

Saving Energy in Process Steam Systems

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ActOnEnergy.com

This presentation covers process steam energy reduction projects supported by the Ameren Illinois ActOnEnergy program.

Practical Items

If you can't hear me, please type a message in the **Chat** feature located on the right-hand side of your screen. You can also check the volume controls on your computer or adjust the WebEx controls.

Please type any questions you have during the presentation into the "Chat" feature located at the bottom, right-side of your computer screen.

Quiz Questions – What do you already know about process steam?

1. How much could repairing a steam trap save a facility per year on its natural gas bill?
2. True or False: Many low-cost steam system improvements have paybacks of less than two years
3. How much of the heat generated by a steam boiler is carried away by the exhaust flue.
4. Which of the following types of steam and hot water equipment does the Ameren Illinois ActOnEnergy program offer incentives for?

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Before we get started, here are four questions to find out what you already know about saving money in process steam systems.

How much could repairing a steam trap save a facility per year on its natural gas bill?

- A. Up to \$100
- B. Up to \$1,000
- C. Up to \$5,000
- D. Up to \$10,000
- E. Over \$10,000**

True or False: Many low-cost steam system improvements have paybacks of less than two years.

- A. True**
- B. False

How much of the heat generated by a steam boiler is carried away by the exhaust flue?

- A. 10%
- B. 20%**
- C. 30%
- D. 40%

Which of the following types of steam and hot water equipment does the Ameren Illinois ActOnEnergy program offer incentives for?

- A. New furnaces and boilers
- B. Steam traps
- C. Boiler burners
- D. Boiler shell and steam distribution system
- E. A, B, and C
- F. **All of the above**

Today's Topics



Best practices in process steam system equipment and application



Incentives available through ActOnEnergy



How to get started on your energy-efficient process steam system project

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The first thing I'll do is introduce the topics we'll cover today. Today we're going to talk about best practices in process steam, the incentives available through the ActOnEnergy program, and how to get started on your project. The information presented today will help you identify process steam energy reduction projects and how to save money on you natural gas bill.

ActOnEnergy Incentive Areas

Lighting	HVAC & Water Heaters
Variable Frequency Drives (VFD)	Process Steam/Steam Traps
Retro-Commissioning – Compressed Air	Custom Electric and Gas

To get to the Online Store, type:
www.ActOnEnergy.com/businessonlinestore
into your browser.

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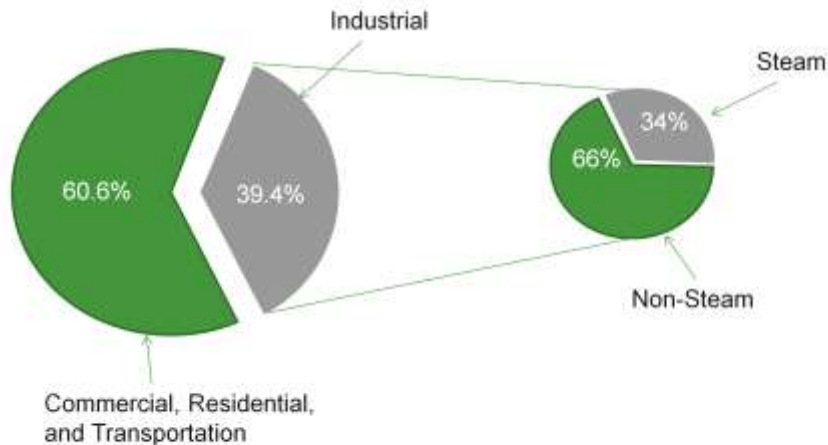
Now I'll tell you a little about the ActOnEnergy Program.

Ameren Illinois' ActOnEnergy program offers financial incentives to customers to be more energy-efficient. Energy-efficient upgrades not only lower your energy bills, they can also reduce maintenance costs, improve comfort, provide precise control and extend equipment life. The Ameren Illinois' ActOnEnergy initiative helps businesses use less energy and save more money.

The ActOnEnergy programs include electric and gas incentives, where the incentive is paid to you after you complete the project. There are also energy-saving products available at the ActOnEnergy Online Store, where the incentive is built into the price. The Online Store is located at www.ActOnEnergy.com/businessonlinestore.

