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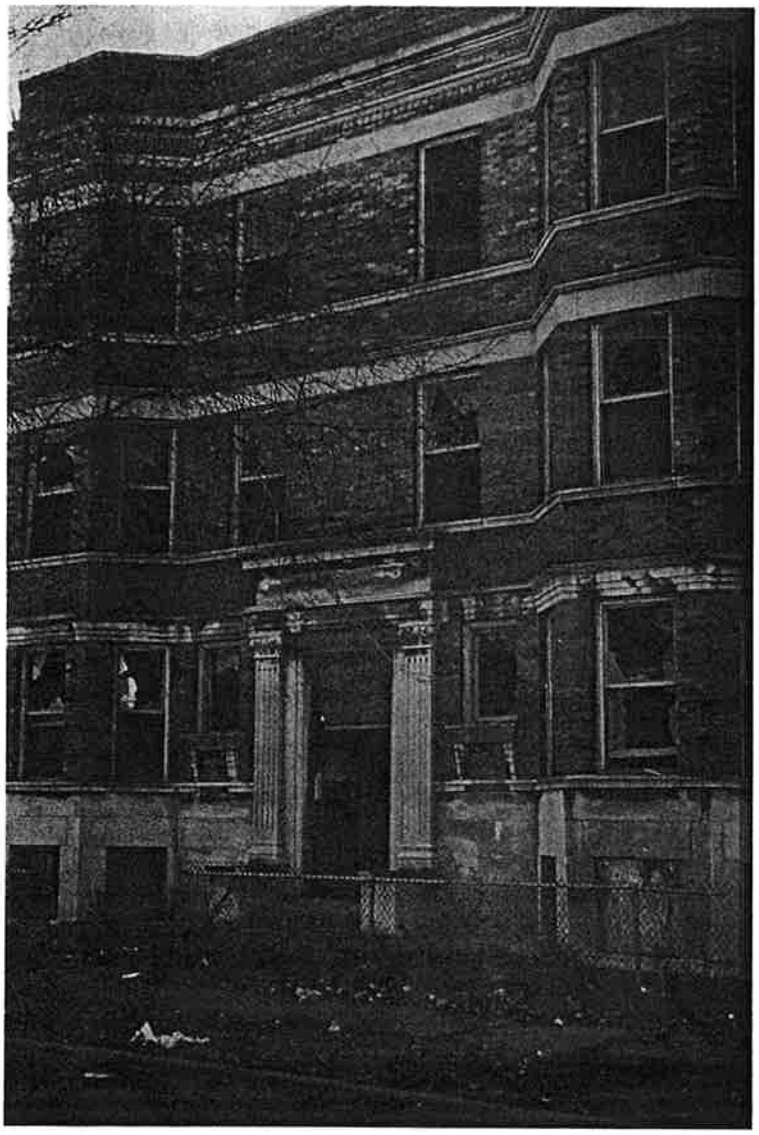
*A rehab program in Chicago is turning abandoned buildings in the city's poorest neighborhoods into energy-efficient affordable housing for low-income residents.*

# Chicago Apartments Get New Lease on Life



PAUL KNIGHT

by Paul Knight

Walking through abandoned multifamily buildings is urban spelunking. The buildings are dark, dreary, and damp. Water drips in from the roof. Pitfalls abound. One must be cautious of dark shafts and mounds of who-knows-what. Hairy and not-so-hairy critters scamper about. Bringing these buildings back to life as energy-efficient affordable housing is very exciting and rewarding.

## Prospecting for Savings

The buildings that we're involved with are typical Chicago-style buildings; three- or four-story masonry walk-ups built in the first half of the century. They range in size from 3 to over 60 units and are located all over the city. The average apartment size is 1,000 ft$^2$. The buildings are architecturally pleasing and they help form the fabric of the inner-city neighborhoods in which they're found.

Unfortunately, many of these buildings have been torn down. Others have been boarded up and abandoned for years.

Nonprofit and for-profit housing developers are acquiring these abandoned buildings and rehabbing them as affordable housing. The buildings are structurally sound but in need of everything else: new roofs; electrical, plumbing, and heating systems; windows; and interior walls and finishes. Opportunities to integrate energy efficiency into this work abound.

