EPA regulations for boilers and efficiencies to reduce NO_x emissions

Kansas SBEAP

September 23, 2014

SBEAP services are paid for (in part) by the Kansas Department of Health and Environment.

Kansas State University

College of Engineering

Engineering Extension

Pollution Prevention Institute (PPI)

Small Business Environmental Assistance Program

Mission

SBEAP's mission is to help Kansas businesses comply with environmental regulations and identify pollution prevention opportunities.

KANSAS SBEAP
Small Business Environmental Assistance Program

Small Business Environmental Assistance Program

* Environmental compliance assistance
* Multimedia (air, waste, water, etc.)
* Confidential, free assistance
* Focus is on businesses with fewer than 100 employees
* Hotline, on-site assistance, Webinars, and workshops
* Contact information
  * Website: www.sbeap.org
  * Hotline: 800-578-8898
  * E-mail: sbeap@ksu.edu

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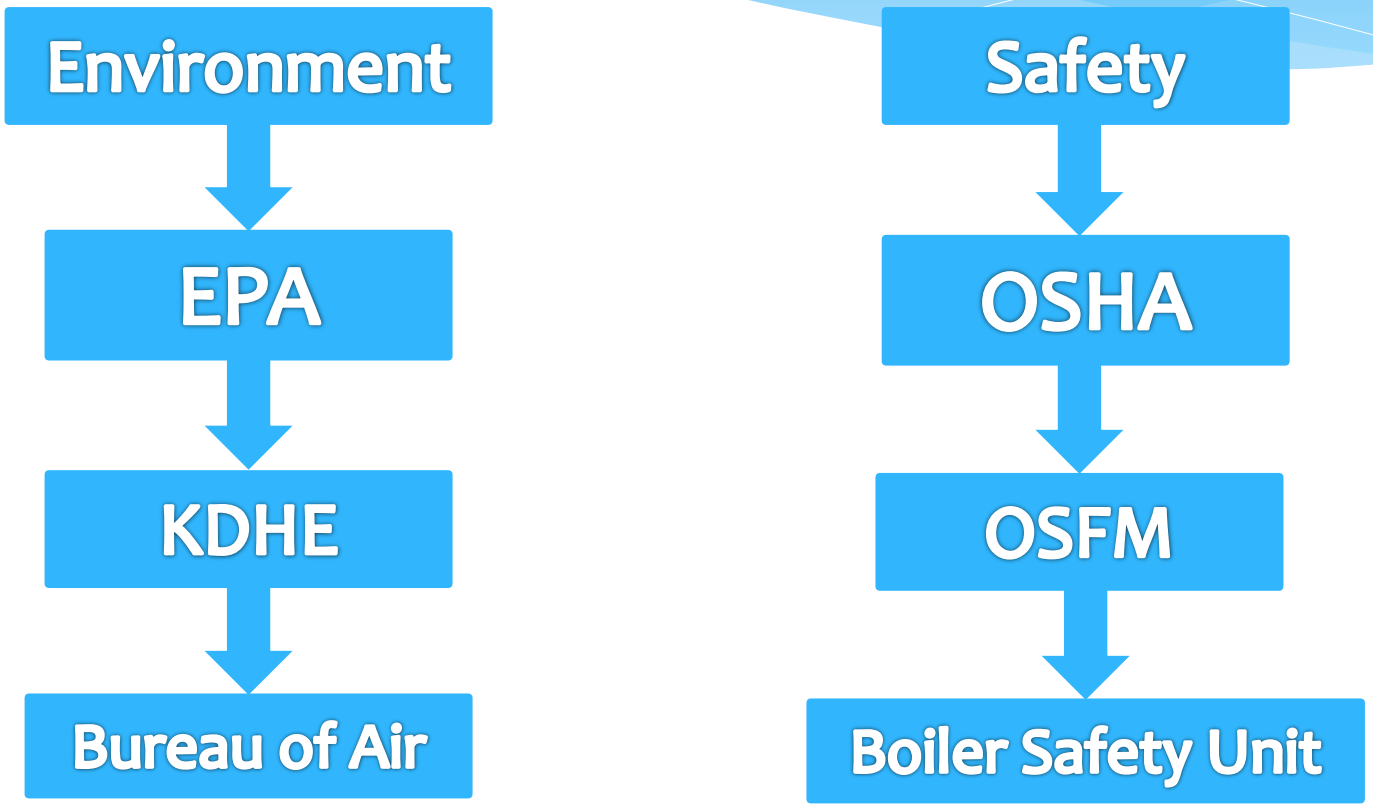
Environmental Regulations