Process Steam Energy Intensity

Steam Use



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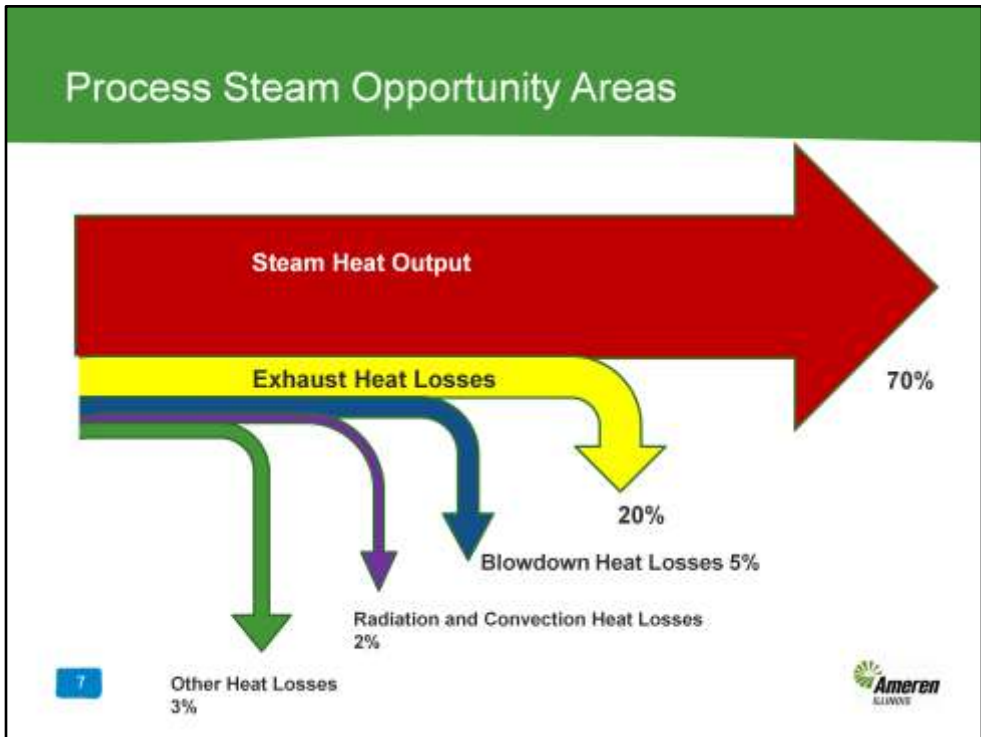


Improving your process steam system can save energy.

Nationally, manufacturers are the single largest users of energy, with over 39% of total energy use for the country. Steam accounts for over one-third of this usage and is a significant cost-center for some manufacturers.

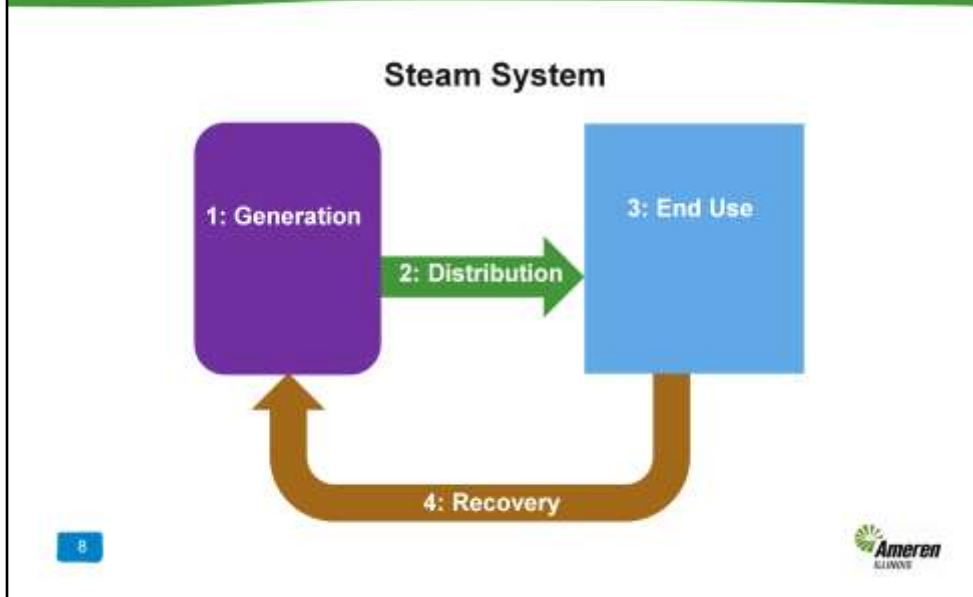
Therefore, reducing energy usage through process steam system improvements can save you money on your energy bill.

