He points out that the Phoenix study ignored latent load and instead looked at Manual J's treatment of sensible load, which is calculated the same regardless of whether it's a hot, dry climate or a wet climate. An additional problem in a humid climate is that an air conditioner that runs on short cycles won't have time to develop much latent capacity, so you end up with a house that's cold but wet. Proctor plans to do a followup study in the Southeast as soon as he can get funding. John Kesselring at the Electric Power Research Institute told *EDU* that his organization is willing to sponsor the study if it can get cofunding from utilities.

For more information, contact: John Proctor, Proctor Engineering Group, 818 Fifth Avenue #208, San Rafael, CA 94901; (415) 455-5700, Fax: (415) 455-0299, E-mail: peg@nbn.com, Web site: http://www.proctoreng.com.

The Cost-Effectiveness of Energy Improvements

The Washington State Energy Office (WSEO) has released a study on the regional costs of conservation for new residential construction. While duct sealing gets a big thumbs up, other popular energy-saving measures rate an unequivocal maybe.

The study, funded by Bonneville Power Administration, tried to gauge the absolute and incremental costs of meeting energy-efficiency standards such as those sponsored by the Super Good Cents program and the Council of American Building Officials' Model Energy Code. Although the survey looked at housing in Montana, Idaho, Oregon, and Washington State, the results should be of interest to anyone involved in energy-efficient housing.

The study used two methods of estimation. First, a cost research advisory group (CRAG) developed estimates using standard industry cost data and software. These were compared with builder cost surveys and found to be accurate. Although fluctuations in lumber prices over the life of the study caused the CRAG estimates to be higher than builder surveys, the report states that this had little effect on incremental costs.

One of the most encouraging findings concerned duct placement. Heating contractors were asked to estimate the costs of installing forced-air heating systems in 1,344-square-foot and 2,200-square-foot prototype homes. Each contractor gave three estimates for each home. The first estimate was for a typical system in which ducts were installed in the home's crawlspace. The second was for improved air sealing of these ducts. The third estimate was for installing ducts in the heated space (see Table 1).

The survey determined that sealing the ducts outside of the heated space added between $415 and $589 to the cost of the HVAC system. Installing the ducts in the heated space cost $308-$417 less than the typical system. Why the savings? Installing ducts in the heated space required shorter duct runs (more on that below), and the ducts didn't need to be insulated. (Washington's energy code requires R-8 insulation when ducts are installed in an unheated space.) In addition, the labor costs were lower for installing the ducts inside, since the installers could work standing up on ladders instead of on their backs in a crawlspace.

Putting the ducts in the conditioned space does generate some extra structural costs. The builder has to complete the home's pressure boundary in the normal manner, including all air sealing and drywall finishing. Only then can the duct chases be framed. Perimeter chases can be installed in large rooms, then used as valence lighting systems. Or a hallway ceiling can be dropped and registers punched out in each bedroom. (The registers are installed high on the wall with a diffuser that gives enough throw to mix the heated air with the room air.) In spite of all this, WSEO researcher Michael Lubliner told *EDU* that the overall costs were still equal to or a little less expensive than putting the ducts in the crawlspace. "It's a zero-cost conservation measure," he says. "In the typical home, duct leakage means that 20%-30% of the heat isn't getting to the house. So you've improved efficiency by 20%-30% for free."

Table 1 — Summary of Duct System Cost Estimates

Duct Measure	1344 Prototype Costs ($)			2200 Prototype Costs ($)		
	Installer 1	Installer 2	Average	Installer 1	Installer 2	Average
Standard duct system (excluding furnace, ducts insulated)	$1,793	$1,756	$1,779	$2,242	$2,312	$2,279
Sealed duct system	$2,272	$2,106	$2,171	$2,894	$2,837	$2,868
Ducts inside heated envelope	$1,426	$1,515	$1,471	$1,809	$1,915	$1,862
Plenum construction costs			$277			$488
Interior duct total			$1,748			$2,350

However, the study also confirmed that installing ducts inside the house takes a lot of planning. "The heating contractor and the designer of the home have to be communicating with the general contractor," he cautions, or else it won't work.