**Table 1. Space-Heating Consumption for Chicago Rehabs**

| | Annual Space-Heating Cost ($/yr) | Normalized Space-Heating Consumption Btu/ft²/HDD |
|---|---|---|
| Energy-efficient multifamily building rehab (average) | $280 | 7.3 |
| Individual heat *(13 buildings, 138 units)* | $200 | 5.2 |
| Central heat *(8 buildings, 256 units)* | $340 | 8.7 |
| Typical multifamily building rehab *(8 buildings, 265 units)* | $960 | 25 |

## The Chicago Experience

The Illinois Department of Energy and Natural Resources (now merged with the Illinois Department of Commerce and Community Affairs, or DCCA) initiated the Energy Efficient Affordable Housing Program in 1988 to act upon these opportunities. Under this program, grants of up to $2,000 per unit are made available to non-profit housing developers to include specified energy-efficient building practices. Program manager Maureen Davlin oversees day-to-day operations. The program is administered by Henry Kurth. Both have provided direction and leadership since the program's inception.

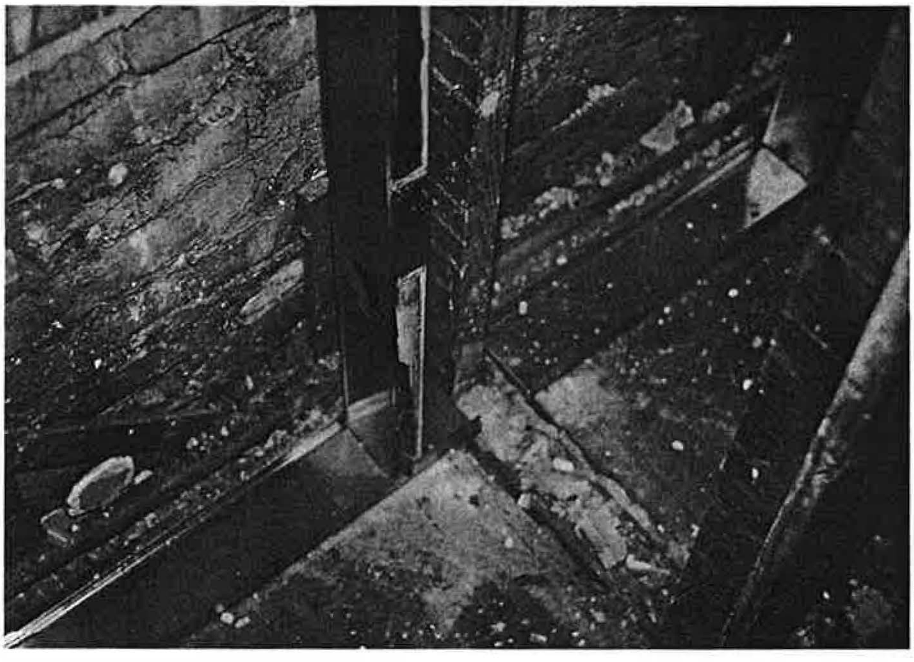
In 1995, ComEd (the northern Illinois electric utility) and Argonne National Laboratory (ANL) joined the partnership to help assure that affordable housing is energy-efficient. They provide nonprofit housing development teams the resources and technical assistance to produce energy-efficient affordable housing (see "The Programs Behind the Rehabs").

### *Results*

To date, 526 units in 32 buildings have been rehabbed incorporating energy-efficient building practices under the Energy Efficient Affordable Housing Program. Eight buildings with 211 units are currently receiving energy-efficient rehabs. In addition, more than 700 units in over 25 buildings are scheduled for such rehabs.

Annual space-heating energy consumption numbers for a typical Chicago-style winter are shown in Table 1. The figures are based on a 1,000 ft² unit, 60¢/therm for natural gas, and 6,455 heating degree-days (HDD).

Energy-efficient multifamily buildings have cut energy consumption more than 66% compared to buildings that received a typical rehab. The energy savings are even larger for buildings with individual unit heating. These units have average annual space heating costs of $200. The greater savings may be partly due to the fact that the individual heating systems in this sample are somewhat more efficient than the central systems.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Since the masonry wall surface is usually rough and uneven, the contractor holds the studs back about 1 or 1½ inches from the walls to produce a straighter frame. This also leaves a deep framing cavity, which can accommodate more insulation.

