in the state. The Board of Building Regulations and Standards, in cooperation with the US Department of Energy and Massachusetts gas and electric utilities, will offer training seminars on the new energy code beginning in February 2000. For more information about the training schedule and registration, and to see the content of the new requirements, visit www.state.ma.us/bbrs/energy.htm.

WASHINGTON, DC — Representative Jay Inslee (D-WA) introduced the Home Energy Generation Act in the US Congress. If enacted, the law would establish a national standard for net metering, allowing consumers who use solar, wind, fuel cells, and other alternative sources to generate electricity to effectively sell excess electricity back to the local utility by rolling back their utility meters. Currently, 30 states have provisions for some type of net metering, but there is no uniformity from one state to the next.

ATLANTA, GA — The American Society of Heating, Refrigeration and Air-Conditioning Engineers has launched a new quarterly publication call *IAQ Applications*. The new publication, aimed at designers, installers, and operators of HVAC systems, will include news about indoor air quality issues, standards development, government actions, emerging health issues, and new products.

OMAHA, NE — A 10 foot x 10 foot ICF wall built by Reward Wall Systems achieved a four-hour fire rating during a test (ASTM E-119) at Omega Point Laboratories in Elmendorf, Texas. "It is important to note that the Reward wall was tested bare," says Kelvin Doerr, director of engineering at Reward. "When building with the Reward 11-inch form, it will not matter what finish is attached to the inside or outside of the wall or how it is attached — the concrete and expanded polystyrene forms alone achieved the four-hour rating."

ARLINGTON, VA — The growth in residential gas demand that began in the mid-1980s — making natural gas the dominant fuel in all US regions except the South — will continue as consumption increases about 1% per year through 2015. That is one of the findings of the *1999 Residential Sector Summary*, produced by the Gas Research Institute (GRI). "Most of the historical growth in residential gas consumption stems from capturing an increased share of the space-heating market due to efficiency improvements in gas equipment," says Kathy Nice, GRI project manager. "However, efficiency improvements are a double-edged sword. With a continued but slower increase in market share, future gas growth for space heating will be largely offset by continued improvements in gas-heating technologies and housing thermal integrity." Most of the projected growth in residential gas consumption will come from gas water heating, clothes drying, and hearth products, the report says. The study can be ordered from the GRI Document Fulfillment Center by fax at (630) 406-5995. The study is $20 for GRI members and $25 for nonmembers.

NORTH VANCOUVER, BC — Richard Kadulski, editor of *Solplan Review*, has published a new book titled *Heating Systems for Your New Home*. The 88-page softbound book is designed to help uninformed home owners make good HVAC choices. The book sells for $19.95. Tel: (604) 689-1841; Fax: (604) 689-1841; E-mail: solplan@direct.ca.

RESEARCH AND IDEAS

Defying All Skeptics, Steve Lentz's Homes Work Great

Time tests all theories — great and small — and builder Steve Lentz is coming out on top.

Back in 1984, when Lentz first began incorporating airtight techniques in his new homes, other Wisconsin builders scoffed at the idea. "They hammered me pretty good in those early days," Lentz remembers. "They told me I was going to have condensation problems and rot problems and indoor air quality problems, and that the extra cost of building tight homes would sink me."

Alas, for the skeptics, Lentz Custom Homes, based in Campbellsport, Wisconsin, is still afloat and doing quite well. Lentz has customers lined up for new homes. Callbacks are as rare as robins in the cold Wisconsin winter. And none of his existing homes has experienced the moisture and air quality problems his critics so loudly predicted.

In fact, with a 15-year track record of doing things right, Lentz's reputation is growing daily. One of his Energy Star-rated homes recently scored the highest Home Energy Rating System (HERS) rating ever given to a conventionally designed home in Wisconsin, at 93.7 five-star plus. (The only Wisconsin home to surpass that mark employs passive and active solar design and wood heat.) That may have silenced Lentz's critics for good.

A Time-Tested Package

The cost of Lentz's homes ranges from a very basic $65 per square foot to $120. But for $1 extra per square foot, any client can get Lentz's time-tested package of air-tightening and insulation measures, which are detailed in the sidebar, "A Time-Tested Package of Energy-Saving Measures."

