tech overview

applicable building types
hotels, multifamily and commercial
implementation
anytime
fast facts
- reduces GHG emissions
- improves comfort and satisfaction
- provides temperature control and balanced distribution
- increases utility savings

tech primer

One-Pipe Steam Optimization

Simple measures for one-pipe steam systems that enhance efficiency and comfort.

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cost & benefits

GHG savings

Tenant Experience Improvements

Utility Savings

Capital Costs

Maintenance Requirements

*ratings are based on system end use, see back cover for details.

Getting to know one-pipe steam systems

Although one-pipe steam is commonly associated with overheating and energy waste, optimizing these systems with a few high-efficiency upgrades can reduce energy bills and improve resident comfort.

How do one-pipe steam systems work?

One-pipe steam systems distribute steam through a building's pipes to radiators that heat occupant spaces. One-pipe systems are similar to two-pipe systems, however the main difference is how condensate (the water created when steam cools) is handled through the layout of piping.

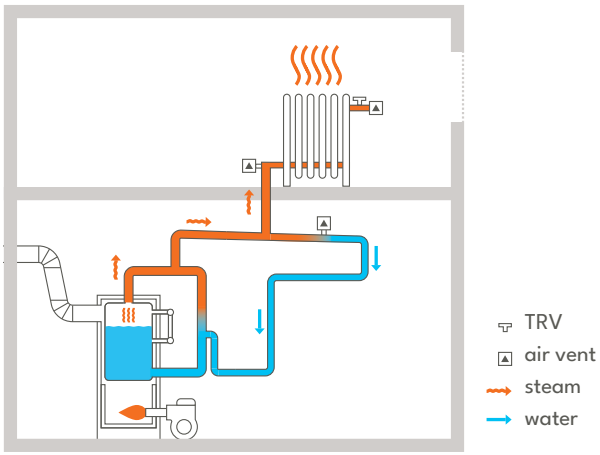
One-pipe steam systems have one pipe that connects to each radiator (see Fig 1.). This single pipe serves as both the supply line that carries steam from the boiler to the radiator, and the return line that drains away water that forms as steam cools and condenses. Steam and water flow in opposite directions in the same pipe at the same time. Vents release trapped air from the distribution system, allowing steam to travel from the boiler to the radiators. One-pipe steam systems are typically found in buildings up to six stories tall.

Many steam heated buildings suffer from loud, clanging pipes, leaky radiators, and simultaneous under- and overheating of apartments. These common problems not only waste energy and make residents uncomfortable, but also drive up utility bills and maintenance costs.

Many of these issues are legacies of steam heating's past. Most steam boilers and their piping distribution systems were designed in the early 20th century to run on coal and have not been updated to perform well using the oil and gas we burn today. Consequently, many steam systems lack sufficient air venting for today's fuels and operate boilers that are more than twice the size needed to deliver cost-effective and high-quality heat.

Fortunately, with proper maintenance and a few simple upgrades, one-pipe steam systems can provide efficient, reliable, and balanced heat for years to come.

Fig 1. An optimized one-pipe steam system, retrofitted with properly sized vents and smart thermostatic radiator valves (TRVs), provides efficient and balanced heat.



Assess
Always consult a qualified service provider before undertaking any building upgrades.

Coordinate Upgrades for Maximum Savings
Implementing one-pipe steam upgrades in conjunction with building envelope improvements that reduce heat loss and infiltration will improve heating system performance.

Energy savings will go unrealized without significant steam control optimization after building envelope improvements are completed.

Engage End Users
Staff and management should educate residents on optimizing heating in their homes, including how to operate thermostatic controls, why not to block radiators or leave windows open, and how to identify and report any heating issues.

Resident training and engagement is critical to ensure systems work properly.

How to upgrade one-pipe steam systems

A one-pipe steam retrofit requires not only tuning and upgrading boilers, but comprehensively improving each radiator, enhancing the distribution, and optimizing controls. High performance is only achieved when the system is addressed as a whole.

Retrofit solutions

A high performance retrofit may start with improving venting, radiators, system controls, and tuning boilers. Installing new, properly sized boilers once existing boilers fail will complete the system optimization.

A **Implement Master Venting –** When a steam system cycles off, air rushes in to fill the pipes and radiators. Before steam can fill the radiators again, air must be vented out of the system. The farther an apartment is from the boiler, the longer it takes for air to be vented and for steam to reach the radiators. To flush trapped air quickly and ensure that steam reaches all apartments evenly, install high-capacity air vents at the ends of steam mains and on the tops of riser lines, a practice known as 'master venting.'

