# Hydronic Heating Retrofits for Low-Rise Multifamily Buildings

Overview of Research Planned
for
Building America Program
U.S. Department of Energy

Conducted by:
ARIES Collaborative

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# Roles

- 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 proving funding for the retrofit
- EnerSpective, Inc., assessing the project for the utility program

# Research Questions

- What is the impact of control strategies that use apartment temperatures for central boiler control on energy consumption and comfort?
- How cost-effective is such a control retrofit?
- How does energy performance and comfort compare  to individual radiator valve controls in each apartment?
- How cost-effective is centralized control of radiator valves?

# 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** (tentative): Install radiator zone valves centrally controlled wireless using space temperature data.

# 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)

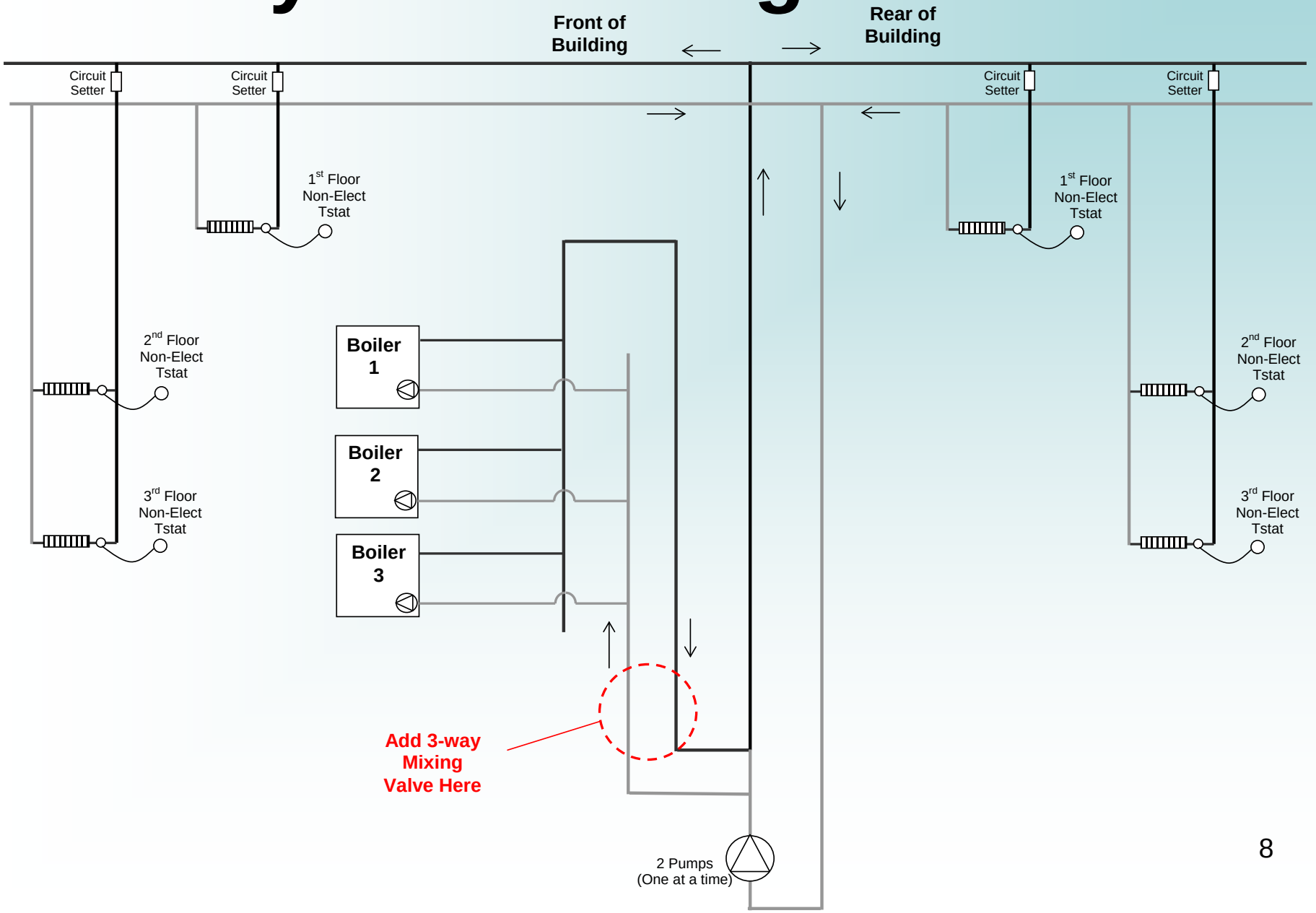
# PHASE II: Local radiator controls

- Central control of individual radiator risers
- Remove existing, mostly failed, non-electric radiator zone valves
- Install new valves in the basement risers, controlled by temperature data in served apartments
- Goal:
  - Obtain additional heating energy savings
  - Distribute only the amount of heat needed at each riser in order to maintain the minimum heat needed in the apartment(s) served by that riser

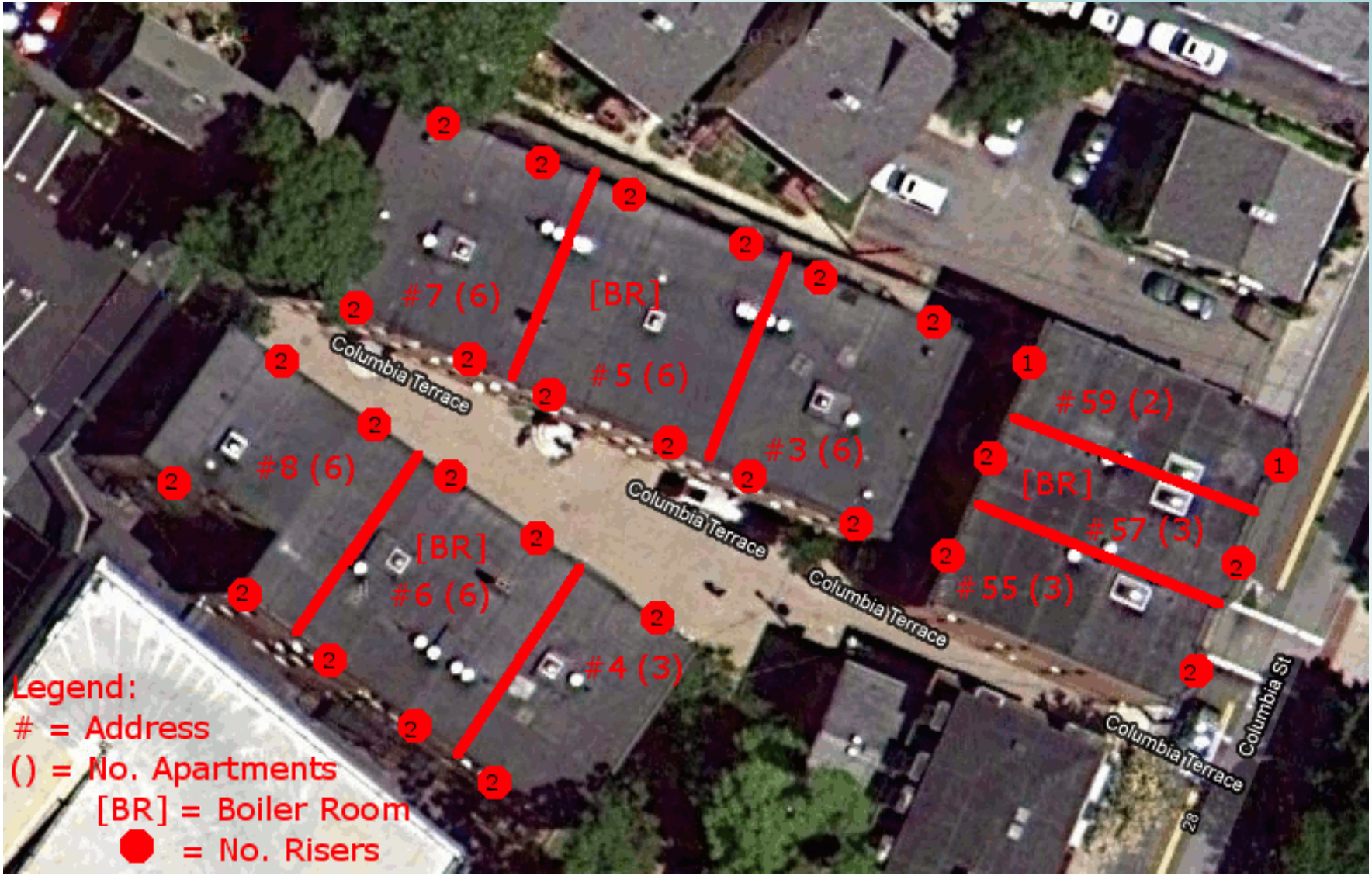
# Test Site

- 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)