SOURCE: U.S. Department of Energy, Energy Information Administration. (DOE-EIA, 2004).



When utilizing steam, the first step is steam production. The diagram shown represents the energy flow in a typical steam production system. As you can see, most of the heat leaves the boiler as steam heat, but there is still significant heat carried away through the exhaust flue and through boiler blowdown. With this in mind, most of the opportunity areas concentrate on the steam output of the demand-side where steam energy reduction will reduce your energy input more than the energy taken off line. But note that there are also opportunities on the supply-side of almost every boiler system.

Process Steam Energy Efficiency Opportunities



This presentation uses four categories to discuss process steam system components and ways to enhance steam system performance: generation, distribution, end use, and recovery. These four areas follow the path of steam as it leaves the boiler and returns via the condensate return system.

In an industrial setting, there are wide ranges of steam system sizes, configurations, end-use applications, and operating practices. As a result, there are many different ways to improve steam system performance and identify improvement opportunities. We will discuss several opportunities you may be able to take advantage of.

Process Steam Energy Efficiency Incentives



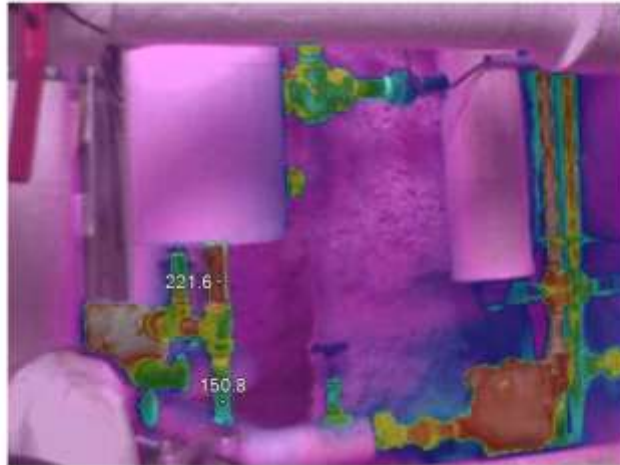
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Now we'll discuss several different opportunities to save energy in your process steam system.

Opportunity #1 – Steam Trap Repair/Replacement

In steam systems that have not been maintained for 3 to 5 years, between 15% and 30% of the installed steam traps may have failed.



In steam systems that have not been maintained for 3 to 5 years, between 15% to 30% of the installed steam traps may have failed, allowing live steam to escape into the condensate return system.

In systems with a regularly scheduled maintenance program, leaking traps should account for less than 5% of the trap population.

If your steam distribution system includes more than 500 traps, a steam trap survey will probably reveal significant steam losses.

Opportunity #1 – Steam Trap Repair/Replacement

- Recommended steam trap testing intervals:
 - High-Pressure (150+ psig) – Weekly to monthly
 - Medium-Pressure (30-150 psig) – Monthly to quarterly
 - Low-Pressure (below 30 psig) - Annually
- Four basic ways to test: temperature, sound, visual, and electronic



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Steam traps are tested to determine if they are functioning properly and not cold plugging or failing in an open position and allowing live steam to escape into the condensate return system. There are four basic ways to test steam traps: temperature, sound, visual, and electronic.

Recommended steam trap testing intervals include:
High-Pressure (150+ psig) – Weekly to monthly
Medium-Pressure (30-150 psig) – Monthly to quarterly
Low-Pressure (below 30 psig) - Annually

Opportunity #1 – Steam Trap Repair/Replacement



- Annual savings can range from \$80 to several thousand dollars
- ActOnEnergy incentives range from \$100/trap to \$400/trap
- Use the ActOnEnergy Steam Trap application for this measure

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When repairing a steam trap, the annual savings can range from \$80 to several thousand dollars, depending on steam pressure, operating hours, and the trap orifice size.

ActOnEnergy incentives range from \$100/trap to \$400/trap, depending on the system type and pressure.

This is a low-cost measure that can be funded out of a facility's maintenance budget and can pay back in less than two years.

Use the ActOnEnergy Steam Trap application for this measure.