Other findings are as follows:

- The use of foam sheathing significantly increases construction costs. That's why a lot of builders build thicker walls and install R-21 high-density wall insulation.
- Foam-core panels can be quite competitive with double-wall construction in some areas. While this is probably only applicable in extreme climates such as Montana, Lubliner believes that a production builder who standardizes around them could lower costs while maintaining energy efficiency.
- Savings from advanced framing techniques are highly dependent on lumber prices. Figure 1 compares the square-foot costs of standard and advance-framed walls, with lumber costs from $100 to $600 per 1,000 board feet (MBF). When lumber prices are low, the increased cost of header insulation and thicker drywall outweighs the lumber cost savings from advanced framing. When prices are high, however, the savings in lumber costs outweigh the additional insulation and drywall costs, making advanced framing more economical.

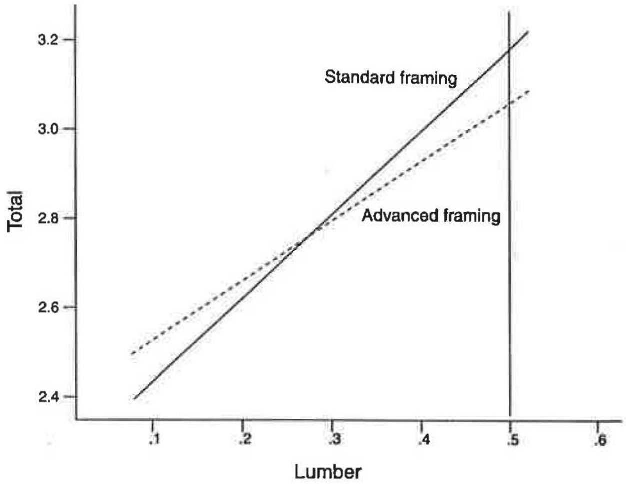


Figure 1 — Relationship of framing lumber cost to overall wall construction cost by framing type. The vertical axis represents overall wall construction costs in dollars per square foot. The horizontal axis represents lumber costs in dollars per board foot, with a vertical line representing a cost of $500 MBF. The graph shows that as lumber costs rise, so do the savings from advanced framing techniques.

Although WSEO was eliminated last June, the report is available from Washington State University. For more information or to order a copy of the report, contact: Michael Lubliner, Washington State University Cooperative Extension, 925 Plum Street SE, Bldg. #4, P.O. Box 43165, Olympia, WA 98504; (360) 956-2082, Fax: (360) 956-2217, E-mail: lublinerm@wsu.edu.

Union Electric Field Test Pits Cellulose Against Fiberglass ... and the Winner Is ...

"It really shocked us when our field test showed no difference between the air tightness of cellulose and fiberglass insulation," says William Conroy, division marketing supervisor for Union Electric, in St. Louis, Missouri. "We had expected the cellulose to provide a somewhat tighter envelope. But that wasn't the case."

Like a lot of other utility execs, Conroy had been scratching his head over the claims and counterclaims made by insulation manufacturers and their advocates regarding their products' ability to reduce air infiltration.

"We wanted to get at the truth of the matter," Conroy tells *EDU*. "I didn't want Union Electric to be accused of playing favorites, as has happened to some other utilities." (See *EDU*, June 1996.)

When a local developer announced plans to build seven new houses that would be nearly identical in design and closely grouped on a single tract of land, Conroy saw his chance to conduct a field test under tightly controlled conditions.

The study, initiated by Union Electric in December 1995, was a joint project with Northside Preservation, the developer of Maple Acres, an all-electric subdivision located on the west side of St. Louis.

