Updating boilers to improve efficiency

Introduction

Recent boiler design and technology updates have resulted in more efficient boilers that do not require as much maintenance as compared to conventional boilers. This efficiency equates to cost savings due to reduced energy consumption and labor. It also results in reduced air pollutants, specifically NO_x or nitrogen oxides a by-product of combustion.

Boiler emissions

In addition, NO_x emissions are an "ozone precursor," meaning NO_x is part of the equation that helps form ground- level ozone. This is sometimes referred to as smog and is harmful to human health, especially respiratory health. In Kansas, several counties are close to or in non-attainment for ozone. Some areas of the U.S. in non- attainment for ozone require facilities to limit NO_x emissions from boilers, sometimes through controls such as low-NO_x burners.

Most boilers in Kansas burn natural gas, and as shown in Table 1, NO_x emissions from natural gas are much lower than from oil or wood. However, because of the number of boilers in Kansas, industrial boilers emit more than 40,000 tons of NO_x emissions each year[1].

Who should update their boilers?

Boilers are workhorses and it can be expensive to replace them, but it can also be expensive not to. Generally, boilers 20 years old or older should be considered for updates or replacement, as well as boilers that burn oil or wood.

Regulatory definition:
Boiler means an enclosed device using controlled flame combustion in which water is heated to recover thermal energy in the form of steam and/or hot water. Controlled flame combustion refers to a steady-state, or near steady-state, process wherein fuel and/or oxidizer feed rates are controlled.

Consider this – an older boiler may still be running, but is it still sized properly for its use? Have processes or facility needs changed? Twenty years ago, boilers were oversized for the worst weather day of the year. Today, engineers size boilers differently; they size them for the average temperature day and boilers have modulators that automatically adjust its fuel use depending on the current weather. This means, in many cases, a steam boiler can be replaced with a smaller hot water boiler, saving even more money.

Table 1. Compare potential to emit emissions for 6 MMBtu/hr or 144 HP[2]

Tons per year by fuel source	Wood	Oil #1 or 2/ #5 or 6	Natural gas	Natural gas low NO_x burner
Nitrous oxides	12.9	3.8/9.6	2.6	1.3
Sulfur oxides	0.7	0.04/13.9	0.02	0.02

[1]Kansas 2001 National Emissions Inventory report prepared by Kansas Department of Health and Environment
[2]Assuming 80% efficiency

No-cost and low-cost boiler updates for efficiency

Operational changes are steps companies can take to more tightly manage or control their energy use. These are often "no-cost" steps that can add up fast. As noted in the case study that follows, Wichita Public Schools were able reduce energy costs nearly 40% by running their boilers on a specific schedule based on the buildings' actual use.

Insulation seems like common sense, but in looking around boiler rooms, many have room for improvement. Uninsulated steam distribution and condensate return lines are a constant source of wasted energy.

According to the Department of energy, insulation can reduce energy losses by 90% and help ensure steam pressure for plant equipment. All surface that reaches temperatures greater than 120°F should be insulated, including boiler surfaces, steam and condensate return piping, and fittings[3].

Boiler tune-ups should be done annually, and some air quality rules require proof of regular tune-ups.

Low-NO_x burners are included with most new boilers, but can be a retrofit option for facilities not planning to replace older units. As previously mentioned, low-NO_x burners emit 50% less NO_x and require less maintenance. These burners are about 10% more expensive, but are designed to control fuel and air mix, and create larger and more branched flames at a reduced flame temperature.

This results in less NO_x formation and improved burner efficiency. Consult with a burner manufacturer to learn the advantages of retrofitting existing burners.

Other ways to improve efficiency and reduce energy use include minimizing boiler blowdown and using economizers for waste heat recovery. Department of Energy tip sheets cover these topics in detail.

[3] http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/steam2_insulate.pdf

What is a condensing boiler?

Condensing boilers use waste heat from exhaust gases to preheat cold water entering the boiler. Energy is transferred much better through water than through air, and that is what makes these boilers much more efficient than conventional, non-condensing boilers.

In fact, most of the new condensing boilers have an efficiency rating of 90-95%, as compared to the ratings of 65-80% for older non-condensing boilers. The physical size of these boilers is often 30-50% smaller than conventional boilers, making small boiler rooms much easier to move around. Other advantages include reduced emissions and maintenance because these boilers burn cleaner.

Wichita Public Schools

This low-NO_x, high-efficiency condensing boiler was installed in 2013. Despite a 20% increase in facility square footage, the new unit used 16% less energy and saved $1,786 the first year it was operated.

The Wichita Public Schools passed bond issues twice, once in 2000 and again in 2008. These bond issues helped the district add low-NO_x burners to existing boilers, and replace some older boilers with condensing hot water boilers.

But even before the bonds were passed, the district had begun implementing operational changes that resulted in significant savings. "*We went from keeping our boilers on 'just in case' there was a meeting outside normal school hours, to operating*

the boilers on a 'just in time' schedule," said David Banks, energy manager for the Wichita Public Schools. This new policy reduced natural gas use by 37% and along with other energy and water saving policies, reduced utility expenses by 31%.

Lyon County

Facility manager, Mark McKenna, stands next to the new condensing hot water boiler. The old, less-efficient boiler is on the right and takes up about twice as much floor space as the new unit.

In 2011, Lyon County received a grant from the Department of Energy to replace one of its old boilers. The grant required Lyon County match the grant dollars for a total project budget of about $245,000.

According to facility manager Mark McKenna, *"Our primary project was to replace one of the older non-condensing hot water boilers with a smaller condensing boiler that also had a low-NO_x burner."* The new boiler is able to modulate down to a 1% firing rate. It also allows for a more seamless supply of needed hot water for the facility's air handling units hot-deck needs.

The condensing boiler, which is integrated with a newly installed building control system, allows for a lower supply set point. The unit's aluminum heat exchanger allows for greater flexibility in operating temperatures, but requires the loop pH to be maintained at 9.

Tax incentives and grants

To monitor for grants and incentives, a comprehensive resource is the Department of Energy's Database of State Incentives for Renewable and Efficiency (DSIRE). It contains federal, state, and local incentives including grants, loans, rebate programs, tax credits, and tax deductions. The Facility Conservation Improvement Program is for Kansas public entities and is administered through the Kansas Corporation Commission. Guide to Financing EnergySmart Schools includes additional incentives for schools.

Recent Air Quality Regulations that Impact Boilers

Which regulations may apply depends on various factors including the date a boiler was constructed or reconstructed, type of fuel burned and heat input capacity of the boiler, and whether the facility housing the boiler has other emission sources. Rules potentially include National Emissions Standard for Hazardous Air Pollutants 6J and 5D, a New Source Performance Standard, and Kansas air quality regulations. Visit the SBEAP air quality rules page to learn more about these rules and get the forms needed to be in compliance. You can also call 800-578-8898 to talk with a specialist about any questions you may have.

Mercury-containing devices

Still have mercury-containing devices laying around? If these devices crack or break and spill mercury, it may cost thousands to properly clean-up the mercury spill. If you have questions about how and where to recycle these old mercury devices, contact the SBEAP environmental hotline at 800-578-8898 or sbeap@ksu.edu.

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