EDU asked Lentz to break out the cost of each of the 10 measures, but he steadfastly refused. "The client must

A Time-Tested Package of Energy-Saving Measures

Wisconsin builder Steve Lentz spent 15 years developing an integrated package of insulation and air-tightening measures that deliver the quality he seeks. All of his new homes test out at 1 air change per hour or less at 50 Pascals and come equipped with air-to-air heat exchangers as standard equipment. The package adds about $1 per square foot to the home's price.

1. Use 2-inch extruded polystyrene on the exterior basement wall instead of the 1 inch specified in the Wisconsin energy code.

Lentz: "Even the 1-inch requirement isn't being widely enforced. Many inspectors let builders exclude the exterior basement insulation if they promise to upgrade the attic insulation or insulate the inside of the basement."

2. Wrap all footings with 3-mil cross-laminated polyethylene instead of ordinary poly.

Lentz: "Ordinary poly is shot full of holes after the pour and virtually useless. The cross-laminated poly has a lower perm rating and won't tear. It serves to keep the footings dry and keeps moisture from wicking up into the basement walls. That way you get less humidity in your basement, which lowers your air conditioning and dehumidification costs, and reduces the likelihood of mold."

3. Locate all ductwork inside the envelope (within conditioned spaces) and seal it with silicone mastic.

Lentz: "We had to educate our HVAC contractor to do this right. And now he does — on every job. Other builders say, 'My subs won't do it!' but that's because they're constantly low-balling their subs to get the lowest possible price, and changing subs as a result. To put it bluntly, they're building cheap houses that are going to cause the owners problems."

4. Use 1-inch extruded polystyrene (R-5) under the basement floor versus none.

Lentz: "The foam insulation helps keep the slab warm and stops heat loss through the basement floor. It's not much, but little things add up."

5. Use 1 inch of polyisocyanurate on the exterior instead of 1 inch of extruded polystyrene.

Lentz: "My upgraded 2x6 wall assemblies end up with an insulating value of about R-30 [1 inch of polyiso at R-7.2 per inch and 5.5 inches of dense pack cellulose at R-4 per inch]. That lets us downsize the heating and air conditioning systems. I also use Ruffco housewrap on the walls, not because I believe in it as an infiltration barrier, but to hold the foam sheathing in place while we blow in the cellulose. I use Ruffco over other brands because of its strength."

6. Use R-64 blown cellulose insulation in the attic versus R-38.

Lentz: "We insist on 17 inches of *settled* density in the attic and do the bag counts to make sure."

7. Use cross-laminated 3-mil polyethylene as your air-vapor barrier instead of ordinary poly.

Lentz: "The cross-laminated variety is easier to handle and much less likely to tear. That makes it easier to install and requires fewer patches."

8. Create a continuous air-sealed envelope.

Lentz: "Wherever plastic hits plastic we either tape or seal it, creating one continuous membrane. If there's a tear or puncture, we always patch it. Most builders probably won't believe this, but my drywallers carry tape on the job and patch any holes or tears they make in the vapor barrier. We also foam the windows, doors, and pipe penetrations and use Lessco airtight electrical enclosures." (See Figures 2, 3, and 4.)

9. Make the attic hatch tight and well insulated.

Lentz: "You can build this type of hatch in about 15 minutes using scrap plywood, weatherstripping, 2 window sash locks, a 6-inch-thick block of polyisocyanurate, and some wood veneer. We actually create a jamb, so the sash locks can draw the door down tight to the weatherstripping. The access hatch is typically located in the ceiling of an unheated walk-in closet, yet I've never had a callback from a homeowner complaining that the closet was cold."

10. Install a radon-approved sealed sump pump.

Lentz: "If there is negative pressure in the house it will draw a lot of air up through an open sump pit, and with that air comes moisture, radon, and other soil gases. I once gave a demonstration, in conjunction with Wisconsin Gas Company, where I invited a number of onlookers to huddle around an open sump pit while I depressurized the house with a blower door. As the wind came up in their faces, drawn up through the gravel underneath the sump, I explained to them that water vapor, radon, and methane could well be part of the air stream. It was fun to watch them jump back."

