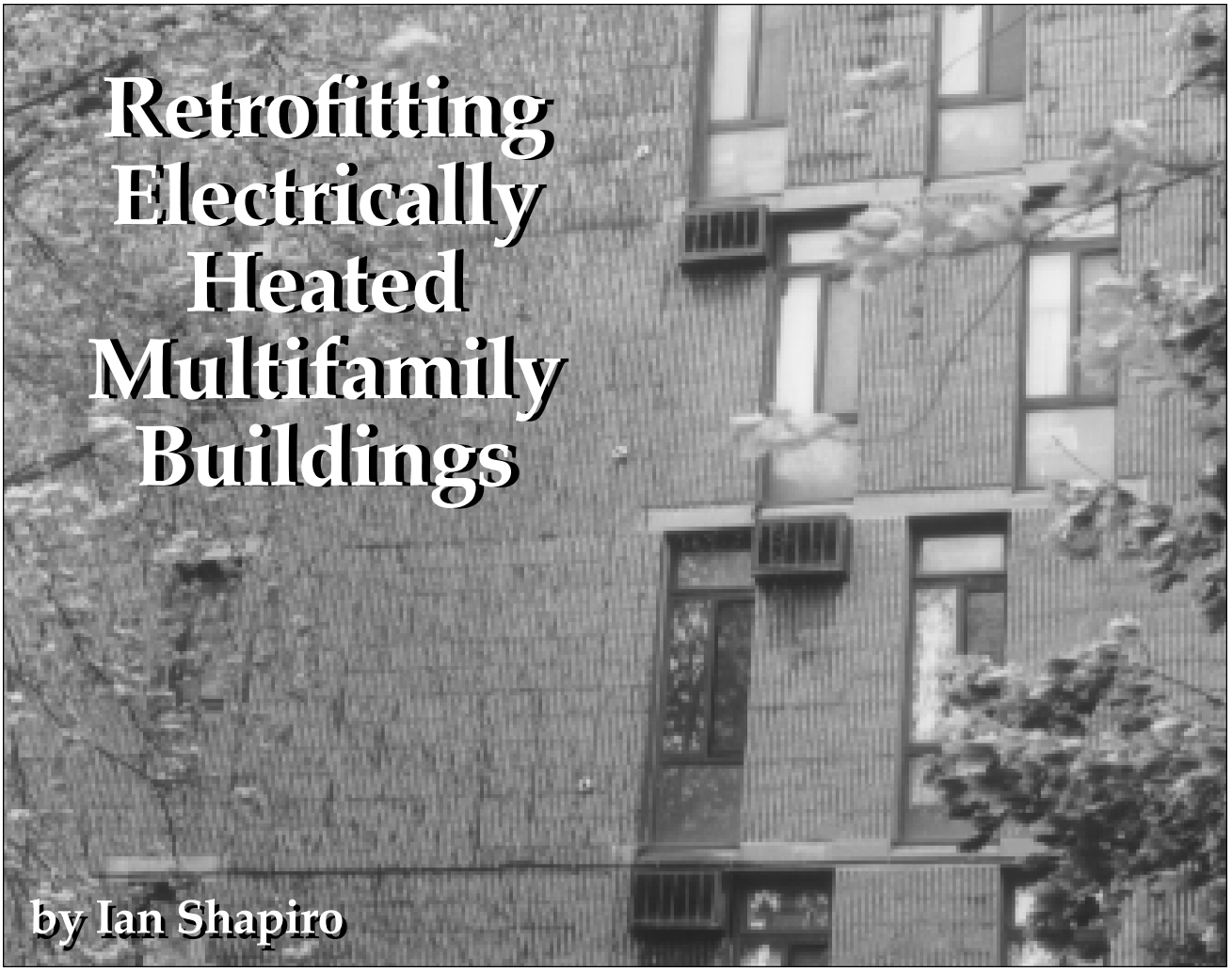
Retrofitting Electrically Heated Multifamily Buildings



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by Ian Shapiro

Residents of apartments warmed by electric baseboard heaters face stiff utility bills. Direct-vent, gas-fired room heaters could be a reasonable means of saving on energy costs.

Imagine converting an apartment's heating system from one fueled by high-priced electricity to a system that offers low installation and operation costs, has no duct or pipe distribution energy losses, and requires no thermostat or electrical work. Direct-vent gas-fired room heaters present such an option. A study in upstate New York is in the process of evaluating whether such heaters will deliver on all these promises. Preliminary results are looking good.

