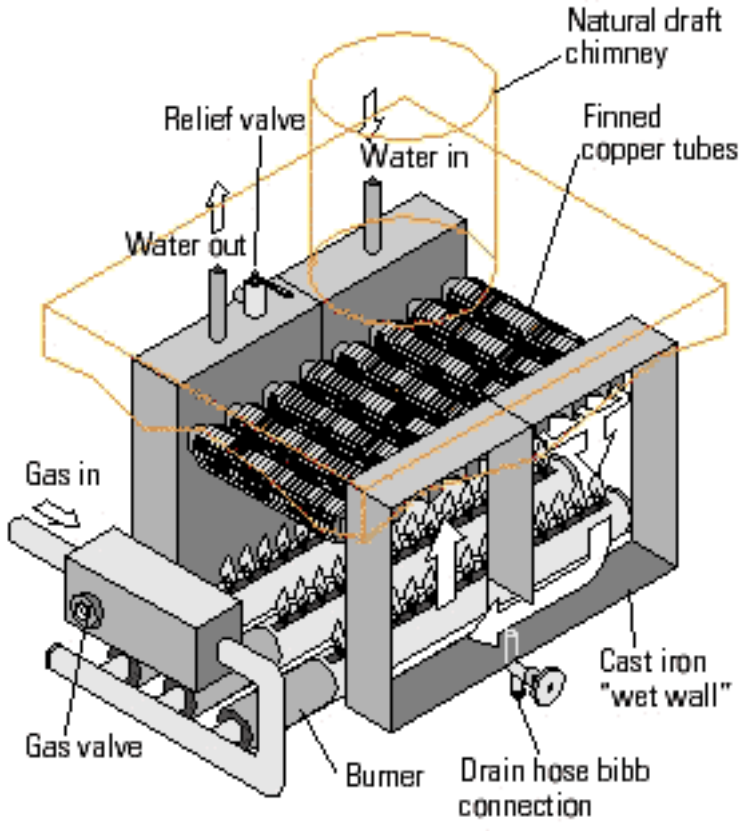
Purchasing Advisor: HVAC: Small Gas Boilers

If you are considering the purchase of a gas boiler, add residential boilers (see **Figure 1**) to your list of options. Even though they are designed for a different market, they can play an effective role in commercial buildings as well. Residential boilers are manufactured in larger quantities than commercial units, which makes them relatively inexpensive and readily available with a wide variety of options. Their small size enables them to be easily moved into and out of buildings, and the most efficient residential units exhibit efficiencies similar to those of their best commercial counterparts. In addition, multiple small boilers can be staged to provide high efficiency over a wide range of heating loads.

Figure 1: Residential boiler

Boilers come in a variety of configurations using cast-iron, steel, or copper heat exchangers with different types of burners and venting systems. In the example shown, cast-iron “wet walls” connected by copper finned tubes contain hot water that has been heated by a gas flame. The system is vented by a natural draft chimney.



Source: Platts

What Are the Options?

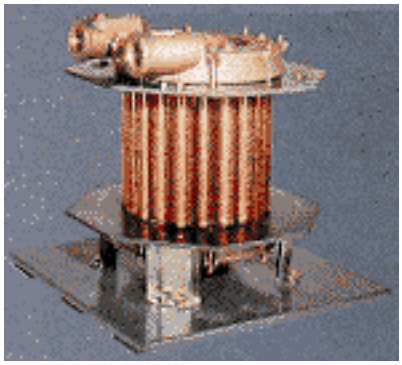
Size. The size of a gas boiler is given in terms of its heating capacity, in Btus per hour (h) of gas input. A Btu is equal to the amount of energy it takes to raise 1 pound of water 1 degree Fahrenheit. In practical terms, 1 Btu is the heat given off by completely burning a single kitchen match. Most residential gas boilers are rated in the range of 40,000 to 300,000 Btu/h.

Efficiency. To reflect losses that occur in actual installations, small boilers are rated according to their annual fuel utilization efficiency (AFUE). AFUE accounts for the effect of part-load efficiency and cyclic losses; a single number represents performance under a specific set of conditions. The conditions, chosen to represent operation in an average climate with a certain usage pattern, include flue and infiltration losses during on and off cycles.

AFUE serves well for comparing two boilers under the same test conditions, but it is less useful for predicting annual fuel use in the field, where local conditions may not match the AFUE test conditions and calculation assumptions. AFUE is based on a residential load profile, which may be quite different than the load profile of a commercial building. Since 1992, the National Appliance Energy Conservation Act has required that small gas boilers have an AFUE of at least 80 percent. The Energy Star Program, which is run by the U.S. Environmental Protection Agency and the U.S. Department of Energy, awards an Energy Star label to boilers with an AFUE of 85 percent or better. The most efficient boilers on the market boast an AFUE of about 97 percent (see **Figure 2**).

Figure 2: High-efficiency condensing-boiler heat exchanger

The highest-efficiency boilers are those with corrosion-resistant heat exchangers that enable boilers to condense the water vapor in the exhaust gases. Significant amounts of heat are captured this way, resulting in efficiencies well above 90 percent. This unit from Raypak boasts a peak efficiency of 97 percent.