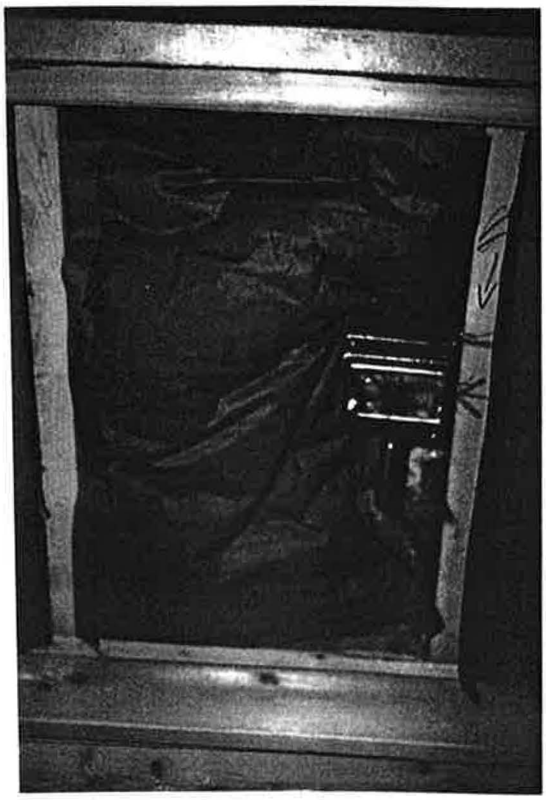
## Opportunities for Energy Efficiency

The heating system is more than just new boilers and furnaces. We look at these buildings in terms of how we can best include energy efficiency in the rehab of the building shell as well as the installation of new heating systems. The shell includes the walls, windows, and roof. Air sealing is part of the mix. We also put in efficient lighting and appliances.

### *Wall Insulation*

A typical multifamily building gut rehab in Chicago entails removal of the plaster and lath from the inside face of the exterior walls. A new framing system consisting of 1 x 2 or 2 x 2 framing members is installed on the wall to hold the new wall finish. Insulation is rarely included in the new framing system.

We use a 2 x 4 framing system and fill the framing cavity with insulation. Fur-



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While fiberglass batts provide a relatively inexpensive insulation option, they often are not installed properly. Compared to unfaced batts, faced batts are even more difficult to cut and fit around obstructions such as this electrical box.

thermore, the contractors hold the wall framing back from the masonry by about 1 to 1½ inches to get away from the rough and often uneven masonry surface. This allows them to frame the wall straight and true. We then have a framing cavity that's about 5 to 6 inches deep. (Although this method reduces floor area somewhat, this is not usually a concern unless the units are very small. In fact, the added wall thickness gives us very deep window wells—a nice feature, and one that the tenants appreciate.)

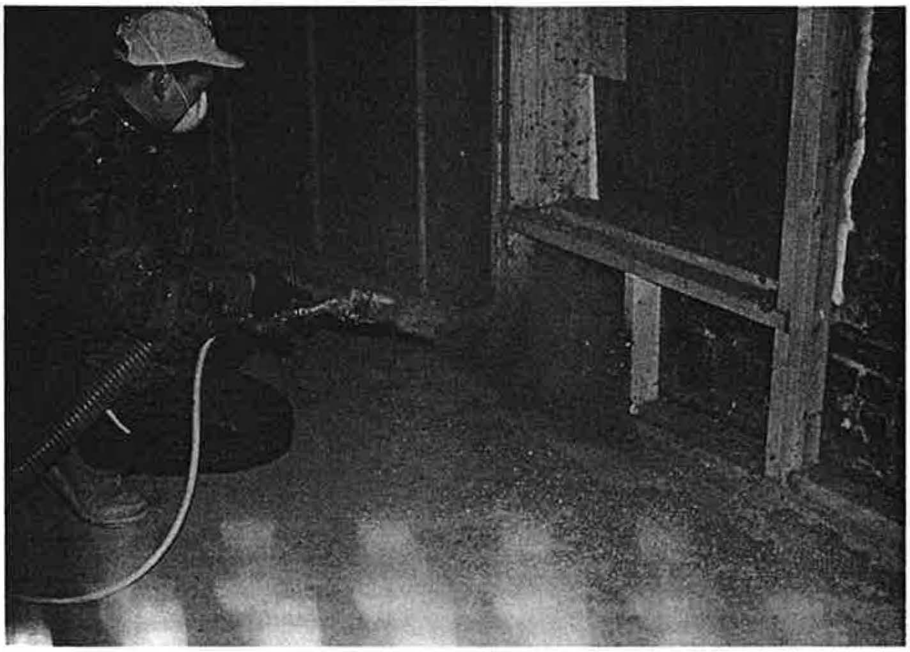
Next step: insulate! We initially used unfaced R-19 fiberglass batts. As with any fiberglass batt job, quality of installation is key to performance. Batt insulation needs to be fluffed and installed so no gaps are left in the insulation or in the wall cavity. The insulation should be cut to fit around junction boxes and conduit. We specifically stayed away from kraft-faced batts because we felt that we could do a better job of eliminating air spaces with unfaced insulation. Though the unfaced batt system is fairly inexpensive and works well when done properly, we found some drawbacks.