- Correctly sized low-capacity or slow vents must also be installed on all radiators.

B **Install Radiant Barrier Insulation –** Installing radiant barrier insulation between the radiator and the wall blocks heat from being absorbed into the wall, redirecting it into the room for improved efficiency.

- Radiant barriers are recommended for enclosed radiators only.

C **Upgrade Controls –** Typical boiler controls rely only on outdoor temperature readings to turn the boiler on or off (regardless of how hot or cold apartments are) resulting in uncomfortable overheating. Upgrading to multi-sensor controls that monitor both indoor and outdoor temperatures makes a steam system more responsive to actual heating needs. The boiler runs only as often as needed to maintain comfort, saving fuel and money.

- Install smart thermostatic radiator valves (TRVs) at each radiator to regulate the flow of steam into radiators and help maintain a desired temperature.
- Smart TRVs also allow for building-wide and room by room setbacks as well as temperature limits.
- Use the indoor temperature feedback from the smart TRVs to improve system operation.
- Install window sensors to monitor when windows are open and turn off heat to individual units.

D **Support Staff Training and Maintenance –** Energy savings can only be realized with regular maintenance conducted by trained staff.

- Refer to page 4 for maintenance recommendations.

E **Tune Existing Boilers –** In order for a steam system to run effectively, it is critical that the boiler produce "dry" steam (steam that does not contain water droplets).

- Clean and skim the boiler water to remove oil.
- Tune the burner– the device that controls the boiler's fuel consumption– to reduce short cycling and limit maximum firing rate.

F **Replace Boilers –** When existing boilers have reached the end of useful life, replace with new boilers that are correctly sized for the distribution system.

- Operate the existing boiler at part-fire to determine the correct size of a new boiler. Completing a building-wide radiator survey can also determine how large a new boiler should be.
- To ensure the production of dry steam, install oversized steam outlets, which slows the steam down, and proper header piping, which removes entrained water droplets.
- Improve the burner's modulation to increase the precision of heat output in response to changing heating demands.
- Utilize linkage-less controls, which are more efficient than traditional, linkage-based modulation, on large burners.

Costs and benefits of one-pipe retrofits*

Greenhouse Gas (GHG) Savings

A comprehensive one-pipe steam upgrade can moderately reduce heating related GHG emissions, depending on the building's base heating fuel usage.

Tenant Experience Improvements

One-pipe steam retrofits greatly improve tenant satisfaction by delivering balanced, even heating throughout the building. Residents can elect to reduce heat in their apartment by adjusting thermostats for each radiator.

Utility Savings

Moderate utility cost savings can be expected from a one-pipe steam retrofit.

Capital Costs

One-pipe steam upgrades require a moderate upfront capital investment. Payback is dependent on a building's fuel type and base heating usage and should be analyzed on a case-by-case basis.

Maintenance Requirements

One-pipe steam systems require a moderate level of maintenance to ensure optimal operating efficiency. Burners need to be tuned annually and air vents should be periodically inspected. Boiler maintenance includes cleaning the boiler water to reduce oil contamination and installing anode bars– which corrode faster than steel– inside the boiler to protect against corrosion. Anode bars must be replaced annually but are often more affordable and effective compared to standard chemical water treatments.

Take Action

This document is one of more than a dozen High Performance Technology Primers prepared by the Building Performance Partnership (BPP) to introduce decision-makers to solutions that can help them save energy and improve comfort in their buildings.

For more information, contact
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The Building Performance Partnership (BPP), created by Building Energy Exchange (BE-Ex) and the Institute for Market Transformation (IMT), supports the creation and operation of local high-performance building hubs that accelerate measurable, equitable, and sustainable action to improve the health, comfort, and performance of buildings. With support from both BE-Ex and IMT, partner hubs serve their respective regions with customized resources that cater to the needs of their communities while benefiting from the existing resources and expertise of our network.

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*The Costs & Benefits rating system is based on a qualitative 1 to 4 scale where 1 () is lowest and 4 () is highest. **Green** correlates to savings and improvements, **dark blue** correlates to costs and requirements. Ratings are determined by industry experts and calculated relative to the system end use, not the whole building.

Note: GHG & utility savings are dependent on existing equipment and fuel type. Assumes existing venting and steam balance are poor.