All-electric apartments typically have high heating bills because electricity is expensive as a heating fuel. However, high installation costs frequently make converting these apartments to gas heat unrealistic. Conversion to hydronic or forced air heating presents significant challenges in high-rise buildings, poured concrete structures, and those without basements or mechanical rooms.

An inexpensive alternative is the gas-fired room heater. Simple venting and combustion air installation, plug-in electric power, a built-in thermostat, and the absence of a distribution system—no ductwork, radiation, registers, or grilles—all contribute to the heater's low cost. A typical gas-fired room heater is small enough to fit below a window. It incorporates a gas heater, a blower, an air filter, a thermostat, gas valves and shutoff valves, and a vent/intake kit. Cabinets are usually painted metal. A 21,500 Btu per hour unit uses 50 watts, primarily for the blower motor.

Of course, cost is never the only consideration in choosing a heating system. Direct-vent gas heaters do not raise the serious safety concerns associated with unvented gas heaters (see "Unvented Gas Heaters: The New York Experience," p. 22). However, regular maintenance is always a good idea with any combustion appliance to ensure safe operation. [Editor's note: All gas appliances also pose a risk of CO poisoning. CO alarms can reduce this risk. See "CO Alarm Standard: Less is More," *Consumer Reports*, October 1998, for information on CO alarms.] Gas leaks

are another potential problem. Minimizing the number of joints in the gas piping and requiring pressure testing of piping installations will reduce the risk of a leak.

In a field trial at an apartment complex in Buffalo, New York, gas-fired room heaters were installed in two different apartment configurations. One was a 1,200 ft², garden-style apartment, with four bedrooms and a living room/dining room/kitchen, all on one floor. The other configuration was a 1,400 ft² town house unit, with the living room/dining room/kitchen downstairs and four bedrooms upstairs. Taitem Engineering monitored two different garden-style apartments; of these, one had a single heater installed in the living room, and the other had heaters installed in the living room and each of the four bedrooms. For the town houses, we monitored one apartment with a single heater in the ground floor living room.

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The Rinnai direct vent room heaters were chosen for their capacity modulation capability, which reduces oversizing-related cycling compared to constant-capacity heaters.

Energy Savings

Energy usage was measured using gas meters on the new room heaters alone, and run-time meters on the electric heaters. Weather corrections were made on the basis of local National Oceanic and Atmospheric Administration (NOAA) heating degree-day data. Utility rates in the study were 11¢/kWh for electricity and 51¢/therm for gas.

The heaters we used in this project are manufactured by Rinnai. Two models were used: one with an input of 38,000 Btu per hour for the living rooms, and an other with an input of 21,500 Btu per hour for the bedrooms. Both models are rated at 81% Annual Fuel Utilization Efficiency (AFUE). The heaters have a spark igniter, so have no standing pilot losses.

Total heating energy costs after the conversion to gas were compared to total heating energy costs if the apartments had not been converted from electric heat. The greatest heating energy cost savings—an 80% reduction—were found in the garden apartment where gas-fired room heaters were installed in the living room and each of the bedrooms (see Table 1). The next best results were found in the town house, where savings were 71% with only one heater installed. Clearly heat from the gas-fired room heater in the living room was rising up to warm the bedrooms as well. However, cost savings were not as high in the town house as in the garden apartment where heaters were installed in all the bedrooms, because the residents in the town house still used a small amount of electric heat in their bedrooms. However, they used on average only 11% of what had previously been used for the whole house.

The lowest savings, 18%, were found in the garden apartment where a gas heater was installed in the living room, but electric heat was kept in the bedrooms. Significant electric heat usage was still measured in the bedrooms, as indicated by the bedroom heater run-time meter. We concluded that heat in the gas-converted living room transports poorly to bedrooms on the same floor. This supports full conversion of all rooms for single-level apartments. Transfer fans, which would carry air from gas-vented rooms to adjacent rooms, have been suggested as a means of extending the effect of a single heater. We have not tested the use of transfer fans to evaluate their effectiveness, but on paper it would seem that they will not help much, and instead will consume electricity needlessly.

Installed Cost

The installed cost of gas-fired room heaters at five installations across upstate New York between 1995 and 1999 ranged from $1,800 to $2,900 per heater. These costs included demolition and removal of electric baseboard heat and associated controls, installation of new gas piping and heaters, cosmetic patching and painting, and utility charges to provide or increase the gas service. Installation costs ranged from $2.35 to $5.50/ft². By comparison, hydronic gas-fired installations are estimated to cost between $4.00 and $16.00 /ft².