Under Union Electric's direction, three of the new houses were insulated with cellulose, by Nu Wool Insulation Co., and three were fitted with high-density fiberglass, installed by Aladdin Insulation. All six of the insulated houses were equipped with a standard air infiltration package. The seventh house, used as a control, was insulated with fiberglass but left unsealed.

"We asked the contractor to use high-density fiberglass, rated at R-15, so that it would be comparable to the R-value of the cellulose," Conroy explains.

When the houses were completed last fall, Union Electric hired Paul Peterson, president of Peterson Energy Service in Fenton, Missouri, to run blower door tests on the houses without telling him what type of insulation they contained.

The results, as shown in Table 1, demonstrate that in new construction, the air infiltration rate is dependent on the sealant package, not the type of insulation installed in the cavity.

"We'd been told by some of the speakers participating in our energy conservation workshops that fiberglass insulation 'leaks like a sieve,' " Conroy says. "Our test showed that a properly installed sealant package can cut air infiltration by 50%, regardless of the insulation."

Union Electric has installed identical heat pumps (12 SEER) in one cellulose-insulated house and one fiberglass-insulated house (the rest have electric-resistance heating) and is monitoring their respective energy use.

Table 1 — Blower Door Test Results

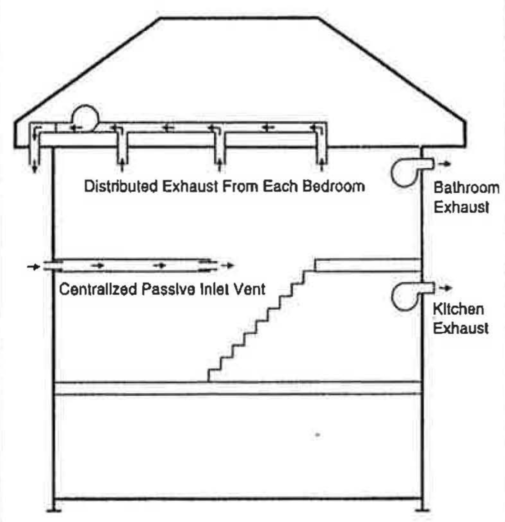
Construction	Air Changes Per Hour (ACH)
Houses with fiberglass insulation and sealant package	.24 (best case)
	.62 (worst case)
	.46 (mean)
Houses with cellulose insulation and sealant package	.23 (best case)
	.65 (worst case)
	.41 (mean)
Control house	.95

The Effectiveness of Simple Ventilation

A study by the Canadian Institute for Research in Construction shows some common simple ventilation systems to be inadequate for the ventilation needs of homes without ducted, forced-air heating systems.

Funded by a consortium of government and industry groups, the study looked at how well various systems met the ventilation requirements of Canada's 1995 National Building Code. The standard referenced in the Canadian code — CAN/CSA-F326-M91, "Residential Mechanical Ventilation Systems" — is similar in approach to ASHRAE's Standard 62 in that it gives a minimum whole-house ventilation rate, as well as minimum rates for individual rooms.

The researchers evaluated three generic systems: a system with local exhaust fans; a partially distributed exhaust system that combined local exhaust fans on the first floor with a central, ducted fan on the second; and a minimal ducted supply system with three exhaust fans and two ducted supply fans.



Partially distributed exhaust system with vent

Figure 1 — Partially distributed exhaust system with vent. Source: Institute for Research in Construction.

The local and partially distributed exhaust systems were tested with and without passive inlet vents. This brought the total to five separate configurations.

The tests were conducted using tracer gas techniques in a 2-story, 3-bedroom, 1½-bath house. They ran throughout the fall and winter, and into the late spring in order to test the systems under various weather conditions.

A and B: Local exhaust fans

Configuration A put local exhaust fans in the kitchen and each bathroom. There were no passive inlets; makeup air was provided by natural leakage through the building envelope.

Configuration B used the same fans but added passive inlet vents in the upstairs bedrooms, as well as in the downstairs living and dining rooms. The living and dining room vents were sized to provide half the home's ventilation air requirement.