Opportunity #2 – Repair Steam Leaks

Steam leaks:

- Are routinely ignored by many manufacturing facilities
- Are inevitable due to day-to-day wear and tear on pipes and valves

There is no recommended steam leak testing interval

- Part of a steam leak repair program
- Should be repaired as quickly as possible



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Another opportunity is to repair steam leaks. Steam piping components fail as a result of improper design, corrosion, external factors, and many other reasons, resulting in leaks.

From an energy analysis standpoint, steam leaks must be eliminated because they are a direct waste of the fuel resources. Similar to the steam trap repair this is a demand reduction which will reduce the steam output and losses at the boiler, reducing the total gas consumption. A steam leak should be repaired as quickly as possible. There is no recommended steam leak testing interval.

Generally, safety concerns are a major driving factor in the repair of steam leaks. However, energy loss can help justify the maintenance expense when safety is not an issue. Basically, the loss associated with a steam leak is identical to that of vented steam.

Opportunity #2 – Repair Steam Leaks

There are three basic ways to identify steam leaks:

- Sound
- Visual
- Electronic



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Leaks can often be detected in 3 ways: by sound, visually, or electronically. In some cases, larger leaks are not immediately repaired simply because the operator thinks that the leak is not a leak but a normal part of the operation. In most cases, steam should not be visible in a plant, as it should be discharged in a return system.

Infrared scanners and ultrasonic equipment can help detect smaller leaks.

Opportunity #2 – Repair Steam Leaks

Repairing a steam leaks can save you from \$400 to several thousand dollars annually

The ActOnEnergy incentive for this measure is \$1.20/therm

Use the ActOnEnergy Custom application for this measure



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Similar to failing steam traps, the annual savings varies greatly between systems and type of leak. But again, this is a low-cost measure that can be funded out of a facility's maintenance budget and can pay back in less than two years.

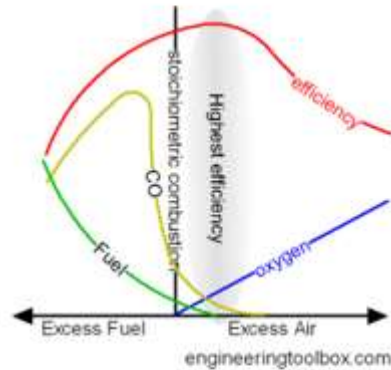
The ActOnEnergy incentive for this measure is \$1.20/therm. You should use the ActOnEnergy Custom application for this measure.

Opportunity #3 – Improve Boiler Combustion Efficiency (Tune Boiler Burners)

Boilers often operate at excess air levels higher than the optimum

Use hand-held, computer-based analyzer (purchase or buy service)

Rule of thumb: boiler efficiency can be increased 1% for each 15% reduction in excess air or 40°F reduction in stack gas temperature



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Operating your boiler with an optimum amount of excess air will minimize heat loss up the stack and improve combustion efficiency. Boilers often operate at excess air levels higher than the optimum.

Combustion efficiency is a measure of how effectively the heat content of a fuel is transferred into usable heat. The stack temperature and flue gas oxygen (or carbon dioxide) concentrations are primary indicators of combustion efficiency. Reducing the amount of heat lost up the stack allows more of the fuel energy to be transferred to the steam.

The correct amount of excess air is determined from analyzing flue gas oxygen or carbon dioxide concentrations. Inadequate excess air results in unburned combustibles (fuel, soot, smoke, and carbon monoxide) while too much results in heat lost due to the increased flue gas flow, lowering the overall boiler fuel-to-steam efficiency. Periodically monitor flue gas composition and tune boilers as needed.

On well-designed natural gas-fired systems, an excess air level of 10% is attainable. There are expensive systems available that complete real time monitoring that can reduce the excess air to the optimal point, they are generally feasible only from the largest boilers. An often-stated rule of thumb is that boiler efficiency can be increased by 1% for each 15% reduction in excess air or 40°F reduction in stack gas temperature.

The recommended measuring and tuning intervals are that there are no set standard; it depends on boiler size, presence of controls, operating hours, & energy usage.

To measure, use a hand-held, computer-based analyzer that you can purchase or buy as a service.

Opportunity #3 – Improve Boiler Combustion Efficiency (Tune Boiler Burners)



- Annual savings can range from several hundred to several thousand dollars
- The ActOnEnergy incentive for this measure is \$1.20/therm
- Use the ActOnEnergy Custom application for this measure.