First, we weren't always sure that we were getting proper batt installation. We know there were air spaces in the insulation around junction boxes. Furthermore, we weren't sure if insulation was getting between the stud and the masonry wall, or if we were leaving a possible thermal bridge in the wall system. Finally, we use the airtight drywall approach (ADA) for air sealing. One component of ADA is gluing the drywall to the framing. Since we were using unfaced batts and couldn't use polyethylene as a vapor retarder, we used foil-backed drywall which added about 8¢/ft² to the cost of drywall.

To get more complete installation and better air sealing, and eliminate the need for a vapor retarder, we started using wet-spray cellulose in the framing cavity. The insulation is installed before the drywall, but after all rough-in work has been completed. The cellulose is mixed with a small amount of water and sticks to everything (see "*Home Energy's* Consumer Guide to Insulation," *HE* Sept/Oct '96, p. 21). The installer can see what he or she is doing and ensure that the entire cavity is filled, including the space between the ceiling and the floor of the unit above. Immediately after filling the cavity, a stud scrubber is used to shave the excess cellulose from the wall and studs. This provides a clean surface for hanging drywall.

Our cost for wet-spray cellulose has ranged from 75¢/ft² to $1/ft². We feel that this method has a number of important advantages. First, the wall is packed with insulation at the fairly high density of 3.5 lb/ft³. Air movement through the wall is reduced significantly at this density. Besides getting R-value, we're getting air leakage reduction. The cellulose fills very nicely around conduit, junction boxes, and other "batt obstacles" found in the wall. We also know that we're getting insulation between the stud and masonry wall. This is especially important when the contractor is using metal studs. Finally, cellulose manufacturers recommend no vapor retarder. Thus, we can use standard drywall. The total insulation value of the cellulose is about R-21.

We've demonstrated both Blown-in Blanket (BIB) and Icynene foam insulation in small, open-wall cavity sections



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A retrofitter applies wet-spray cellulose in the framing cavity before the drywall is installed. This insulation method ensures that the entire cavity is filled, including gaps between the framing and the masonry wall, and provides more air sealing than fiberglass batts. After initial installation, a stud-scrubber is used to shave away excess cellulose to provide a clean surface for hanging drywall.