EPA vs OSHA


Environment
EPA
KDHE
Bureau of Air
Safety
OSHA
OSFM
Boiler Safety Unit

What is a boiler?

* 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.*

Health benefits

* Cuts emissions of pollutants such as mercury, particle pollution, sulfur dioxide, dioxin, lead, and nitrogen dioxide.
* Pollutants can cause a range of dangerous health effects - from developmental disabilities in children to cancer, heart attacks and premature death.
* EPA estimates that Americans would receive $13 to $29 in health benefits for every dollar spent to meet the standards.

Source: U.S. EPA Webinar: Summary of 2012 Rules and Adjustments to Requirements, January 10, 2013

Air quality rules

* NESHAP "6J" – 40 CFR Part 63, subpart JJJJJJ
  * Area sources
* MACT "5D" – 40 CFR Part 63, subpart DDDDD
  * Major sources
* NSPS "Dc" – 40 CFR Part 60, subpart Dc
  * ≥10 and ≤100 MMBtu/hr
  * Installed after June 9, 1989
* KDHE construction permit or approval
* Class I or Class II air operating permits

What boiler rules apply?

* Area or major source facility
* Boiler fuel type
* Boiler construction date
* Boiler size

Area vs Major Sources

* NESHAP – National Emission Standards for Hazardous Air Pollutants
  * **major** source – facility emits or has PTE at least 10 tons/yr single HAP or 25 tons/yr combinations of HAPs
  * **area** source – not a **major** source

Boiler fuel type

* Natural gas
* Coal
* Oil
* Biomass
* Other solid and liquid non-waste materials

Boiler construction date

* Existing source – commenced construction or reconstruction on or before June 4, 2010
* New source – commenced construction or reconstruction of the boiler after June 4, 2010

	AREA	MAJOR
EXISTING	1/20/14 initial notification 3/21/14 in compliance 7/19/14 notification of compliance	5/31/13 initial notification due 1/31/16 in compliance
NEW	Initial notification due w/in 120 days of startup Be in compliance at startup	Initial notification due w/in 15 days of startup Be in compliance at startup

Possible requirements

* Conduct tune-up
* Conduct one-time energy assessment
  * Compiling a list of energy assessors
  * No certification needed – perform activities in the regs
* Meet emission limits

Example EPA tool to help determine area source compliance requirements

http://www.epa.gov/ttn/atw/boiler/imptools/fastfactsareasourcemarch2013.pdf

Example boiler:

- Oil-fired
- Constructed on or before June 4, 2010
- Heat input capacity = 12 MMBtu/hr

Fast Facts: Area Source Requirements
Industrial, Commercial, and Institutional Boilers
40 CFR Part 63, Subpart JJJJJJ

Do the Emission Limits Requirements Apply?

Heat Capacity (Btu/Hr)	Existing Coal Units	New Coal Units	Existing Oil Units	New Oil Units	Existing Biomass Units	New Biomass Units
≥10 MM	Yes [1]	Yes [1]	No	Yes [1,2,3]	No	Yes [1,2]
<10 MM	No	No	No	No	No	No

Am I required to do a One-Time Energy Assessment?