Comfort

Spot measurements taken in the three different apartments showed that temperature uniformity was maintained in large rooms, such as living rooms, when a single gas-fired room heater replaced two electric baseboard heaters. When the two electric heaters were operating, the temperature difference bet-

Table 1. Annualized Energy Cost Comparisons

	Annualized Energy Cost Before	Annualized Energy Cost After	Annualized Electricity Use Before (kWh)	Annualized Electricity Use After (kWh)	Annualized Gas Use After (CCF)	Projected Payback Period
One-story apartment: convert all rooms	$1,762	$344	16,011	0	674	7.1 yr
One-story apartment: convert living room	$1,615	$1,328	14,683	11,482	136	7.0 yr
Two-story apartment: convert living room	$1,289	$374	11,534	1,428	426	2.2 yr

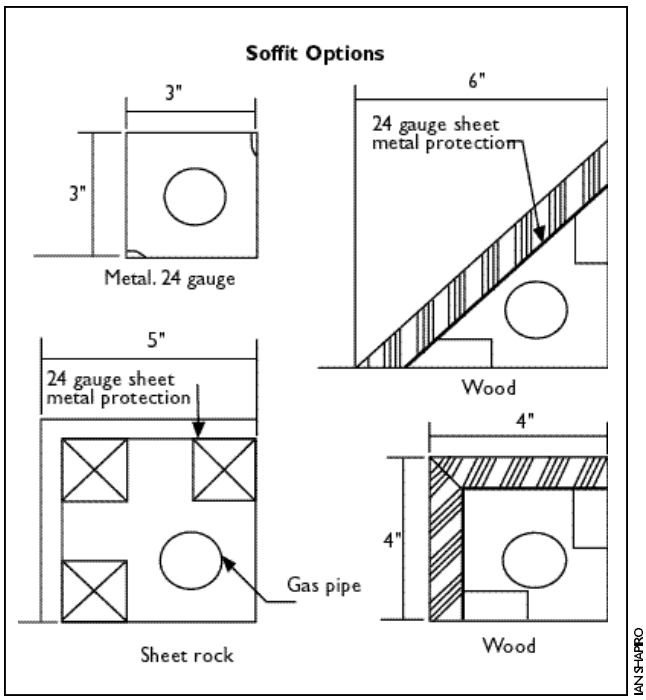

Figure 1. Where gas piping must be concealed in open corners or below the ceiling, several soffiting options can be considered.

ween the middle of the room and a wall where one of the heaters was located ranged from −0.7˚F to 1.2˚F, with an average difference of 0.3˚F warmer at the wall. After the gas-fired room heaters were installed, the temperatures at this same wall, which was across the room from the new gas heater, were from 0˚F to 1˚F warmer than the temperatures in the middle of the room. The far-wall temperatures being warmer than the middle of the room may be partially explained by the fact that the front door was closer to the heater and the kitchen was closer to the far wall. (The outdoor temperature was 44˚F on the day preretrofit measurements were taken and 30˚F on the day of postretrofit measurements were taken.) The gas-fired room heater is clearly able to maintain uniformity in the room and can even successfully supply heat to the far wall.

Temperatures in the test apartments generally run high. In our study, indoor temperatures, which were taken both pre- and postretrofit in a total of 21 rooms in the three apartments, ranged from 71.2˚F to 82.9˚F, and averaged 76.9˚F. The high indoor temperatures occurred with both electric and gas heaters and occurred even in apartments where windows were kept open. These findings indicate that, if manufacturers provided a temperature-limiting capability for the thermostat, there would be a potential energy-conserving benefit.

Comments from tenants were favorable for the gas units and for each style of installation. Notes from garden apartment residents included: "Much warmer with new unit," "A definite improvement warmth-wise," and "We like the new gas heater. Nice and toasty in living room." A town house tenant's comments were: "Heater works great. No problems with noise. First day had to adjust to dry air. No problems with dry air since."

Table 2: Soffit Construction Comparison

Advantages	Disadvantages
Wood	
Material readily available	Variable appearance and quality of material
Easily fabricated in shop and on site	Appearance affected by temperature and humidity
Relatively inexpensive	Effects of age more noticeable
Easily repaired or replaced	Hard to clean
No special tools or training required	Larger outside dimensions
	Subject to damage
	Protection for flex gas pipe must be included
Metal	
Uniform appearance	Material is custom fabricated off site
Appearance not subject to environmental conditions	Relatively expensive
Easy to clean	Repairs must be made with material to match
Smaller outside dimensions	Installation techniques more critical
Resistant to vandalism	
Gas pipe well protected	
Sheetrock	
Material readily available	Effects of age more noticeable
Easily fabricated in shop and on site	Hard to clean
Relatively inexpensive	Larger outside dimensions
Easily repaired or replaced	Very easily damaged
	Protection for flex gas pipe must be included

Gas Piping

The cost of installing gas piping is among the highest costs associated with the conversion process. Where gas piping is run vertically, the least expensive option is to route it through closets, where it can often be run exposed. Gas piping can also be run exposed through attics, crawlspaces, basements, and behind cabinets.

