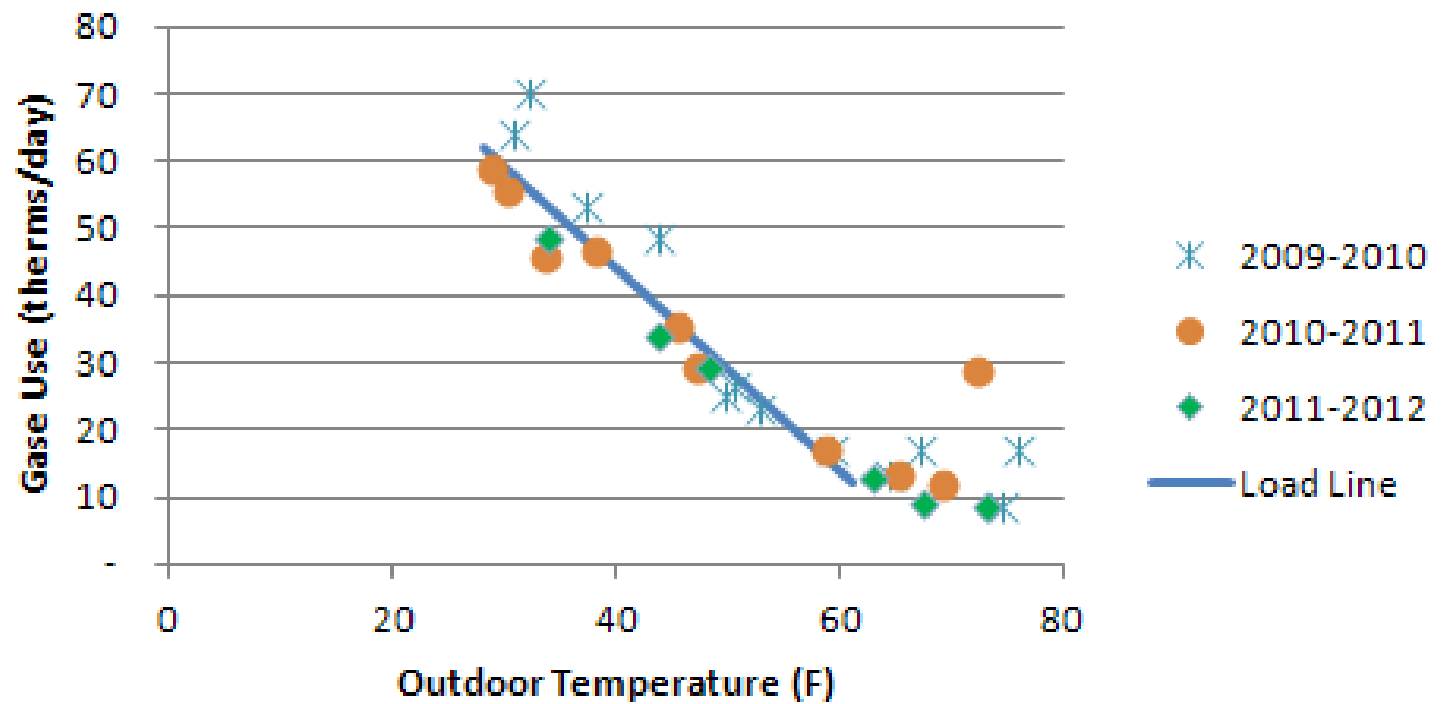
Some days
show
unexpected
behavior



Boiler
runtime data
not
meaningful
before Feb 2



Bldg 4



Bldg 55