Heat Capacity (Btu/Hr)	Existing Coal Units	New Coal Units	Existing Oil Units	New Oil Units	Existing Biomass Units	New Biomass Units
≥10 MM	Yes [1]	No	Yes [1]	No	Yes [1]	No
<10 MM	No	No	No	No	No	No

Am I required to do a Tune-Up Every 5 Years?

Heat Capacity (Btu/Hr)	Existing Coal Units	New Coal Units			Existing Biomass Units	New Biomass Units	Existing Seasonal or limited use units	New Seasonal or limited use units
≥10 MM	No	No			Yes [4]	Yes [4]	Yes	Yes
<10 MM	Yes [4]	Yes [4]			Yes [4]	Yes [4]	Yes	Yes

			Existing Oil Units	New Oil Units				
>5 MM			Yes [4]	Yes [4]				
≤5MM			Yes	Yes				

[1] Provided the boiler does not meet the definition of limited-use boiler
[2] Provided the boiler does not meet the definition of seasonal boiler
[3] Boilers combusting only oil containing >0.50 weight % sulfur or a mixture of 0.50 weight % sulfur oil with other fuels not subject to PM emission limit and do not use a post combustion technology (except a wet scrubber) are not subject to emission limits
[4] Provided the boiler uses an oxygen trim system that maintains an optimum air-to-fuel ratio, otherwise tune-ups required biennially.

Boiler tune-ups

* Inspect burner, clean/replace components
* Inspect flame pattern, adjust burner to optimize flame pattern
* Inspect system controlling air-to-fuel ratio, ensure calibrated
* Optimize CO and NO_x emissions, consistent w/manufacturer's specs

Annual tune-ups (major)

* New & existing boilers and process heaters
  * heat input capacity >10 MMBtu/hr
  * without a continuous oxygen trim system

Biennial tune-ups (major)

* New & existing boilers or process heaters without a continuous oxygen trim system
  * heat input capacity of <10 MMBtu/hr
  * heavy liquid or solid fuel subcategories
* New & existing boilers or process heaters
  * <10 MMBtu/hr, but >5 MMBtu/hr
  * in any of the following subcategories:
    * gas 1
    * gas 2 (other)
    * light liquid

Tune-up every five years (major)

* New & existing boilers or process heaters with a continuous oxygen trim system that maintains an optimum air to fuel ratio
* New & existing boilers or process heaters
  * ≤ 5 MMBtu/hr
  * In any of the following subcategories
    * gas 1
    * gas 2 (other)
    * light liquid
* Limited-use boilers or process heaters

Biennial tune-ups (area)

* New & existing coal-fired boilers,
  < 10 MMBtu/hr
* New & existing biomass-fired boilers
* New & existing oil-fired boilers
  > 5 MMBtu/hr

(Provided none meet definition of seasonal or limited-use boiler, or use oxygen trim system that maintains an optimum air-to-fuel ratio.)

Tune-up every five years (area)

* New & existing seasonal boilers
* New & existing limited-use boilers
* New & existing oil-fired boilers, ≤ 5 MMBtu/hr
* New & existing boilers with an oxygen trim system that maintains an optimum air-to-fuel ratio (otherwise subject to a biennially tune-up)

One-time energy assessments (major)

* All existing affected boilers and process heaters
* http://www.epa.gov/ttn/atw/boiler/imptools/SummaryEnergyAssessmentsAreaSourceBoilersFinal.pdf
  * explains what an energy assessment must cover
  * defines a qualified energy assessor
* http://www1.eere.energy.gov/manufacturing/tech_deployment/energy_assessment.html - DOE guidance on energy assessments

One-time energy assessments (area)

* Existing coal, biomass, or liquid-fuel fired boilers ≥10 MMBtu/hr (except limited use boilers)
* http://www.epa.gov/ttn/atw/boiler/imptools/SummaryEnergyAssessmentsAreaSourceBoilersFinal.pdf
  * explains what an energy assessment must cover
  * defines a qualified energy assessor

Boiler Efficiency

Why boiler efficiency?