Figure 2 — Lentz is meticulous in air-sealing the floor systems in his new homes. As shown here, the crew installs a sheet of 3-mil cross-laminated polyethylene between the top of the basement wall and the mud sill, leaving an exterior flap. The flap is then taped, using 3M tape, to the 10-mil Teno Arm poly that covers the box joist. The box joist is later covered with 2-inch-thick polyisocyanurate, completely sealing the floor system.

Figure 3 — Looking up into the roof of one of Lentz's new homes, we see the careful attention given to air sealing. The airtight box for the recessed light fixture is made of 1-inch-thick pieces of scrap foam assembled with tape and expanding foam. Lentz says he likes to leave plenty of air around the light to prevent overheating. He says that none of his houses have ever experienced the "blinking light syndrome," indicative of overheating. The Lessco airtight electrical box to the left is for a hard-wired smoke detector.

accept the entire package, because it won't work piecemeal," he insists. "That would be like buying a new truck and asking the salesman how much less it would cost if you removed the right front wheel. This is a system in which the whole is greater than the sum of the parts."

Lentz readily concedes that some of the elements in his package are not cost-effective on their own. For example, the 1-inch XPS foam he puts under the basement floor would probably have a 20-year payback in terms of energy saved — a measure that wouldn't make the cut with most builders. "I know it's not cost-effective when you look at the payback on it," Lentz says. "But the system falls apart without it." He tells ***EDU*** that the package as a whole will pay for itself in just three to five years.

"According to the sizing recommendations in *Manual J*, a 2,200-ft² home with a full basement should have a heating load of 102,000 Btu's an hour," he notes. "But the real load on one of my houses that size is just 31,000 Btu's an hour. That translates into a smaller heating system for my customers and real savings on their annual heating bills."

Lentz tells ***EDU*** that he can only remember one customer who refused the $1-per-square-foot energy upgrade. "The architect had convinced him that all he needed was a four-inch wall with high-density batts," Lentz relates. "He came back to me the following winter, full of regrets, and apologized for not listening to me."

Building Tight and Ventilating Right

Since all of Lentz's houses test out at 1 air change per hour or less at 50 pascals, it is not surprising that he insists on mechanical ventilation. "I won't build a house without whole-house ventilation," he says. "Some of the new houses being built in Wisconsin have very poor indoor air quality. We have to start controlling the air quality or we're going to end up killing people."

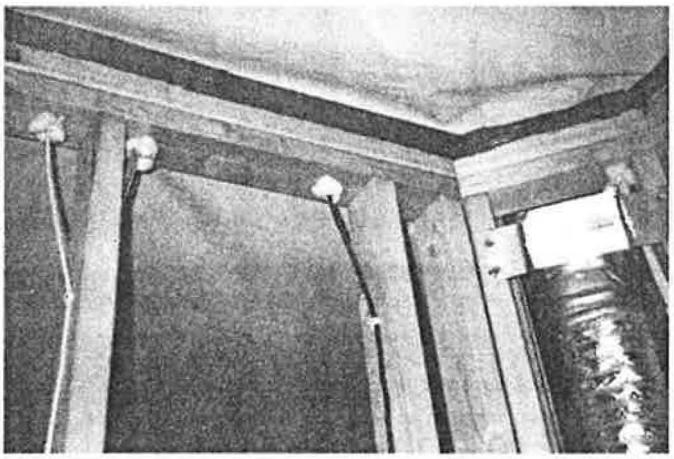

Figure 4 — Before the framed wall was stood up in this bedroom, Lentz's crew covered the top plate with a strip of 6-mil poly, leaving a flap along the edge. After the walls were raised, the crew taped the ceiling air-vapor barrier to the flap, creating a continuous membrane. Note that the holes for the electrical cables running up into the attic have been filled — right through the double top plate — with expanding foam. The duct shown on the right is an exhaust port for the heat recovery ventilator, which is located in the basement.

Since 1984, Lentz has experimented with three different makes of air-to-air heat exchanger. Today he uses mostly Venmar equipment. Exhaust vents for the heat exchanger are located in each bedroom and bathroom and in the laundry room.

