BY ALLISON BAILES

The primary purpose of housewrap is water protection, as shown here where it serves as a drainage plane to keep wind-driven rain and snow out of the walls. Housewrap doesn't make a good air barrier. While the seams can be taped to improve its air resistance, it should never be taped at the bottom, otherwise it can trap water. You're better off air sealing with a combination of peel-and-stick tapes, sealants, and gaskets.

Top 10 Building Science Secrets

Editor's note: *In reviving* JLC's *Energy column, we are pleased to offer a contribution by Dr. Allison Bailes. Don't let the "Dr." worry you. Yes, he's a Ph.D. physicist (which means he knows something about heat and moisture transfer through buildings), but Dr. Bailes is also one of the most down-to-earth practitioners of the building sciences, and his blog postings (energyvanguard.com) and twitter feeds (twitter.com/Energy Vanguard) are must-reads for anyone interested in the energy performance of buildings. You can read more about these top 10 "secrets" in-depth on the Energy Vanguard blog, and we will be exploring them more here in the future.*

Overall, the state of the construction industry is improving. Many builders and remodelers are learning, either out of interest or coercion, about building science and how to apply it. But while we're headed in the right direction, plenty of builders and remodelers aren't getting the message, and plenty of houses are being built with problems that shouldn't be that difficult or expensive to fix. Here, then, is a start. The 10 "secrets" below aren't really secrets, but judging by some of the conversations I have with people in the construction industry, they might as well be.

1 Housewrap isn't installed to be an air barrier. Many people believe that by putting housewrap on a building, they have their air barrier taken care of. But the air barrier's job is to minimize the amount of air that crosses the building enclosure between conditioned and unconditioned spaces. The

Power ventilators, even solar-powered ones, can cool the attic only if the fan pulls outside air into the attic. This air cannot come from the house, or you're just sucking away conditioned air. This means the ceiling plane must be airtight. But if you have an airtight ceiling, you don't need an attic fan. Bottom line: Power ventilators are a waste of money and a liability.

An attic pull-down stair, all 10 square feet worth, doesn't seem like much area. But in a 1,000-square-foot attic insulated to R-38, that 1% increase in area can result in a 27% decrease in the ceiling insulation R-value.

real purpose of housewrap is to be the drainage plane behind the cladding, and although housewrap can theoretically qualify as an air barrier material, it must be meticulously installed to effectively stop air leakage.

Builders usually do a decent job taping seams in the field, but rarely at the top edges. To qualify as an air barrier, housewrap would also need to be sealed at the bottom edge, but there's a good reason why this should never be done: You'll trap water inside when it gets behind the housewrap and can't drain out at the bottom of the wall.

Then there are all the mistakes. For example, housewrap at an inside corner often "cuts the corner." This sometimes prompts cladding contractors—who need to install siding tight to the corner—to slit the housewrap to get it to lie flat. And the innumerable tears, rips, and cuts that occur rarely get sealed before cladding, allowing air to move across the housewrap.

Finally, research shows that housewrap doesn't work effectively as an air barrier in both directions. We want an air barrier that works in both directions because the building is subject to both infiltration and exfiltration, depending on the direction of pressure gradients acting on a building.

But when we test homes for air leakage, we pretty much always test them in only one direction: from outside to in. We put the house under negative pressure with a blower door and then measure the air flow through the fan, which tells us how much air is leaking in through the building enclosure.