* More efficient boilers –
  * Use less energy;
  * Can save a facility money if operated at optimum level;
  * Emit fewer pollutants, specifically NO_x; and
  * Are required under some air quality regulations.

Many older boilers are oversized and single-stage (on-off).

Annual estimated savings for every $100 of fuel costs by increasing your heating equipment efficiency*

Existing System AFUE	New/Upgraded System AFUE 55%	60%	65%	70%	75%	80%	85%	90%	95%
50%	$9.09	$16.76	$23.07	$28.57	$33.33	$37.50	$41.24	$44.24	$47.36
55%	----	$8.33	$15.38	$21.42	$26.66	$31.20	$35.29	$38.88	$42.10
60%	----	----	$7.69	$14.28	$20.00	$25.00	$29.41	$33.33	$37.80
65%	----	----	----	$7.14	$13.33	$18.75	$23.52	$27.77	$31.57
70%	----	----	----	----	$6.66	$12.50	$17.64	$22.22	$26.32
75%	----	----	----	----	----	$6.50	$11.76	$16.66	$21.10
80%	----	----	----	----	----	----	$5.88	$11.11	$15.80
85%	----	----	----	----	----	----	----	$5.55	$10.50
90%	----	----	----	----	----	----	----	----	$5.30

*Assuming the same heat output

Source: http://www.energy.gov/energysaver/articles/furnaces-and-boilers

Boiler pollutants

Oil

- Carbon Monoxide
- Lead
- Nitrogen Oxides
- PM-Primary
- PM-Filterable
- PM-Condensible
- PM10-Primary*
- PM10-Filterable*
- PM2.5- Primary*
- PM2.5-Filterable*
- Sulfur Oxides
- Benzene
- Beryllium & Compounds
- Cadmium & Compounds
- Chromium & Compounds
- Cobalt Compounds
- Dioxins/Furans as 2,3,7,8-TCDD TEQ
- Ethylbenzene
- Formaldehyde
- Lead & Compounds
- Manganese & Compounds
- Mercury & Compounds
- Methyl Chloroform (1,1,1-Trichloromethane)
- Nickel & Compounds
- Toluene
- Xylenes (includes o, m, and p)
- Dioxins/Furans as 2,3,7,8-TCDD TEQ
- Ethylbenzene
- Formaldehyde
- Lead & Compounds
- Manganese & Compounds
- Mercury & Compounds

* PM10 and PM2.5 refer to PM less than or equal to an aerodynamic diameter of 10μm and 2.5μm, respectively.

Source: *Preferred and Alternative Methods for Estimating Air Emissions from Boilers*, Emission Inventory Improvement Program, Vol. II, Ch. 2, Jan 2001.

Boiler pollutants

POLLUTANTS ASSOCIATED WITH BOILER EMISSIONS

Criteria Pollutants	Hazardous Air Pollutants
Coal	
• Carbon Monoxide	• Antimony & Compounds
• Lead	• Benzene
• Nitrogen Oxides	• Beryllium & Compounds
• PM-Primary	• Cadmium & Compounds
• PM-Filterable	• Chromium & Compounds
• PM-Condensible	• Cobalt Compounds
• PM10-Primary*	• Dioxin/Furans as 2,3,7,8-TCDD TEQ
• PM10-Filterable*	• Ethylbenzene
• PM2.5- Primary*	• Formaldehyde
• PM2.5-Filterable*	• Hydrogen Chloride
• Sulfur Oxides	• Hydrogen Fluoride
	• Lead & Compounds
	• Manganese & Compounds
	• Mercury & Compounds
	• Methyl Chloroform (1,1,1-Trichloroethane)
	• Methyl Ethyl Ketone (2-Butanone)
	• Nickel & Compounds
	• Toluene
	• Xylenes (includes o, m, and p)

Source: *Preferred and Alternative Methods for Estimating Air Emissions from Boilers*, Emission Inventory Improvement Program, Vol. II, Ch. 2, Jan 2001.