Where gas piping must be concealed in open corners or below the ceiling, several soffiting options were evaluated (see Figure 1). The lowest-cost option is a single strip of wood molding, enclosing the pipe in a triangular space at the junction of two walls, or a wall and a ceiling. Care must be taken to provide a high-quality finish. In a qualitative ranking, prefabricated metal soffits ranked highest (see Tables 2 and 3).

For exterior routing, exposed piping is the most cost-effective. Where it must be concealed, two methods can be used, depending on the exterior finish. With siding, the piping can be routed horizontally underneath an aluminum chase, fabricated

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Furniture should not be placed this close to a gas-fired room heater. The Rinnai heater has a built-in shut-off device that stops the heater from working when its air flow is substanially blocked.

and painted to match the siding. Casually viewed from a slight distance, these covers blend well with the building. On brick or similar surfaces, galvanized and painted sheet metal may be used. Attention must be paid to design and installation in order to avoid sharp edges, unpainted details, and scratches that might allow corrosion.

Metering Issues

Piping is typically more complex with individual gas meters, and the costs can be much greater. The monthly utility charge for individual meters can add up and should be factored in, as an offset to energy savings. For example, if the apartment complex in the study had its 208 apartments individually metered at $20 per month, the resulting monthly charge would be $4,160. This is substantially more than the $20 monthly charge for one master meter. The gas utility should be consulted early in the project to determine acceptable meter locations. Gas meters take up a fair amount of room, and provision should be made for this. Other restrictions to possible locations for gas meters include the proximity of vents and possible obstructions. Some gas utilities charge for the installation of a new gas service or for enlarging an existing service.

Venting

Next to the cost of installing gas piping, the highest cost associated with gas-fired room heaters is that of installing venting. Manufacturers' vent kits accommodate typical exterior walls up to 9 inches thick. Extension piping will accommodate walls up to 31 inches thick, but can add $80–$120 to the project's per unit cost.

Vents must be accessed from the outside for installation. This is most easily done by locating a vent under a window, which the National Fuel Gas Code allows if the vent is at least 9 inches below the window frame. If such a location is not available in high-rise buildings, a crane or lift access is required. Tenants must be instructed to keep areas around vents clear, both outdoors and indoors, so as not to block air flow. One case was reported of a room heater vent melting a hole in the side of a plastic trash can.

To minimize venting cost, heaters should be located on exterior walls. When heaters are installed in apartments that are below grade or partially below grade, vent piping should be routed above grade, with removable chase covers to allow access for service.

Vents drip condensate under a variety of outdoor conditions. However, no ponding or freezing of puddles was observed in our tests. Further observations and measurements are being taken and will be available in the final project report, which is due out in spring.

Table 3. Soffit Cost Comparison and Ranking Cost/Ft

	Wood		Metal	Sheetrock
	4 in x 4 in	Diagonal	3 in x 3 in	5 in x 5 in
Material	$3.98	$3.06	$6.35	$2.28
Labor	$4.06	$2.84	$6.80	$5.46
Total	$8.04	$5.90	$13.15	$7.74
Ranking*				
Cost	2	3	1	2
Appearance	2	1	3	2
Durability	2	2	3	1
Maintenance	1	1	3	2
Total	7	7	10	7

*1 = poor; 3 = best

Minimizing Oversizing Problems

Since gas piping accounts for much of the overall installation cost—almost 40% in the Buffalo project—it is important not to oversize the heaters. Heaters should also be sized as closely as possible to their load to avoid cyclic losses. Oversizing is often unavoidable because the input capacity of the smallest available heaters ranges from 15,000 to 20,000 Btu per hour, while individual room loads frequently are closer to 4,000–8,000 Btu per hour. However, newer heaters are coming on the market with input capacities that range from 10,000 Btu per hour to less than 6,000 Btu per hour. The Rinnai heaters used in the Buffalo project were chosen in part for their capacity modulation capability, which reduces oversizing-related cycling.

Three features that would further enhance gas-fired space heaters are temperature limiting thermostats, smaller heating capacities, and the capability to heat two adjacent rooms with one heater. Packaged terminal air conditioners (PTACs), which are often used in motels, have offered this last feature for many years through use of a side discharge optional duct accessory. This accessory feature would facilitate the conversion of many high-rise, one-bedroom apartments by way of a single heater.