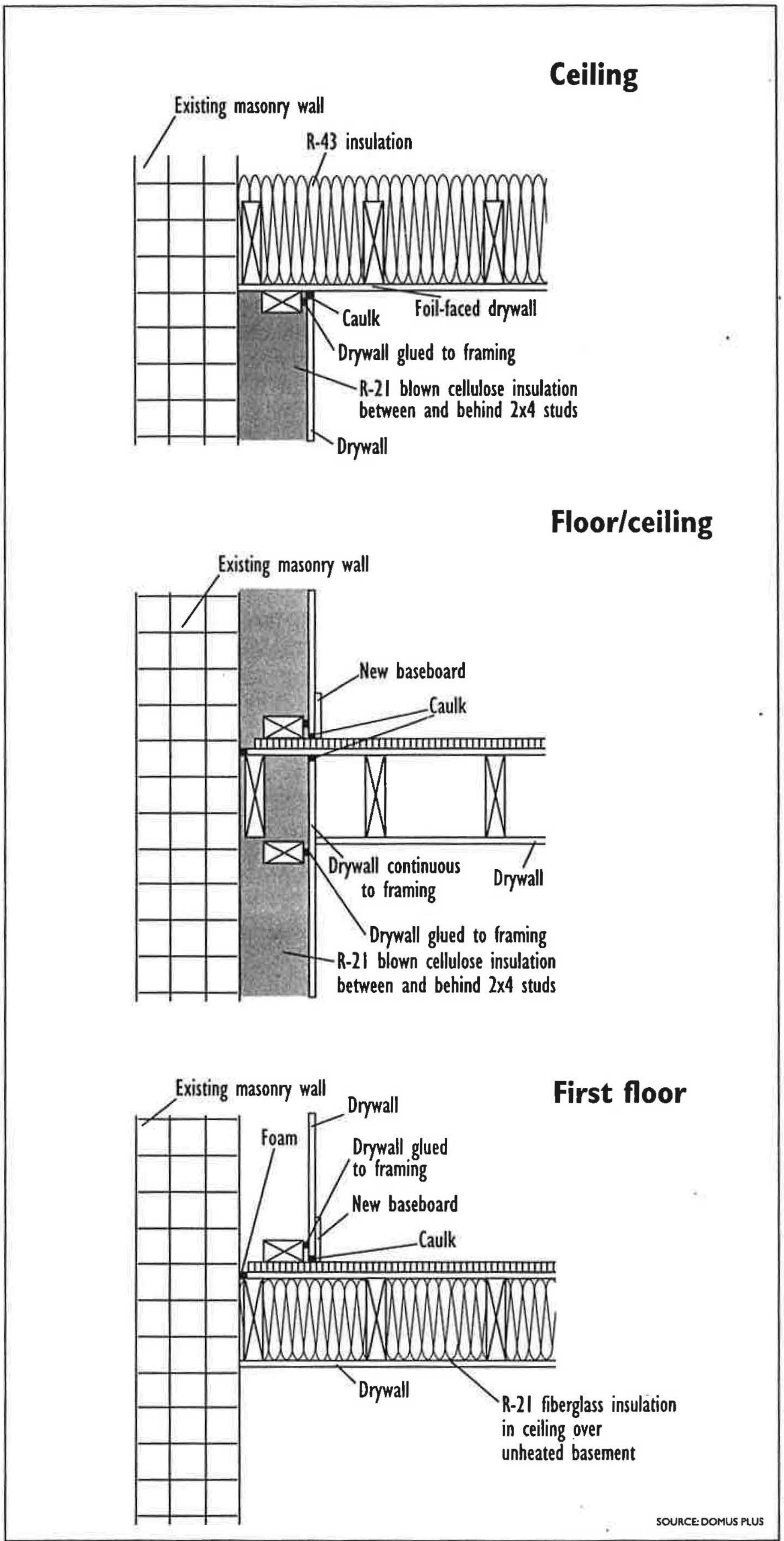


Figure 1. Details of insulation and drywall methods used by the program.

in a multifamily building undergoing rehab. With BIB, a net is attached over the studs and fiberglass is blown behind it. Icynene is an expanding foam. The excess foam is trimmed off, providing a clean surface for drywall. Both products look very promising. However, we have not yet done any entire buildings utilizing either of them.

Any insulation in these walls is better than none. The typical masonry wall in these buildings is 12 inches thick, which gives it an R-value of R-2.4 for the brick alone, or about R-3.7 including air films and the gypsum board finish. The wall would have to be over 8 ft thick to get the same R-value that we get by adding cellulose. But even by adding an R-11 fiberglass batt, we've increased the insulating value of the wall by a factor of three. We like cellulose for the reasons listed above, but if you can't afford cellulose, properly installing any insulation product will have a dramatic impact on the energy efficiency of the building.

We're currently looking at how to insulate a masonry wall in a moderate rehab that does not require the removal of plaster and lath from the inside face of the exterior walls. These walls have a ¾-inch gap (fur space) between the masonry and the plaster and lath. We're looking at injecting Icynene insulation in the ¾-inch fur space. Even though the insulation is only ¾ inch thick, this would about double the R-value of the wall (the Icynene would provide about R-4). We also believe it would significantly reduce air leakage.

We're in the process of testing to determine the cost-effectiveness of this approach. We tested it on a worst-case wall to see if there was any risk of the Icynene pushing marginal plaster off the lath. It worked fine, and we hope to be using it in a 50-unit building later this year. One word of warning, though: window replacement should be part of the work scope, as the Icynene will fill the existing pulley wells of double-hung windows.

### *Roof Cavity and Windows*

A typical multifamily building rehab in Chicago usually includes replacing windows with double-glazed units and adding either R-19 or R-30 in the roof cavity. We upgrade the windows to double-glazed with a low-e coating. At the start of the program, the cost differ-

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The contractors use the airtight drywall approach (ADA) for air sealing the perimeter walls of each unit. While standard drywall stops at the bottom of the ceiling joists, installers using the ADA method extend the drywall to the framing of the floor above. Contractors notch the drywall to fit around any joists that are perpendicular to the wall.

ence was about $\$2/ft^2$ of window surface. However, there appears to be no or a almost no cost difference at present. In fact, costs have come down enough that we're beginning to use double-glazed, low-e coated, argon gas-filled windows in our projects. We also increase roof cavity insulation to R-43 with cellulose.

### *Air Sealing*

The second energy efficiency opportunity lies in air sealing the unit. Note: that's unit, not building. In terms of air sealing, we treat each multifamily unit as if it were a single-family home. We concentrate on air sealing the unit perimeter: walls, floor, and ceiling—not just the exterior walls. Our intention is to reduce infiltration heat loss caused by wind and stack effect and to increase building comfort in the process.