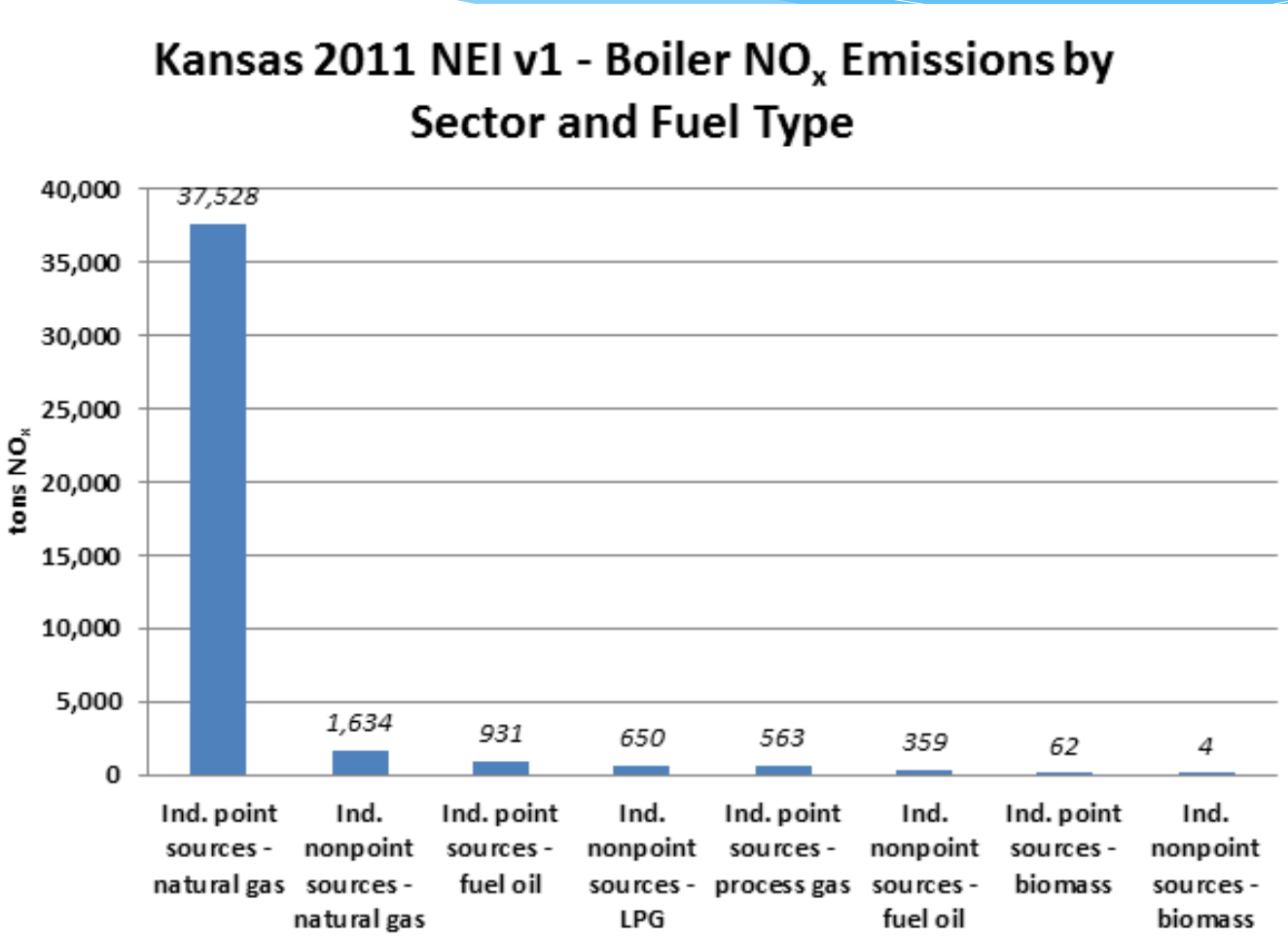
Boiler pollutants

POLLUTANTS ASSOCIATED WITH BOILER EMISSIONS

Criteria Pollutants	Hazardous Air Pollutants
Natural Gas	
• Carbon Monoxide	• Benzene
• Lead	• Cadmium & Compounds
• Nitrogen Oxides	• Chromium & Compounds
• PM-Primary	• Cobalt Compounds
• PM-Filterable	• Formaldehyde
• PM-Condensible	• Lead & Compounds
• PM10-Primary*	• Manganese & Compounds
• PM10-Filterable*	• Mercury & Compounds
• PM2.5- Primary*	• Nickel & Compounds
• PM2.5-Filterable*	• Toluene
• Sulfur Oxides	

Source: *Preferred and Alternative Methods for Estimating Air Emissions from Boilers*, Emission Inventory Improvement Program, Vol. II, Ch. 2, Jan 2001

Kansas NO_x data



Source: NEI and KDHE BOA

Why boiler efficiency?

* More efficient boilers –
  * Use less energy = $; and
  * Emit fewer pollutants, specifically NO_x.

* NO_x (nitrogen oxides)
* NO_x emissions are also an ozone precursor.
* NO_x emissions are associated with adverse respiratory health effects[1].

[1]http://www.epa.gov/air/nitrogenoxides/

Who should consider these upgrades?

* Boilers that use wood, oil or coal
* Boilers greater than 20 years old
* Non-condensing boilers

Emissions data in tons/yr for different fuel and technology (compares boilers 6 MMBtu/hr or 144 HP)

	Wood	Oil #1 or 2/ # 5 or 6	Natural gas uncontrolled	Natural gas low NO_x
NO_x	12.9	3.8/9.6	2.6	1.3
SO_x	0.7	0.04/13.9	0.02	0.02

Source: http://www.sbeap.org/content/page/potential-to-emit-calculators

Low-cost options

* Implement operational changes.
* Insulate distribution line.
* Perform regular tune-ups.