Conclusions and Projections

More than 5,000 gas-fired direct-vent heaters have been installed in

Unvented Gas Heaters in New York

Without much fanfare, New York state passed a law in August 1998 permitting the use of unvented gas heaters in homes. This law was passed despite deep concerns on the part of indoor air quality professionals, thanks to strong lobbying by the Vent-Free Gas Products Alliance, the New York Propane Gas Association, and others who wanted to sell the heaters. Product distributors and retailers immediately initiated a strong marketing campaign, with widespread advertising using banner headlines such as "Now Legal in New York." As a result, vent-free gas heaters are now carried in virtually every hardware store and home improvement center in the state.

A critique prepared for the New York State Energy Research and Development Authority (NYSERDA) before the law was passed warned of potential problems posed by unvented gas heaters. This critique included an independent review of a previous study by the American Gas Association Research Division (AGARD) that has been widely used by manufacturers to support safety claims relating to the heaters. The NYSERDA critique concluded: "Residential concentrations of nitrogen dioxide [NO_2] are expected to exceed health guidelines in the vast majority of use conditions. Relative humidity resulting from many heater use conditions is likely to reach levels that could encourage the growth of allergenic organisms and result in structural damage to homes."

To counter concerns about unvented gas heaters, the new law makes a weak attempt to address the likelihood of heaters causing problems. Specifically, the law requires that the heaters not be used as the primary source of heat in a home. The law also requires that retailers post cautionary warnings near the point of sale of the heaters and provide literature to address the sizing of the heaters. An informal survey of several heater distributors indicates that these requirements are not being met. Taitem Engineering's Paula Peters visited three local hardware stores and two major home improvement centers that had the heaters in stock. Three out of five sites had heaters on display on the sales floor, and none had any cautionary warnings posted. Two of the five sites did not display any literature regarding sizing of the units. When Peters asked these two if they could provide literature, they said they had none.

The requirement that the heater not be used as the primary source of heat is itself absurd. There are no provisions to prevent this. For example, an unvented gas heater in the same room as an electric baseboard heater would need only to have its thermostat set higher for it to become the primary source of heat. The typical homeowner cannot be expected to avoid such a situation. Marty Devit, owner of Thermal Associates, a heating contractor in Glens Falls, New York, in commenting on this requirement, says, "The criteria for sale [not primary heat] leaves too much room for abuse. Especially for low-income folks on electric heat. I am shocked that these units were approved like this."

Unvented gas heaters are a growing number of accidents just waiting to happen.

Professionals familiar with indoor air quality risks in New York state are outraged by the new legislation. Larry Kinney, president of Synertech Systems Corporation in Syracuse, says, "NOx is probably the worse part of the output of a well-tuned heater, but CO can happen, and water vapor happens all the time. In all events, the New York state legislature should be ashamed of itself." Judy Crawford, a certified industrial hygienist, adds, "I'm totally against unvented gas heaters. They introduce trace irritant combustion gases and carbon dioxide at best. If we were investigating an IAQ complaint, we'd turn off such equipment right away as good practice." Noel Kurtz, a professional engineer in Ithaca, states emphatically "It strikes me as a step backward. Personally, I would never install or specify such a unit in anything tighter than a barn."

New York state over the last five years. These heaters appear to offer the benefits of low installation costs, high energy savings without duct/pipe distribution losses, and good tenant comfort. We are continuing to assess any safety risks posed by these heaters. We are also continuing to evaluate the heaters' long-term service and maintenance requirements as part of our ongoing research.

One might expect that gas-fired heaters would require more maintenance than electric baseboard heaters, since baseboards have no moving parts and no filter. However, anecdotal reports to date indicate that service and maintenance on the gas-fired room heaters is low. Careful project design, installation, and user instruction can maximize efficiency gains, while minimizing installation and operational costs and risks.

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Vents must be located at least 9 inches below any window frame.

Payback is particularly good in two-story open-stairwell apartments, where a single heater is installed downstairs. However, full savings can be achieved only if heaters are installed in all bedrooms, and in this case, the installed cost begins to approach that of hydronic systems. If heater manufacturers were to offer a heater that could heat two rooms, such as the living room and single bedroom layout that is very common in high-rise buildings, the potential for full energy savings and low installation cost would be even greater.

Ian Shapiro is president of Taitem Engineering, a consulting firm performing HVAC design and research located in Ithaca, New York. Fred Schwartz and Paula Peters of Taitem Engineering assisted in the calculations for, and preparation of, this article.

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