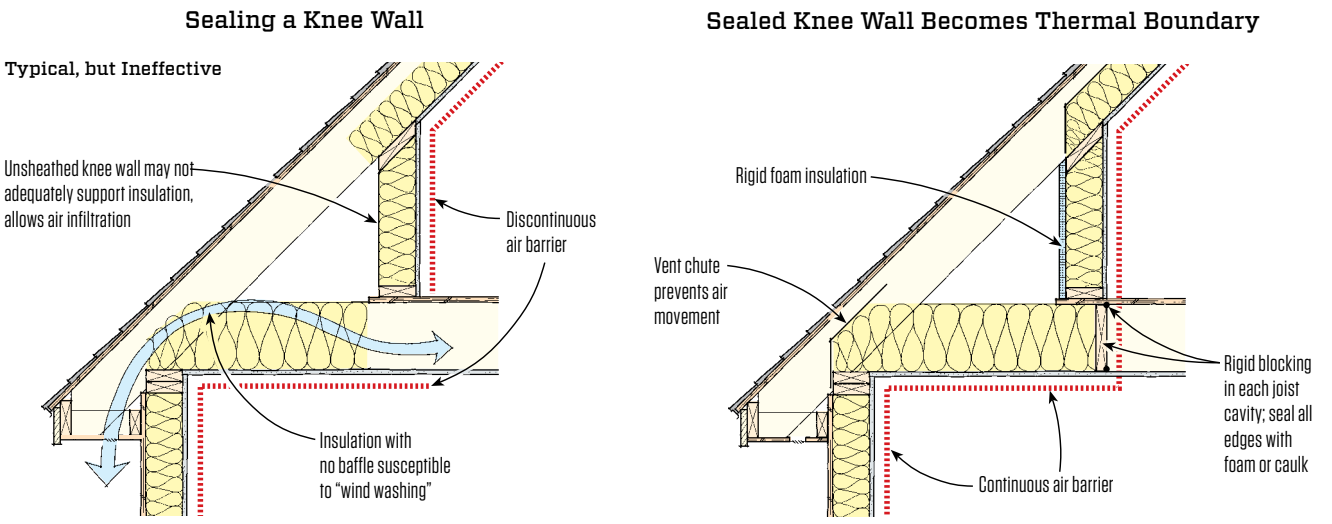
When homes that are air sealed with housewrap are tested under positive pressure, they perform far worse than those same homes tested under negative pressure. The reason for this is probably that air leaking out of gaps in the sheathing pushes the housewrap out, filling it like a balloon, and then the air readily finds the leaks at edges and penetrations through the housewrap and siding.

2 Power attic ventilators are a liability, not a feature. While power attic ventilators will probably keep your attic cooler, a significant portion of the cooling in your attic will be provided by your air conditioner.

When that power attic ventilator runs, it's going to pull air from wherever it can find it. Since air takes the path of least resistance, some of it will likely be coming from the conditioned space in your home. So basically what you're doing is air conditioning your attic. The longer the fan runs, the more conditioned air it pulls into the attic.

3 A house does not need to breathe. People need to breathe. A house needs to have good "control layers":

- A thermal control layer, also known as insulation.
- A water control layer, or weather-resistive barrier, that limits the entry of rain and snow.



Unprotected knee-wall insulation is prone to falling out and allows air to flow through it, as shown in the illustration above, left. To solve this problem, the exterior side of the knee wall should be sheathed, as shown on the right. Rigid insulation works well as a sheathing to cover the knee-wall insulation because it adds R-value to the knee-wall assembly. Be sure the floor below the knee wall is blocked off, as well. Otherwise airflow will short-circuit through the floor framing.

■ An air-control layer, also known as a continuous air barrier, to stop unconditioned air from leaking into the building and conditioned air from leaking out. Air also carries water vapor, and this can be a significant source of moisture in buildings. So the air barrier will also help control humidity.

A house cannot be too tight in my opinion. Yes, a tight house can have problems, but it's generally not because of the air sealing. The problem is the lack of systems thinking.

Here are the three main problems that may occur with tight houses:

■ Poor indoor air quality (IAQ)
■ Backdrafting of combustion appliances
■ High humidity, mold growth

The solution to the first of these problems is source control and mechanical ventilation. The solution to backdrafting is to use sealed combustion equipment or to isolate atmospheric combustion appliances from the living space and give them their own combustion air supply. The third problem, humidity, is often solved by properly sizing the cooling system, having a good ventilation system, and using materials that don't trap moisture.

So instead of saying that the house needs to breathe, we should substitute these three rules:

■ People need to breathe.
■ Don't mix combustion air and people air.
■ Houses need to be able to dry out.

