



Improve boiler efficiency and reduce emissions

Introduction

Recent design and technology updates have resulted in more efficient boilers that require less maintenance than conventional models. However, for facilities not ready to replace their boilers, proper operation and maintenance is important to maximize efficiency. This will equate to cost savings due to reduced energy consumption and in some cases, reduced chemical use. It also results in reduced air pollutants, specifically NO_x, or nitrogen oxides, a by-product of combustion.

Boiler emissions

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 have been 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,

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.

because of the number of boilers in Kansas, industrial boilers emit more than 40,000 tons of NO_x emissions each year¹.

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.

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

Table 1. Compare potential to emit emissions for 6 MMBtu/hr or 144 HP²

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

¹Kansas 2011 [National Emissions Inventory](#) report prepared by Kansas Department of Health and Environment

²Assuming 80% efficiency

differently; they size them for the average temperature day and fit them with modulators that automatically adjust 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.

Low-cost boiler updates for improved efficiency

Insulation seems like common sense, but many facilities have room for improvement. Uninsulated steam-distribution and condensate return lines are constant sources 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 surfaces that reach temperatures greater than 120°F should be insulated, including boiler surfaces, steam and condensate return piping, and fittings³.

Low-NO_x burners are included with most new boilers, but can be a retrofit option for facilities not planning to replace older units. 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.

Installing an **RO unit** will reduce minerals in the water problematic to boiler maintenance. Treating the water can improve the amount of condensate return, minimize blowdown and decrease use of chemicals needed to maintain boilers.

Operational and maintenance tips

Operational changes are steps companies can take to more tightly manage or control their energy

use. These are often low- or no-cost steps that result in much savings. As noted in the case study that follows, Wichita Public Schools were able to reduce energy costs nearly 40% by running their boilers on a specific schedule based on the buildings' actual use.

Boiler tune-ups should be done annually and some air quality rules require proof of regular tune-ups. (Read more about air quality rules toward the end of this document.)

Clean Morrison and firetubes to improve heat transfer. To clean the Morrison tube, use soap and water, followed by a light coating of #2 diesel fuel to keep it from rusting. For firetubes, use portable firetube cleaning equipment, such as a tube-punching machine. It loosens scale and soot while collecting loosened deposits with a vacuum.

Other

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.

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.

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

Case Studies

Wichita Public Schools

The Wichita Public Schools passed bond issues twice, once in 2000 and again in 2008. These 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%.



This Wichita Public School 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.



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.

According to facility manager, Mark McKenna, “Our primary project was to replace one of the older noncondensing 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 nine (9).

Robert J. Dole VAMC

The Veterans Administration Medical Center, or VAMC, in Wichita is a joint commission- accredited, complexity-level-1C medical center facility that serves more than 25,000 veterans living in 59 counties of the state. Facility size is about 464,000 square feet. A boiler plant serves the medical center, which is comprised of a 41-bed hospital, 32-bed nursing facility and eight- bed hospice unit.

Lyon County

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



VAMC boiler plant manager, Keith Holt, next to a firetube boiler. Annual cleaning improves heat transfer.

Although three of its firetube boilers are 50 years old and one wet-back, firetube boiler is 31 years old, they have never been re-tubed and run at about 84% efficiency. The VAMC attributes this to the following dedicated operation and maintenance practices:

- ◆ Annually clean firetubes with soap and water, followed by a light coating of diesel fuel to improve heat transfer.
- ◆ Approximately twice per year, test combustion using an in-house analyzer; adjust settings, if needed.
- ◆ Train personnel on all equipment.

VAMC has reduced maintenance needs, such as boiler blowdown, after installing a reverse osmosis, **or RO, unit**. Treating the water has reduced minerals that are problematic to boiler maintenance. It has increased the amount of condensate return and decreased the need for chemicals to maintain the boilers.

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Tax incentives and grants

To monitor for grants and incentives, a comprehensive resource is the Department of Energy's [Database of State Incentives for Renewables & Efficiency](#). It contains federal, state and local incentives including grants, loans, rebate programs, tax credits and tax deductions. The [Rural Energy for America Program](#) is funded through the USDA and provides funding for energy efficiency and renewable energy projects for rural businesses and agricultural producers. The [Facility Conservation Improvement Program](#) is for Kansas public entities and is administered through the Kansas Corporation Commission. The [Guide to Financing EnergySmart Schools](#) includes additional incentives for schools.

Air Quality Regulations that Impact Boilers

Regulations that may apply to your boiler depend on various factors including the date it was constructed or reconstructed, type of fuel burned, heat input capacity and whether the facility housing it 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 and get the forms needed to be in compliance. You can also call 800-578-8898 to talk with a specialist about 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 of dollars to properly clean up the mercury spill. If you have questions about how and where to recycle these devices, contact the SBEAP environmental hotline at 800-578-8898 or sbeap@ksu.edu.

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