* Install low-NO_x burners.
* Minimize blowdown.
* Eliminate mercury switches.

Operational changes

* No more “keep it on just in case”
  * Usage based on specific schedule
* Savings 30%
* Boilers with modulating burners allow you to program based on outdoor weather, using only as much fuel as needed.

Insulate steam distribution*

Heat Loss Per 100 Feet of Uninsulated Steam Line

Distribution Line Diameter, inches	Heat Loss Per 100 Feet of Uninsulated Steam Line, MMBtu/yr			
	Steam Pressure, psig			
	15	150	300	600
1	140	285	375	495
2	235	480	630	840
4	415	850	1,120	1,500
8	740	1,540	2,030	2,725
12	1,055	2,200	2,910	3,920

Based on horizontal steel pipe, 75°F ambient air, no wind velocity, and 8,760 operating hours per year.

*U.S . DOE's AMO's steam Tip Sheet #2, http://www1.eere.energy.gov/manufacturing/tech_assistance/steam.html

Insulate steam distribution

Boiler tune-ups

* Inspect burner, clean/replace components
* Inspect flame pattern, adjust burner to optimize flame pattern
* Inspect system controlling air-to-fuel ratio, ensure calibrated
* Optimize CO and NO_x emissions, consistent w/manufacturer's specs

Low NO_x burners

* Retrofit option
* Costs ~10% more than regular burner
* Reduces NO_x emissions by almost 50%
* Best to talk with your burner manufacture

Minimize boiler blowdown*

* Review blowdown practices to identify energy-saving opportunities.
* Examine operating practices for boiler feedwater and blowdown rates developed by the American Society of Mechanical Engineers (ASME).
* Consider an automatic blowdown control system.