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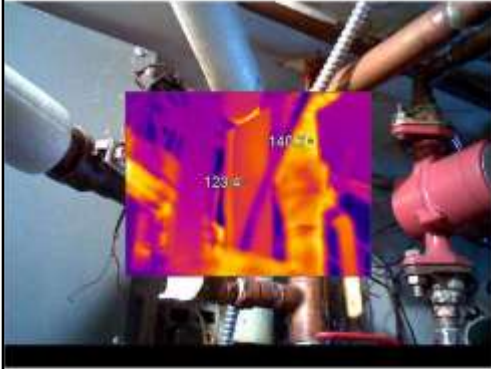


Tuning a boiler, the annual savings can range from several hundred to several thousand dollars, depending on steam production, steam pressure, operating hours, stack temperature, and excess air level.

This is a low-cost measure that can be funded out of a facility's maintenance budget and can pay back in less than two years.

The ActOnEnergy incentive for this measure is \$1.20/therm. Use the ActOnEnergy Custom application for this measure.

Opportunity #4 – Insulate Hot Water, Steam Distribution, and Condensate Return Lines



Insulation reduces energy loss from piping and equipment surfaces

- Note that all of the energy losses cannot economically be eliminated
- Conduct analysis to determine insulation composition, thickness, and areas of installation

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Uninsulated steam distribution and condensate return lines are a constant source of wasted energy. Any surface over 120°F should be insulated, including boiler surfaces, steam and condensate return piping, and fittings.

Insulation frequently becomes damaged or is removed and never replaced during steam system repair. Damaged or wet insulation should be repaired or immediately replaced to avoid compromising the insulating value.

Eliminate sources of moisture prior to insulation replacement. Causes of wet insulation include leaking valves, external pipe leaks, tube leaks, or leaks from adjacent equipment. After steam lines are insulated, changes in heat flows can influence other parts of the steam system.

The amount of heat loss due to inadequate insulation is a function of the surface area exposed, beyond the straight line pipe insulation. Removable insulating jackets are available for valves, flanges, steam traps, and other fittings. Remember that a 6-inch gate valve may have more than 6 square feet of surface area from which to radiate heat.

Opportunity #4 – Insulate Hot Water, Steam Distribution, and Condensate Return Lines



- Annual savings can range from several hundred to several thousand dollars
- The ActOnEnergy incentive for this measure is \$1.20/therm
- Use the ActOnEnergy Custom application for this measure

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Insulating a line, the annual savings can range from several hundred to several thousand dollars, depending on steam temperature, operating hours, pipe diameter, and the length of pipe.

For spot repairs and small projects, this is a low-cost measure that can be funded out of maintenance budget. For larger projects, this is a medium-cost measure that will require capital funding. You can also install removable insulation on valves and fittings.

Both smaller and larger projects can pay back in less than two years. The ActOnEnergy incentive for this measure is \$1.20/therm and you should use the ActOnEnergy Custom application for this measure.

Just as a reminder before we have our next quiz question that the steam production and distribution are two separate but connected systems. The boiler in the bottom picture which has all the insulation stripped off has the highest combustion efficiency of any boilers of that technology I have tested. The project still recommended replacing the boiler.

Quiz Question – Do All ActOnEnergy Custom Projects Require Pre-Approval?

- A. Yes
- B. No

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Opportunity #5 – Upgrade Boilers with Energy-Efficient Burners (Replace Burners)

- Provide the proper air-to-fuel mixture throughout the full range of firing rates, without constant adjustment
 - Many burners with complex linkage designs do not hold their air-to-fuel settings over time
 - Often, they are adjusted to provide high levels of excess air to compensate for inconsistencies in the burner performance
- A new energy-efficient burner should be considered if repair costs become excessive, reliability becomes an issue, or the energy reductions are significant



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Now I'm going to tell you about more capital-intensive process steam system opportunities. A boiler will run only as well as the burner performs. A poorly designed boiler with an efficient burner may perform better than a well-designed boiler with a poor burner. Burners are designed to maximize combustion efficiency while minimizing the release of emissions.

You want to provide the proper air-to-fuel mixture throughout the full range of firing rates, without constant adjustment. Many burners with complex linkage designs do not hold their air-to-fuel settings over time. Often, they are adjusted to provide high levels of excess air to compensate for inconsistencies in the burner performance.

An efficient natural gas burner requires only 2% to 3% excess oxygen, or 10% to 15% excess air in the flue gas, to burn fuel without forming excessive carbon monoxide. Most gas burners exhibit turndown ratios of 10:1 or 12:1 with little or no loss in combustion efficiency.