We utilize ADA on the unit perimeter walls, as it is not possible to install an exterior house wrap on a masonry multifamily building. Since a new interior drywall finish is part of the rehab work scope, we make the drywall serve double duty by also using it as our air barrier. Surprisingly, it takes little extra effort to do this.

The most obvious difference between a standard drywall installation and an ADA installation in a multifamily building (and the one that raises the eyebrows of the drywall contractor) occurs at the ceiling. We install the drywall from subfloor to subfloor of the unit above, rather than stopping the drywall at the bottom of the ceiling joists (see Figure 1). The drywall is notched to fit around the joists where the joists are perpendicular to the wall. Where the joists are parallel to the wall, the drywall is simply installed up to the subfloor.

Before the drywall is installed, a continuous bead of drywall adhesive is laid along the top and bottom plates, the corner studs, and the rough-opening members to seal the drywall to the framing. The bottom edge of the drywall is sealed to the subfloor, and the gap between the drywall and the framing members at the top of the drywall is also sealed to complete the air barrier. These joints are usually sealed with caulk. Any penetrations through the drywall (around junction boxes, for example) are also sealed with caulk.

We seal around the windows with acrylic latex caulk. We seal the drywall to the window frames and we seal the window trim.

The stack effect can be quite pronounced in multifamily buildings. It is not that uncommon to see open windows on the top floor of multifamily buildings in the dead of winter. The folks upstairs are overheating while people on the first floor are chilly.

Tenant comfort can be improved and energy saved in the process. Air has a way of finding holes in floors and ceilings on its journey to the top of the building. These air leakage paths are like unintentional chimneys, and many of them are revealed during the rehab process. We try to reduce the stack effect by sealing these chimneys between floors.

Plumbing chases act as large air leakage paths. These chases, which are fully exposed during gut rehab, are open from the basement ceiling right up to and through the top-floor ceiling. We seal these openings at each floor level and at the top-floor ceiling with a combination of materials: fiberglass batt (used as a backer), expanding foam, and drywall scraps that are caulked in place. All openings into the plumbing walls—around drains, hot- and cold-water pipes, recessed medicine cabinets, and junction boxes—are sealed with caulk or foam. Bathroom exhaust fan housings are also caulked in place.

Interior stairwells create another unintentional chimney. We seal the units from the stairwells by weatherstripping the unit doors to the stairwells and installing a door sweep or a threshold with a vinyl bulb. Air sealing these interior doors usually elicits more raised eyebrows from the contractor.

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Expanding foam is used to seal around hot and cold water pipes, medicine cabinets, electrical boxes, and similar openings through walls.


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In 64 of the rehabbed units, the contractors installed combination heating systems (made up of a water heater with a fan coil) that meet both space and domestic water heating needs.

Another air leakage path commonly found in masonry buildings occurs at the joint between the subfloor and the masonry wall. When these buildings were first constructed, floor joists were set in pockets left in the masonry wall. Furring strips ¾ inch deep were fastened to the wall to hold the plaster-and-lath wall finish. The furring strips, however, were extended down past the floor joists. Consequently, the subfloor butts up against the furring strips, rather than the masonry wall. This leaves a ¾-inch gap between the subfloor and the masonry wall, both around the perimeter of the building and at the interior bearing walls. The gap is exposed when the plaster and lath are removed, and it may also be exposed if only the baseboard is removed.

This gap should be sealed with expanding foam if fiberglass batts are used for wall insulation. However, the gap does not have to be sealed if cellulose, BIB, or Icynene is used. All of these products are sufficiently dense to stop warm air moving from floor to floor.

Despite all the air sealing, the units are not overtight. We use a blower door to spot-check air leakage in units as they are completed. The blower door helps the contractor to find air leaks that were missed. Our standard is to get air leakage around 5 air changes per hour (ACH) at 50 Pascals (Pa). We usually end up around there, but we don't know how much of that leakage is coming from neighboring units and how much is coming from outside.

### *Heating Systems*

During the planning stages of rehab, nonprofits make the decision whether to install individual heating units or new central-heating systems. Either approach can be accommodated within the Energy Efficient Affordable Housing Program. We simply ask three things from the heating system.

First, the system must be highly efficient. If individual forced-air furnaces are installed in the units, they need to have a minimum of 90% annual fuel utilization efficiency (AFUE). Central systems installed in rehabbed buildings are hot water with baseboard convectors. Existing steam systems have not been replaced with steam in any of the energy-efficient rehabs. We put in hot-water systems because they have better controls. The boilers must have a minimum of 88% AFUE.