*U.S.DOE's AMO's Steam Tip Sheet #9, http://www1.eere.energy.gov/manufacturing/tech_assistance/steam.html

Use feedwater economizers for waste heat recovery*

* Feedwater economizer –
  * Transfers heat from flue gas to incoming feedwater
  * Reduces steam boiler fuel req'ts, often by 5-10%
  * Pays for itself in < 2 yrs
  * Use when insufficient heat transfer surface exists within the boiler to remove combustion heat
  * Excellent candidate: > 100 Bhp, > 75 psig, significantly loaded all year

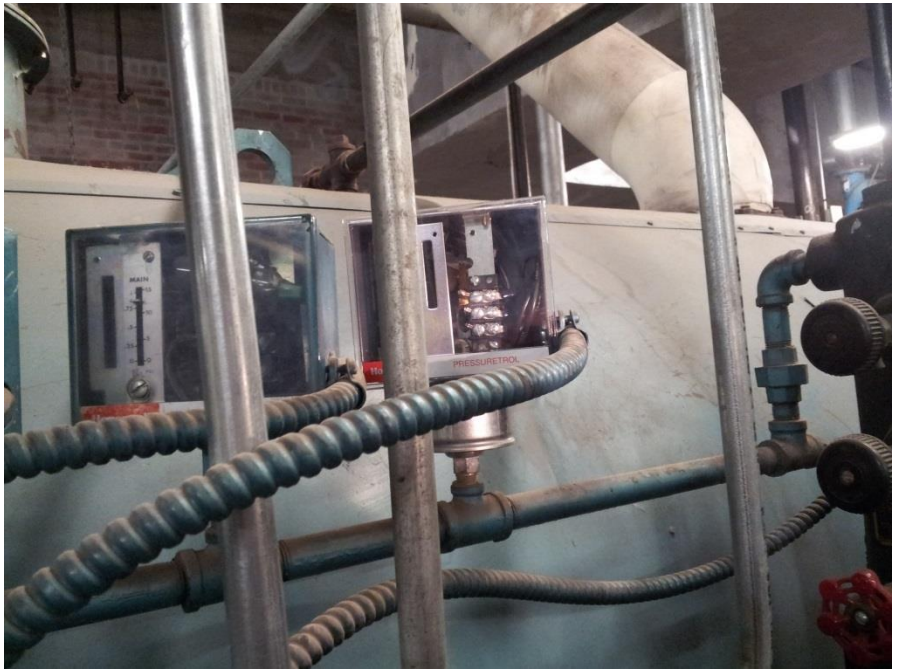
*U.S.DOE's AMO's Steam Tip Sheet #3, http://www1.eere.energy.gov/manufacturing/tech_assistance/steam.html

Upgrades

* Condensing boilers
  * 20-30% more efficient
  * Reduce or eliminate chemical blowdown and labor associated with blowdown
  * Reduce physical footprint

Eliminate mercury

* Safety and spill-prevention tip.
* Huge cost savings if a spill occurs.



Case study 1

* USD259 Wichita Public School
* 105 buildings
* 52,000 students
* 10,000,000 square feet of occupied space

Wichita Public School
105 Buildings
7,200,000 Square feet

	1993-1994	1999-2000	
Elec.	50,683753 Kwh	43,247,487 Kwh	15%
Nat. Gas	371,888 Mcf	233,246 Mcf	37%
Water	259,678 K-gal	150,284 K-gal	42%
	$6,476,774	$4,465,797	31%

Wichita Public School

* **2000 bond**
* Replaced 90% of old steam boilers with hot water boilers
* Low-NO_x burners
  * Burn cleaner and require less maintenance
* **2008 bond**
* Added condensing hot water boilers
* Two examples

Pleasant Valley Elementary

* 20% increase in square feet
* 2.4 MMBtu/hr steam replaced in 2013 with 2.3 MM Btu/hr hot water boiler (high efficiency, low NOx burner)
* 16% reduction in gas (weather adjusted)
* $1,786 annul estimate savings

Coleman Middle School

* Replacing two 4.5 MMBtu/hr steam boilers with four 2.0 MMBtu/hr condensing hot water boilers
* Zoning flexibility
* High Efficiency
* Projected savings 25%