C and D: Partially distributed exhaust

Configuration C used exhaust fans in the kitchen and bathrooms. Another fan was installed in the attic with ductwork leading to it from each upstairs bedroom. No passive inlets were provided.

Configuration D added one central, passive outdoor-air intake. The intake opened into the stairwell between the first and second floors.

E: Minimal ducted supply system

Configuration E, the minimal ducted supply system, used the same local exhaust fans as Configuration A. The difference was that it included a ducted air supply to each room. The supply consisted of two subsystems. A fan in the basement supplied air to each room on the

Table 1 — The Effectiveness of Various Simple Ventilation Strategies

	System Description	Results
A	Local exhaust	Provides only marginally better results than natural air leakage.
B	Local exhaust with vents	Over-ventilation of the house overall. Under-ventilation of the second story.
C	Partially distributed exhaust	Air supplied to the second-floor bedroom was largely indoor air.
D	Partially distributed exhaust with central vent	Outdoor air reached bedrooms.
E	Minimal ducted system	Effective at meeting the standard's ventilation requirements for supply air and for distribution to all rooms.

Source: Institute for Research in Construction.

first floor and in the basement. A fan in the attic supplied the rooms on the second floor. The ducts were sized to meet the outdoor air requirements for each room.

The results

The results are summarized in Table 1. The local exhaust fans provided the worst air distribution and failed to meet the code's ventilation requirements, even with the passive inlet vents. Air distribution to the upstairs bedrooms was especially poor. At the same time, the ground floor and basement were over-ventilated. One possible reason was that the depressurization caused by the fans raised the structure's neutral pressure level, increasing the vacuum in the lower rooms and drawing more air in through the inlets. Dr. James Reardon, the researcher in charge of the study, says that the passive inlet vents tended to aggravate the over-ventilation of the downstairs rooms, while not improving the second-floor air supply.

The minimal ducted supply system was by far the most effective system tested, since it met the code's requirements while supplying just enough air to each room. However, it was also the most complicated and expensive system to install and operate. The partially distributed exhaust system will probably find better acceptance among builders, since it provided better ventilation to the upstairs bedrooms than the local exhaust fans without over-ventilating the downstairs rooms. Reardon is planning further research on the partially distributed and minimal ducted systems.

For more information or to obtain a copy of the study, contact Dr. James Reardon, Institute for Research in Construction, National Research Council, Ottawa, ON K1A OR6, Canada ; (613) 993-9580, Fax: (613) 954-3733.

PRODUCTS

Efficient, Clean-Burning Fireplaces

Many people who build tight homes shun masonry fireplaces. Not only are fireplaces energy losers, but the emissions they give off are a serious environmental concern. The response has been a new generation of proprietary, clean-burning "new technology" masonry fireplace cores. Not only do these products make efficient supplemental heat sources, but their emissions meet the strictest environmental standards.

At least three systems have hit the market so far. Two of these systems — the Buckley Rumford marketed by Buckley Rumford in Port Townsend, Washington, and the Frisch-Rosen from Lopez Quarries in Everett, Washington — use the traditional Rumford fireplace design. The advantage of the Rumford is that it burns hot and gives off a lot of radiant heat. Its streamlined throat eliminates turbulence and carries away smoke with little loss of heated room air. The third — the Moburg MRC from the Portland, Oregon-based Firespaces, Inc. — looks like a standard fireplace but is built around a masonry heater.

Strict air-quality standards

These products come in response to growing opposition to fireplaces among environmental groups. In fact, masonry fireplaces have been outlawed in most of Colorado, as well as in parts of Nevada and California. Some observers expect them to be banned in all of California, Washington, Arizona, Oregon, and other states in the West in the next year or two. If the trend continues, masonry fireplaces will not be permitted in new construction or in remodeling unless they are certified. Already some regulators are working on a national US Environmental Protection Agency (EPA) fireplace emissions standard.