Second, the system must be sized properly. If we do our jobs by insulating and air sealing right, we end up with fairly small heating loads—around 20,000 Btu per hour for a 1,000 ft² unit in Chicago. Contractors generally want to use 60,000 Btu, and in some cases even 80,000 Btu, models. However a 40,000 Btu furnace is already oversized to meet this load. It is also necessary that boilers in the centrally heated buildings be correctly sized and properly controlled for the reduced building load. We need to talk the contractors down—in both furnace size and cost.

Finally, furnaces installed in the units must be direct-vent sealed combustion. We just don't think it's a good idea to use indoor air to support furnace and water heater combustion and ventilation, especially after all the air sealing work that has been done. But even with direct venting, we need to be careful where we vent combustion gases. For

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In one 10-unit building the contractors had a chance to install a radiant floor heating system. The building floors were in such bad shape that plans called to level them with lightweight concrete, so the contractors installed the radiant system's plastic tubing over the existing floors before adding the concrete. This method saved $10,000 in first costs over installing baseboards, and the building is both comfortable and efficient.

**Table 2. Effect of Superinsulation Rehab on Housing Costs**

| Building | Actual Monthly Costs (Typical Rehab) | | | Estimated Monthly Costs [1] (Energy-Efficient Rehab) | | | Change in Monthly Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | Rent | Energy Cost | Housing Cost | Rent[2] | Energy Cost | Housing Cost | Rent | Energy Cost | Housing Cost |
| A | $405 | $87 | $492 | $423 | $33 | $456 | +$18 | -$54 | -$36 |
| B | $460 | $63 | $523 | $478 | $21 | $499 | +$18 | -$42 | -$24 |
| C | $387 | $63 | $450 | $404 | $24 | $428 | +$17 | -$39 | -$22 |
| D | $410 | $40 | $450 | $427 | $17 | $444 | +$17 | -$23 | -$6 |
| E | $384 | $66 | $450 | $401 | $17 | $418 | +$17 | -$49 | -$32 |
| F | $467 | $69 | $536 | $485 | $14 | $499 | +$18 | -$55 | -$37 |
| G | $508 | $57 | $565 | $525 | $16 | $541 | +$17 | -$41 | -$24 |
| H | $362 | $58 | $420 | $377 | $20 | $397 | +$15 | -$38 | -$23 |

[1] These costs are based on the average energy use of 7.3 Btu/ft²/HDD found in the superinsulated buildings we rehabbed.
[2] Rent raised to cover cost of superinsulation work at $2,000/unit, amortized at 8% over 30 years.

sidewall vents, proper clearances need to be maintained from nearby windows. Exhaust vents should never terminate over stairs or walks, as the water vapor present in the combustion gases can drip on these surfaces, causing ice to build up during the winter. Generally, we vent these systems through the roof in the building rehab. We do not exceed the appliance manufacturer's specifications for vent length, whether we vent through the sidewall or through the roof.

Boilers for centrally heated systems are located in basement mechanical spaces. These boilers do not have to be sealed combustion as long as they have sufficient outside combustion air.

For the most part, our rehabbed buildings with individual heat use 90% AFUE furnaces that are direct-vent sealed combustion. Weil-McLain (GV Series), Aerco, Lochinvar, and Hydro-Therm Pulse boilers have been used in our centrally heated buildings. There are two notable exceptions.

With design heating loads below 20,000 Btu per hour, you can literally heat the unit with a water heater. That's what we've done in 64 completed units through the use of combination heating systems. A combination system is simply a water heater with a fan coil that meets both space-heating and domestic hot-water needs. When space heating is required, water is pumped from the water heater to the fan coil. A blower then passes air over the coil, where heat is exchanged. The warmed air is distributed through a standard duct system (sealed with duct mastic, of course). We try to keep the ducts inside the conditioned space.

These systems have a number of advantages for energy-efficient affordable housing projects. Instead of installing a furnace and a water heater, we install one appliance, and we usually save some floor space in the process. In addition, the combination systems meet all of our requirements. They have a seasonal efficiency of 90%; they're sealed combustion; and the fan coils are sized around 40,000 Btu. The cost difference between the combination system and a 90% sealed-combustion furnace plus a standard-efficiency sealed-combustion water heater is almost nil. An added advantage is that we're providing domestic hot water

## The Programs Behind the Rehabs

Renaissance Illinois is an affordable housing program initiated by ComEd in 1995 that is focusing efforts on energy efficiency improvements and increased home ownership in neighborhoods showing signs of rebirth. The program targets vacant, structurally sound brick buildings that can be redeveloped into high-quality affordable housing for low- and moderate-income families. Nonprofit housing development corporations acquire buildings through the city of Chicago's Abandoned Property Program (CAPP). ComEd works with developers by reviewing architectural plans and providing recommendations for energy efficiency improvements. ComEd then provides grants toward energy efficiency upgrades in lighting, insulation, windows, and air sealing.