# System Configuration

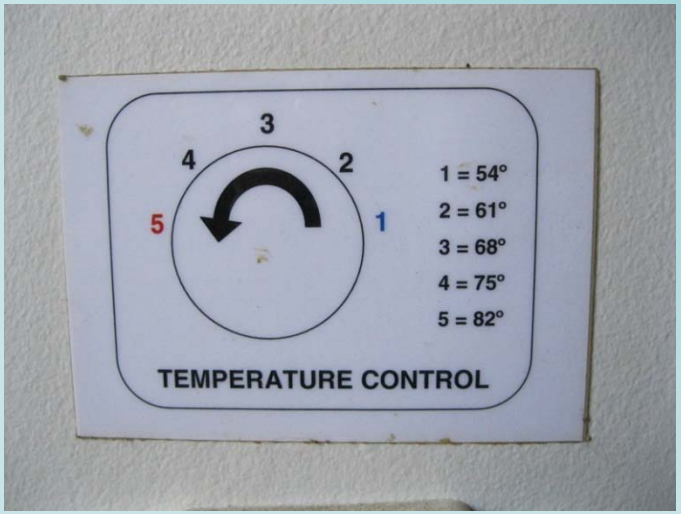


# Apt Complex Layout



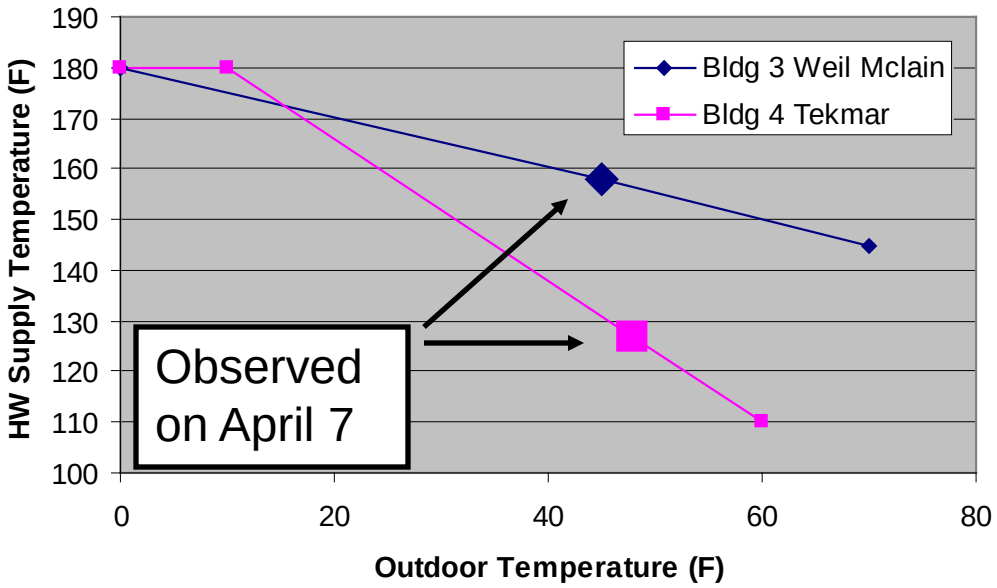
# Current Controls

- 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

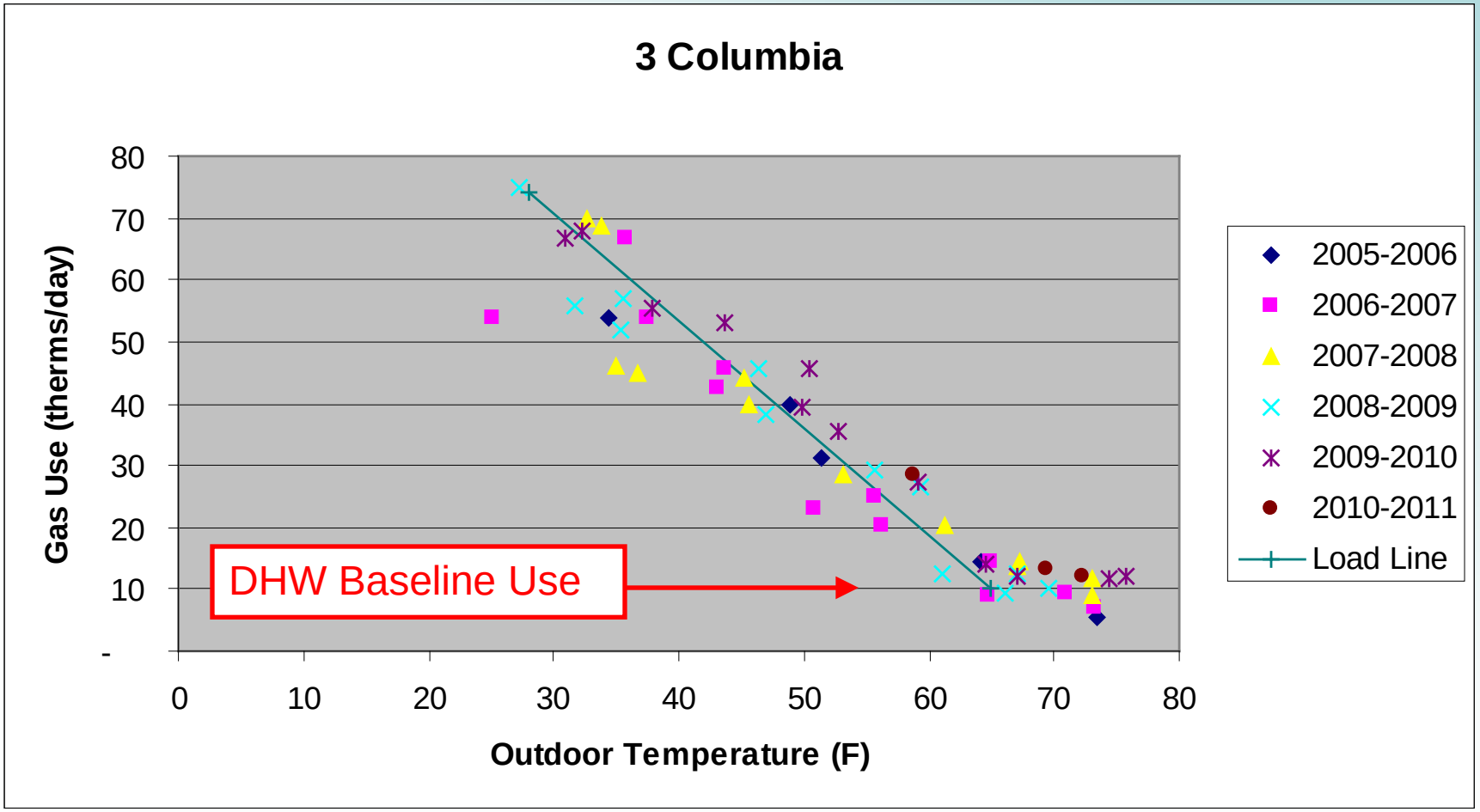
- Both Buildings have Outdoor Reset control
- Supply T about 30°F higher in Bldg 3 on April 7


# Savings & Cost-Effectiveness

- Target: Reduce heating costs by 15% to 25%
- 20% savings = 4,539 therms per year ($5,447 at $1.2/therm)
- Initial Assumption:  cost to install the control system (PHASE 1) was $25,000
- Simple payback is 4-5 years
- Payback is longer due to small size of building and multiple boiler rooms

# Baseline Performance




**Load line of monthly gas use vs. temperature 2005-2011**

# Data Collection

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 Control Modes

- Control Modes:
  1. Existing conditions (baseline outdoor reset)
  2. Indoor temperature-based control (two different strategies)
  3. Indoor temperature-based control with one-time manual balancing of system using riser valves (one building)
- 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
  - Related monthly runtimes to gas use to discern impact on fuel use

# Summary

- Seek to document that new control strategies are viable and cost-effective in affordable low-rise multifamily buildings in cold climates
- Test program designed to gather quantitative data to verify energy efficiency and occupant comfort