"Some of my competitors would have their clients believe that poor indoor air quality and condensation

on the windows, even *ice*, are the natural byproducts of modern construction," Lentz says. "They put these disclaimer clauses in their contracts — to avoid liability — warning their clients about the possible problems that come with 'high-quality windows' and 'the latest construction techniques.' I've suggested to them that they offer air-to-air heat exchangers — or at least an exhaust-only ventilation system — to their customers as an option. *Then*, if the customer refuses, it's legitimate to have them sign the disclaimer. But not many builders will listen."

Kudos for Lennox's Complete Heat

While Lentz doesn't work for Lennox, or receive any commissions, he may be one of the best salespeople the company has. Almost all of his new homes in the past five years have been equipped with Lennox Complete Heat, a packaged combo system that combines a high-capacity water heater with an air handler, delivering hydro heat to the home's ductwork. "It's a beautiful piece of equipment," he says. "I tell my clients that they can get a furnace and a conventional water heater, which won't have the capacity to fill up their hot tubs in one draw. Or, for about $300 more, they can get a Complete Heat combo system, with unlimited hot water." With a wink he adds, "They *always* make the right decision. I haven't installed a furnace since 1993."

Right About Cathedral Ceilings, Too

Nowhere was Lentz more roundly criticized than for the way he builds cathedral ceilings. His method is to blow the cavity (e.g., between 2x12 rafters) full of tightly packed cellulose, leaving no air space at all. On the bottom side of the cavity, between the rafters and the ceiling membrane, he installs an air-vapor barrier made of 3-mil cross-laminated polyethylene. The poly is meticulously installed and sealed, so that no air from the room below can enter the cavity. The topside of the roof assembly is closed in an orthodox manner, with ½-inch OSB, roofing felt, and shingles.

"Some critics said that no matter how we blew the cellulose, it would settle, leaving cold, uninsulated spots along the roof line," Lentz relates. "Others said that no matter how carefully we installed the vapor barrier, warm, moist air would get up into the cavity, condense, and produce mold and rot."

Lentz tells ***EDU*** that after one particularly heated discussion at a building science conference a few years ago, he wrote down his antagonist's name and address, went home, cut away the ridge on one of his cathedral ceilings, videotaped the results, and mailed it off to the man with a terse note: "See!"

"That cathedral ceiling had been there for more than four years," he reports. "When I opened it up, we found that the cellulose hadn't settled. There was no mold. And no rot. The key, of course, is that you must seal off the bottom of the assembly completely. The stack effect can't transport moisture up there if you do a very, very good job of air sealing. And you must make sure your cellulose is tightly packed. If you don't handle these details properly, you could end up with a catastrophe on your hands."

Fear and Loathing for HERS, Energy Star

Lentz reports that the Home Energy Rating System (HERS) and Energy Star programs have scarcely made a dent in Wisconsin home-building practices.

"It's not the government's fault," he explains. "And it's not the utilities' fault. It's that the home builders here are saying to themselves, 'The economy's great. I'm making money hand over fist. Why should I change?'"

Lentz says that Wisconsin builders are "deathly afraid" of HERS because they don't want to be graded or compared. "The better attitude would be to find out why the new house across the street rated 93 while the house you built only rated 84. But that takes effort and a willingness to change."

Though Lentz has come a long way up the learning curve and is pretty satisfied with his present construction methods, he is always looking for ways to improve. "On our last two or three houses we starting using more expandable foam sealant," he reports. "It's a worthwhile improvement for sealing windows, doors, and Lessco electrical box enclosures."

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Autoclaved Concrete Versus 2x6 Stick and Batt

Energy-conscious designers and builders are always striving to get the most bang for their buck. But how do you get apples-to-apples performance comparisons on wall systems that are fundamentally different?

That's why we have been especially interested in the ongoing test work at Oak Ridge National Laboratory (ORNL), where researchers have come up with a reliable way to characterize the dynamic benefit for massive systems (DBMS). This makes it possible to compare the true thermal performance of massive walls — in this case, autoclaved aerated concrete (AAC) block — with standard stick-and-batt construction.

The ORNL team, including Jeff Christian, Jan Kosny, Andre Desjarlais, and Phillip Childs, used dynamic hot-box testing and finite difference computer modeling to