A new energy-efficient burner should be considered if repair costs become excessive, reliability becomes an issue, or the energy reductions are significant. For example, consider purchasing a new energy-efficient burner if your existing burner is cycling on and off rapidly. Rotary-cup oil burners that have been converted to use natural gas are often inefficient. Determining the potential energy saved by replacing your existing burner with an energy-efficient burner requires several steps.

First, complete recommended burner-maintenance requirements and tune your boiler. Conduct combustion efficiency tests at full- and part-load firing rates. Then, compare the measured efficiency values with the performance of the new burner. Most manufacturers will provide guaranteed excess levels of oxygen, carbon monoxide, and nitrous oxide.

Opportunity #5 – Upgrade Boilers with Energy-Efficient Burners (Replace Burners)

- The ActOnEnergy incentive for this measure is \$1.20/therm
- This is a large-cost measure that will require capital funding
- This measure can pay back in less than two years
- Use the ActOnEnergy Custom application for this measure



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Annual savings can range from several hundred to several thousand dollars, while the ActOnEnergy incentive for this measure is \$1.20/therm.

This is a high-cost measure that will require capital funding. It can pay back in less than two years.

Opportunity #6 – Clean Boiler Waterside Heat Transfer Surfaces

- Even on small boilers, the prevention of scale formation can produce substantial energy reductions
- Even thin layers of scale serve as an effective insulator and retard heat transfer
- The result is overheating of boiler tube metal, tube failures, and loss of energy efficiency
- Fuel waste due to boiler scale may be 2% for water-tube boilers and up to 5% for fire-tube boilers



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Heat transfer surfaces should be cleaned periodically. Cleaning intervals depend on individual systems based on the boiler type and amount of makeup water used. Boiler water sampling can detect fouling on the water side.

Even on small boilers, the prevention of scale formation can produce substantial energy reductions. Even thin layers of scale serve as an effective insulator and retard heat transfer. The result is overheating of boiler tube metal, tube failures, and loss of energy efficiency. Fuel waste due to boiler scale may be 2% for water-tube boilers and up to 5% for fire-tube boilers.

It is recommended that surfaces be cleaned at least once a year. Correct blowdown and water treatment will aid in keeping the water side surface clean. Insufficient blowdown will increase the amount of dirt in the steam system.

An indirect indicator of scale or deposit formation is flue gas temperature. If the flue gas temperature rises (with boiler load and excess air held constant), the effect is possibly due to the presence of scale.

Opportunity #6 – Clean Boiler Waterside Heat Transfer Surfaces



- The ActOnEnergy incentive for this measure is \$1.20/therm
- This is a low- to medium-cost measure that can be paid using either the maintenance budget or, when piggy-backed with another measure, through capital funding
- This Best Practice can pay back in less than two years
- Use the ActOnEnergy Custom application for this measure

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Annual savings can range from several hundred to several thousand dollars, while the ActOnEnergy incentive for this measure is \$1.20/therm.

For smaller projects, this is a low-cost measure that can be funded out of a facility's maintenance budget. Larger projects will require capital funding. Both smaller and larger projects can pay back in less than two years.

Opportunity #7 – Recover Waste Heat and Reuse

- Several different options, all capital intensive
 - Return condensate to boiler
 - Recover heat from boiler blowdown
 - Install feedwater economizer to capture heat from the flue gas and transfer to incoming feedwater
 - Install heat recovery heat exchanger to warm some other load
- This list is not exhaustive; there are many other opportunities available for process steam generation and distribution systems



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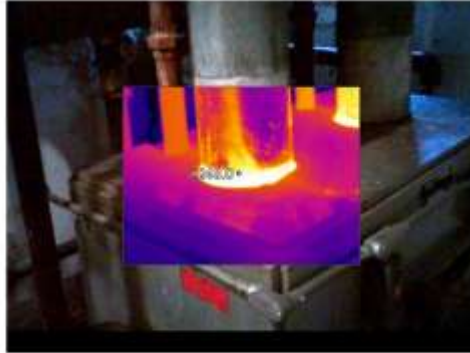
Heat losses are unavoidable in the operation of all boilers. Air and fuel are mixed and burned to generate heat, and a portion of this heat is transferred to the boiler and then on to water to make steam. When the energy transfer reaches its practical limit, the spent combustion gases are removed (exhausted) from the boiler via a flue or stack to make room for a fresh charge of Combustion gases. At this point, the exhaust flue gases still hold considerable thermal energy.