Case study 2

* Lyon County
* 6 hot water boilers
* Updates to the jail (DOE grant) and other buildings

Lyon County

* DOE matching grant
* County jail
* Replaced 1993

2.4 MMBtu/hr boiler

* New condensing

1.1 MMBtu/hr hot water boiler

* pH considerations

Mark McKenna standing by new and old jail boilers

Lyon County

* 1952 3.4 MMBtu/hr steam boiler
* Converted to hot water boiler
* Pulled radiators
* Pro's and con's

Case Study 3

* Douglas County, Kansas
* Energy Efficiency Initiatives – Boilers

* Eileen Horn,
  Sustainability Coordinator

Douglas County Sustainability Goals

Douglas County will:

operations

- incorporate sustainable landscaping practices.
- continue to implement an organization-wide document management system to reduce paper waste.
- reduce waste (priority order: reduce consumption, reuse existing equipment, recycle or buy recycled products)
- incorporate sustainable practices into road operations.
- be more efficient with fuel consumption.

buildings

- **reduce energy consumption by 30% by 2015.** (2009 baseline)
- strive to meet LEED standards for certification in new County buildings.

employees

- create and deliver a sustainability employee education and action campaign.
- encourage sustainability as a routine and normal practice for Douglas County employees.

policies

- adopt policy to articulate that sustainability is a valued position.

community

- provide services to citizens in their homes when appropriate (i.e. online services).
- facilitate community understanding of sustainability practices.

Boiler Replacement – Courthouse Building

Existing Boiler
(Installed 1976)

- 80% fuel efficiency rating (at installation in 1976).
- Likely fuel efficiency after 33 years = 55-60%.
- Annual natural gas costs for Courthouse = **$14,456** (3 year average)

New Aerco Boiler
(25-30 year lifespan)

- 99% fuel efficiency rating.
- Cost of equipment and installation = $50,000
- Energy savings = 300-600 mcf of natural gas/year.
- Projected annual utility bill savings = **$5,783**

(Time to payback = 9 years)

Additional Considerations:

- Likelihood of a mid-winter outage increases due to current boiler age. **Cost of temporary boiler = $20,600.**
- Reduced maintenance costs with new equipment.
- Eligible for historical tax credits (up to 25% of cost)

- Over *new boiler lifetime*, avoids **650 tons of CO2 =**

Annual greenhouse gas emissions from **124 cars**

CO_2 emissions from **1,511 barrels of oil**

CO_2 emissions from **55 homes for one year**

Sustainability and Energy Savings Reinvestment Fund

buildings

* Created in November 2011
* Initially seeded with $300,000 (in equipment reserve) Available funds: $173,000
* **Projects funded to date: 11**

  * **<u>Priority for funding given to projects that:</u>**
    1. Reduce energy costs and operating expenses.
    2. Promote the implementation of innovative sustainability solutions.
    3. Demonstrate County's commitment to sustainability, stewardship, and conservation.

Funding resources

* www.dsireusa.org – Database of State Incentives for Renewables & Efficiency
  * KC BPU Rebate Program (install electric boilers)
  * How$mart® – Midwest Energy electricity or gas customers
* Facility Conservation Improvement Program (FCIP) – public entities
* Guide to Financing EnergySmart Schools
* Business Energy Investment Tax Credit (ITC) – const begin before 12-31-11
* Energy-Efficient Commercial Buildings Tax Deduction – expired 1-1-14

Resources

* http://www1.eere.energy.gov/manufacturing/tech_assistance/steam.html - Steam tools, training, assessments, case studies, tip sheets, tech pubs
* www.energystar.gov/guidelines - Energy Star guidelines for energy management
* http://www.epa.gov/ttn/atw/boiler/boilerpg.html - EPA ICI boiler and process heater, rules and tools
* http://www.youtube.com/watch?v=DqTOxmFg6NM – technical training on "Efficient Upgrade-Condensing Boilers"
* www.sbeap.org/aqrules - 6J and 5D air quality rules

Questions?

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