The objectives of the Existing Buildings Efficiency Research (EBER) program at Argonne National Laboratory are to identify, verify, and implement cost-effective energy conservation strategies for existing low-income housing in the Midwest. These goals are pursued by working directly with the architects, contractors, and developers of affordable housing so that (1) researchers can appreciate the barriers to incorporating state-of-the-art energy conservation measures in housing and (2) architects, contractors, and developers can gain access to and experience with the tools, techniques, and technologies of energy efficiency. Working directly with people who are developing low-income housing in communities, the EBER team at Argonne hopes to lower energy bills for local community housing and lower greenhouse gas emissions for the nation.

with a Polaris or CompleteHeat water heater that has a combined annual efficiency (CAE) of 90%. Overall, the combination systems are performing very well, with normalized space-heating consumption averaging 5.3 Btu/ft²/HDD for the 1995–96 heating season.

Typically, the central systems installed in our rehabbed buildings are hot water systems with baseboard convectors. We had the opportunity in one ten-unit rehab to do a variation of this system and save some money in the process. The floors were in terrible shape, and plans called for lightweight concrete to be poured to level them. We decided to install plastic tubing on the existing floor, pour the concrete over the tubing, and create a radiant floor heating system. Three Weil-McLain GV Series boilers were installed to provide the hot water. We actually saved about $10,000 in first costs by doing it in this manner rather than using baseboard convectors. The building is very comfortable, and normalized consumption for the 1995–96 heating season was 5.4 Btu/ft²/HDD.

Our ventilation systems are rather basic. We require exhaust fans in all bathrooms and kitchens, even though the local building code may not require them. All exhaust fans must vent to the outside—no recirculating fans in the kitchen. Our goal is to get rid of moisture as it's generated in the units. Bathroom fans are rated at 70 cubic feet per minute (CFM) and must have a noise rating no higher than 1.5 sone. Kitchen exhaust fans must be rated at a minimum of 150 CFM. (These CFM rates follow the Chicago building code and are higher than the new ASHRAE 62R, which requires 50 CFM in bathrooms and 100 CFM in kitchens.)

### Lighting and Appliances

Energy-efficient lighting is also part of the rehab. We put fluorescents in common areas and three hard-wired compact fluorescents in each unit. All new refrigerators installed must use less than 600 kWh per year.

## Energy Efficiency and Affordable Housing

Does energy efficiency really contribute to making housing affordable? From our perspective, the answer is a resounding Yes! Let's take a closer look at this by making a couple of assumptions. First, let's assume that the typical rehabbed buildings in Table 1 received an energy-efficient rehab. Let's further assume that we would have reduced normalized consumption from 24.7 Btu/ft²/HDD ($960) to 7.3 Btu/ft²/HDD ($280), the average for all multifamily buildings that received an energy-efficient rehab. At 60¢/therm, our annual savings per unit are $670, or $56 per month.

Second, let's assume that the cost to upgrade to the energy-efficient building standards is borrowed as part of the primary mortgage rather than received as a grant. The average monthly rent would have to increase by about $18 per unit to cover the increased mortgage payment.

Increase the rent for affordable housing—perish the thought! But the net savings to the tenants are $38 per month. Even though the rent is higher, it's actually cheaper to live in the units (see Table 2).

### Beyond Project Completion

Keeping first cost low is key to affordable housing production. My experience in this field is that energy efficiency is often sacrificed in an effort to produce affordable housing. This is due to either a lack of understanding of how to make a building energy efficient or a lack of financing. The process seems to be: get the construction cost as low as possible, do it, and then move on to the next project without really thinking about the energy cost burden placed on the people who are going to live there.

The hearts of affordable housing developers are in the right place. I truly believe they want to produce high-quality housing. However, all parties involved with affordable housing production need to expand their vision beyond the completion date and realize that investing in energy efficiency is a good deal. The housing will be more affordable from the day people move in, if energy efficiency is built into the project.

While exploring the cavernous reaches of an abandoned building (or any building to be rehabbed as affordable housing), remember that energy efficiency is a key ingredient in the affordable housing equation. We must expand our creative vision by seeking opportunities to integrate energy efficiency wherever possible in the rehab process.

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The completed buildings are not only energy efficient and affordable, but also aesthetically pleasing.