Additionally, boiler blowdown and condensate return also contain significant amounts of thermal energy. Reducing these losses should be a high priority for anyone interested in improving the energy efficiency of process steam systems.

These four measures concentrate on recovering waste heat and reusing it either at the boiler or elsewhere in the plant. Whenever possible, waste heat should be recovered. In addition to energy reductions, heat recovery also reduces water and chemical use of the boiler.

Opportunity #7 – Recover Waste Heat and Reuse

- The ActOnEnergy incentive for these measures is \$1.20/therm
- These are medium- to high-cost measures that will require capital funding
- These Best Practices have a range of paybacks, depending on the system and usage
- Use the ActOnEnergy Custom application for these measures



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Annual savings can range from several hundred to several thousand dollars, while the ActOnEnergy incentive for these measures is \$1.20/therm.

These are high-cost measures that will require capital funding. The paybacks range widely, depending on the system and usage.

Case Studies



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Now, let's look at a couple of case studies so you can see how the incentives work to help you save energy and money.

Case Study #1 – Chemical Plant



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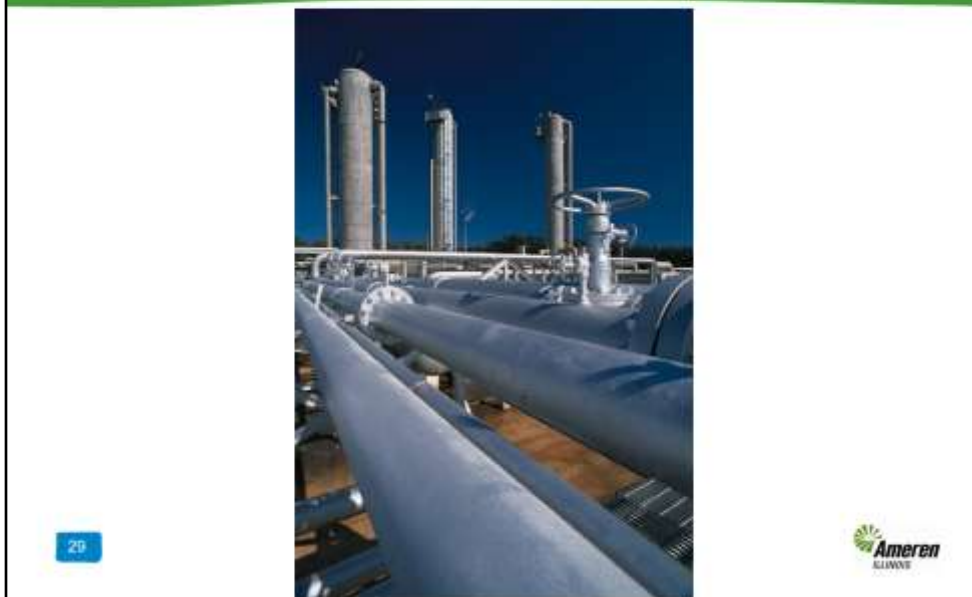
The first case study involves a chemical plant, where changes in some of the plant's processes led personnel to evaluate the feasibility of reducing the steam header pressure. The team decided to incrementally decrease header pressure while monitoring the effects of this change on system performance.

The pressure was reduced twice, and each time the system was carefully monitored to ensure there was no detrimental impact on system operation.

The plant now operates the system at 100 psig, down from 125 psig, resulting in annual energy savings of 8% and an annual cost reduction of \$142,000.

We don't know where this chemical plant is located and whether the chemical plant received incentive dollars for this project. However, if an industrial facility conducted a similar project in the Ameren Illinois territory and applied for ActOnEnergy incentives at today's incentive levels, they could receive incentives for as much as 50% of the project cost under the Custom Gas application.

Case Study #2 – Fertilizer Plant



The second case study we'll look at involves a fertilizer plant. The three following measures were implemented at a fertilizer plant that conducted an assessment of its process steam system.

The plant balanced its steam load by operating natural gas-fired utility boilers when the plant load exceeds the capacity of the two acid plants. Under certain conditions excess steam is vented to atmosphere to maximize sulfuric acid production. This steam could be used for process steam, replacing steam generated by the utility boilers. This resulted in a 10% reduction in vented steam that reduced energy consumption by 640,000 therms and saved \$295,000 annually.

