Building America Case Study
Technology Solutions for New and Existing Multifamily Homes

Advanced Boiler Load Monitoring Controllers

Chicago, IL

PROJECT INFORMATION

Project Name: Field Test of Boiler Primary Loop Temperature Controller

Location: Chicago, IL

Partners: Partnership for Advanced Residential Retrofits (PARR), Greffen Systems

Building Component: HVAC

Application: New or retrofit; Multi-family

Year Tested: 2013-2014

Applicable Climate Zone(s): Cold, Very Cold, Mixed/Humid

PERFORMANCE DATA

Cost of Energy-Efficiency Measure (including labor): $7,700

Projected Energy Savings: up to14% heating savings

Projected Energy Cost Savings: $1600-$2000/year

Building America SM U.S. Department of Energy

Chicago's older multifamily housing stock is predominantly heated by centrally metered steam or hydronic systems, and the cost of heat for tenants is typically absorbed into the owner's operating cost and then can be passed to tenants. Central boilers typically have long service lifetimes, the incentive for retrofit system efficiency upgrades is greater than equipment replacement for the efficiency-minded owner. System improvements as the "low hanging fruit" are familiar, from improved pipe insulation to aftermarket controls such as Outdoor Temperature Reset (OTR) or lead/lag controllers for sites with multiple boilers.

Beyond these initial system efficiency upgrades are an emerging class of Advanced Load Monitoring (ALM) aftermarket controllers that dynamically respond to the boiler load, with claims of 10% to 30% of fuel savings over a heating season. PARR installed and monitored the performance of one type of ALM controller, the *M2G* from Greffen Systems, at multifamily sites in the city of Chicago and its suburb Cary, IL, both with existing OTR control, with the following characteristics:

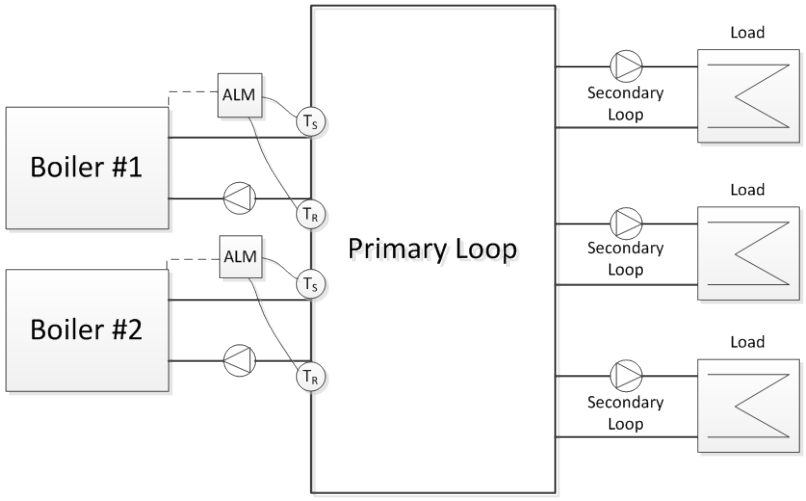
- Controllers are compatible with hydronic boilers only
- They perform load monitoring, with continuous measurement of supply and in some cases return water temperatures
- Energy savings are derived from dynamic management of the boiler differential, where a microprocessor with memory of past boiler cycles prevents the boiler from firing for a period of time, to limit cycling losses during perceived low load conditions
- They differ from OTR controllers, which vary boiler setpoints with ambient conditions while maintaining a fixed differential
- Results show that energy savings depend on:
  - How much boilers are oversized for their load (cycling rates)
  - Time of year, savings vary with cycling rates, with greater savings observed in shoulder months.
- Over the monitoring period, oversized boilers at one site showed reductions in cycling and energy consumption in line with prior laboratory studies, while less oversized boilers at another site showed muted savings.

DESCRIPTION

ALM controllers are primarily used in large commercial and industrial settings, however savings are possible for low-rise multifamily retrofits. As residential hot water boilers are typically operated with wider boiler differentials than commercial/industrial boilers, 20°F vs. 10°F or less, there are fewer opportunities for reductions in cycling losses by dynamic widening of this differential.

Installation is brief, with temperature sensors installed external to hot water piping and limited labor required to splice into the thermostat wiring. ALM controllers were installed on average in less than 2 hours per boiler.

These ALM controllers do not require calibration, they infer boiler temperature settings and are compatible with OTR systems



The ALM controller works with hydronic heating systems with "Primary/Secondary" piping arrangements, shown above, by monitoring primary loop temperatures and, following a call for heat by the boiler aquastat, the ALM controller may delay this firing by up to 15 minutes depending on temperature data. ALM controllers do not activate a standby boiler, nor do they stop a firing boiler, they limit cycling losses by selectively lengthening firing cycles. Savings are proportional to how oversized boilers are, such features will reduce the energy savings potential: multi-stage/modulating combustion, existing OTR; while others will increase the savings potential such as envelope/pipe insulation improvements. At this time, they are not compatible with central steam boilers as they only monitor pipe surface temperatures.

Lessons Learned

- One site, with oversized boilers cycling 100 times a day or more saw cycling reductions of 32% with therm savings of 14% during shoulder months (weather adjusted).
- A second site, with 50 cycles/day or less, saw a reduced impact of 17% fewer cycles and 7% therm savings during shoulder months.
- In widening differentials, heating temperatures can be lower than designed, over the monitoring there were no tenant complaints.
- Both sites had existing OTR controllers. While ALM controllers operated successfully in parallel, benefits were reduced.

Looking Ahead

As energy savings from ALM controllers are site-dependent, their prediction requires advanced knowledge of the boiler system, such as typical cycling rates, oversize/utilization factors, and temperature differential settings. This first field study of its kind, complementary to a laboratory study performed by PARR member Gas Technology Institute (GTI), can assist utilities in identifying means of reliably predicting energy savings for prescriptive measures, something GTI is currently working with utilities in the Chicagoland area to do.

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