Courtesy: Raypak

To find out the efficiency rating for a particular boiler, look at the EnerGuide label, check the Gas Appliance Manufacturers Association's **Consumers' Directory of Certified Efficiency Ratings** or consult the manufacturer's literature.

Combustion air source. Boilers draw the air they need for combustion either from inside the heated space or directly from the outside. Drawing air directly from outside, typically through a plastic pipe that runs through an outside wall, is more efficient and safer. This method is usually referred to as sealed combustion because the gas is burned in a chamber that is closed to occupied areas. This configuration virtually eliminates any risk that combustion gases could leak into occupied space. It does, however, require some complicated installation techniques, so check the manufacturer's installation instructions carefully.

Efficiency options. Several options that are standard on some, but not all, models are available to improve the efficiency of a boiler heating system. These include:

- Motorized dampers that close the flue pipe outlet when the boiler is idle to prevent the loss of heated room air between boiler cycles;

- Electric ignition, which eliminates the need for a standing pilot light; and

- Fan-assisted combustion systems (forced-draft, power-burner, pressure-fired, induced-draft, power-vent), which do not require a large natural draft chimney and can be vented through a smaller flue pipe directly through a wall.

How to Make the Best Choice

Pick the right size. Heating contractors sometimes oversize boilers so they can spend less time selecting a model and can still guarantee that it will maintain comfortable conditions. The problem with that approach is that an oversized boiler is noisier, less efficient, and more expensive than an accurately sized unit. To determine the proper size, calculate the heat load served by the boiler by following the procedure explained in the **American Society of Heating, Refrigerating, and Air-Conditioning Engineers' Fundamentals Handbook**. Many software products are also available that can guide you through the calculations, and several boiler manufacturers include sizing guidelines or software on their web sites.

Compare the cost-effectiveness of boilers with different efficiency ratings. High-efficiency boilers cost more than lower-efficiency models. To determine if a more efficient unit will be cost-effective, compare initial costs and annual energy costs to estimate the payback period. **Table 1** presents an example of a simple cost-effectiveness calculation.

Table 1: Cost-effectiveness calculation

In this example, it is assumed that the average annual operating hours are known. By multiplying those hours times the input capacity and the annual fuel utilization efficiency (AFUE), the annual energy consumption is estimated. This example calculation yielded a simple payback period of about five years.

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	Minimum- efficiency boiler	**High- efficiency boiler**
AFUE (%)	80	95
Annual operating hours	1,875	1,579
Annual energy consumption (therms)	2,344	1,662
Annual energy cost ($)	938	665
Annual energy cost savings ($)	N/A	273
Cost differential ($)	N/A	1,400
Simple payback (years)	N/A	5.1
Assumptions: Boiler input is 100,000 Btu/hour. Energy cost is assumed to be $0.40/therm.		
N/A = not applicable		
Source: Platts		

Consider installing multiple small boilers. If building loads are highly variable—as is often the case in commercial buildings—multiple boilers are a good option. Not only are the most efficient small boilers more efficient than the most efficient of their larger counterparts, but multiple small boilers can operate more efficiently than a single large system. This is because each boiler can operate more often at or close to its full load, which is the most efficient operating point for a boiler. Multiple small boilers also provide redundancy, which can reduce system downtime. In addition, small boilers can reduce installation costs, because they're light enough to be handled without a crane (unlike many large boilers).

A small, high-efficiency boiler can also be teamed with a large,

inefficient, old boiler to improve overall efficiency. Applied in this manner, the small unit turns on whenever there is a heating load, but the old unit only kicks in during periods of high load.

For domestic water heating applications in both commercial and residential applications, consider using gas-fired instantaneous water heaters. These units heat water on demand instead of storing hot water in a storage tank. Instantaneous water heaters have a modulating burner to match heater output to the actual load, and provide excellent combustion efficiency. The absence of a storage tank eliminates standby losses and reduces space requirements. For more information, see the "Tankless Water Heaters" Purchasing Advisor.

Check the manufacturers installation instructions. To achieve high efficiencies, many boilers use venting systems that were virtually unknown a decade ago. Installing these systems properly is tricky. Furthermore, premium-efficiency boilers condense water out of combustion gases, and that condensate stream must be properly disposed of. Before buying a boiler, check the manufacturer's instructions to make sure it can be correctly installed in your building.

What's on the Horizon?

Several manufacturers either currently offer or are in the process of developing systems that produce both steam and electricity. These combined heat and power (CHP) systems are typically sized to meet the thermal load of a facility and produce electricity as a by-product. CHP systems for the residential market are gaining popularity in Japan and England, where the high cost of electricity and gas utility subsidies make them economically attractive alternatives to conventional boilers in new construction. Several companies are currently developing CHP appliances for the North American market, but these are unlikely to gain much market share unless there are sharp increases in electricity prices or substantial subsidies.