From a completed steam trap survey, it was found that annual energy reductions of 210,000 therms that would save \$98,000 were feasible from repairing the plant's failed steam traps.

A steam leak survey was also conducted at this fertilizer plant, which indicated that repairing these leaks could yield annual energy reductions of more than 12,600 MMBtu and associated savings of \$59,000.

If the fertilizer plant in this example was eligible and had applied for ActOnEnergy incentives at today's incentive levels, they could have received incentives of up to \$200,000 for all of the projects mentioned under the Custom Gas and Process

Steam/Steam Trap applications.

Getting Started



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You may be wondering how to get started on your process steam project. There are several options.

A first check would be to see if you can determine what equipment you have. To find out what equipment you have, find the model numbers and performance ratings using the nameplates, cut sheets, and operator guides. An Internet search of manufacturer and distributor websites can also reveal information on your equipment.

Another way to get started is conduct a survey of your steam traps to see if they are in working order. There are incentives available to conduct surveys of the steam traps in your process steam systems under the Steam Trap Survey program. There are incentives in the amount of \$30 to \$50 per steam trap for process steam and steam trap surveys, depending on the amount of pressure, and incentives of \$30 for surveys of your HVAC system. Complete the Process Steam/Steam Trap application to apply for these incentives.

The incentives for surveys are in addition to the incentives available for replacing components of your process steam systems.

Energy Advisors



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Yoelit Hiebert yoelit.h.hiebert@saic.com	309.336.2045



Another way to get started on your project is to contact an Energy Advisor. This map shows which Energy Advisors cover each territory in Illinois. Contact the Energy Advisor for your territory to speak with someone from the ActOnEnergy program about your energy-efficiency project.

Resources

Program

- Website: www.ActOnEnergy.com
- Phone: (866) 800-0747
- Fax: (309) 677-7950
- E-mail: ActOnEnergyBusiness@Ameren.com

Natural gas lead/Technical Reviewer

- Dave Kilgore e-mail: dkilgore@ameren.com

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Here are some resources where you can get more information about the ActOnEnergy Program. Please visit our website to learn more and to determine which projects are right for you.

Other Resources

U.S. Department of Energy Industrial Technologies Program

Steam Source Book:

<http://www1.eere.energy.gov/industry/bestpractices/pdfs/steamsourcebook.pdf>

Tip Sheets:

http://www1.eere.energy.gov/industry/bestpractices/tip_sheets_steam.html

Technical Fact Sheets:

http://www1.eere.energy.gov/industry/bestpractices/techpubs_steam.html

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Here are some other resources that may help you identify or quantify process steam system projects at your facility.

Other Resources

Smart Energy Design Assistance Center (SEDAC)

Energy Assessments

<http://smartenergy.arch.uiuc.edu/energy-assessment.html>

Illinois Department of Commerce and Economic Opportunity (DCEO)

Large-Customer Energy Analysis Program (LEAP):

http://www.commerce.state.il.us/dceo/Bureaus/Energy_Recycling/Energy/Energy+Efficiency/meep_program.htm

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Finally, here are links to the energy assessment resources we mentioned earlier.

Quiz Questions – What do you already know about process steam?

1. How much could repairing a steam trap save a facility per year on its natural gas bill?
2. True or False: Many low-cost steam system improvements have paybacks of less than two years
3. How much of the heat generated by a steam boiler is carried away by the exhaust flue.
4. Which of the following types of steam and hot water equipment does the Ameren Illinois ActOnEnergy program offer incentives for?

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Now it's time to take the final quiz to see what you learned today.

How much could repairing a steam trap save a facility per year on its natural gas bill?

- A. Up to \$100
- B. Up to \$1,000
- C. Up to \$5,000
- D. Up to \$10,000
- E. Over \$10,000**

True or False: Many low-cost steam system improvements have paybacks of less than two years.

- A. True**
- B. False

How much of the heat generated by a steam boiler is carried away by the exhaust flue?

- A. 10%
- B. 20%**
- C. 30%
- D. 40%

Which of the following types of steam and hot water equipment does the Ameren

Illinois ActOnEnergy program offer incentives for?

- A. New furnaces and boilers
- B. Steam traps
- C. Boiler burners
- D. Boiler shell and steam distribution system
- E. A, B, and C
- F. **All of the above**

Questions

- Measures
- Natural gas program
- ActOnEnergy® program