4 A small uninsulated area can make a huge difference in heat gain or loss. Uninsulated can lights, attic scuttle holes, and other bare spots can lead to efficiency and comfort complaints from your clients. One example: Say we have 1,000 square feet of ceiling area and we put R-38 everywhere except at the 10 square feet of the attic pull-down stairs. That mere 1% of uninsulated ceiling results in a 27% decrease in the ceiling insulation's average R-value. This decrease applies to insulation that's not uniformly distributed, as well. If you have a lot of lumps in blown attic insulation, for example, you could drastically increase the actual R-value of the ceiling just by raking it smooth.

5 The quality of processes, more than the quality of products, determines the quality of the house. Just because you spend a lot of money to install spray foam insulation, heat-pump water heaters, and ground-source heat pumps doesn't mean that you're building a great house. What matters is how careful you are when installing housewrap, insulation, and air-barrier materials. If you do these right, you have a good chance of actually achieving a high-performance home.

I know that mastic, caulk, and insulation installed to grade aren't as sexy as geothermal heat pumps and photovoltaic modules. But the basic design details, material choices, and installation methods

are actually a lot more important than trendy "green" products.

6 Ductwork is important. When you attach high-efficiency HVAC equipment to crappy ducts, you're the equivalent of a snake-oil seller. Homeowners end up paying a lot of money for super high-efficiency equipment that often gets installed with an average or below-average duct system. Undersized, kinked, entangled, and leaky ducts rob all the high-efficiency afforded by the equipment. In most cases, a home would be better served by spending less on the heating and cooling equipment and more on the duct system.

The duct shown in the photo at left fails on two fronts: 1) It runs through the attic, which may be the most stupid place you can put ducts in an air-conditioned home. 2) The duct run is pinched where it passes through the truss webs. This constricts airflow, increasing duct pressures so the conditioned air carried in the duct flows out of the leaks faster.

7 Attic knee walls need more insulation and an attic-side air barrier. Those walls around the room in a finished attic separate conditioned space from unconditioned attic space, and they need to be air sealed and insulated like an exterior wall. The problem with many knee walls is that they have fiberglass batt insulation with nothing covering them on the attic side. If the batts don't make contact with the air barrier (the drywall), air moves through and around them, and they fall out of the attic knee wall. In other words, they're pretty much worthless.

The state of Georgia, where I work, recognized this problem about a decade ago and started requiring all attic knee walls to have sheathing on the attic side and to be insulated to at least R-18.

The best way to provide the sheathing is to use a rigid material. I've seen OSB (oriented strand board), rigid insulation, and structural or non-structural cardboard sheathing materials such as Thermo-ply. I've also seen attic knee walls sheathed with non-rigid materials—mainly housewrap—but I think the rigid material will do a better job with air sealing and will stay intact longer.

But no matter what material you use, keep an eye on the electricians, HVAC contractors, and other trades who get in there. Anyone who cuts a hole in the knee-wall sheathing must be held responsible for sealing it.

8 Duct systems should not be in unconditioned attics, especially in hot climates. The rate at which heat flows by conduction depends on the temperature difference. An attic can get up to about 130°F in the summer, and the conditioned air entering the ducts is about 55°F or so. With hundreds of square feet of duct surface area in the attic and a temperature difference of 75°F, the air coming out of the vents in your home will be significantly warmer than 55°F. Duct leakage makes the problems even worse.

The report, "Ducts in the Attic? What Were They Thinking?" (nrel.gov/docs/fy10osti/48163.pdf) summarizes research about putting ductwork in unconditioned attics. This report basically says it's about the stupidest thing we can do in homes that frequently run air conditioners. I encourage you to download it and read it. And if you're building or remodeling a home, make sure the HVAC contractor gets a copy.

9 Heat pumps can be more comfortable and efficient than furnaces in high-performance homes, even in colder climates. As you add insulation to a home and tighten up the building envelope, the heating load drops much faster than the cooling load. This makes sense because the temperature difference between inside and out in winter is much greater, and infiltration rates are typically higher. Heat pumps and/or hydronic forced-air heat are more appropriate because system capacity can be aligned more closely with the load. This ensures good air mixing at design conditions, an important prerequisite for comfort.

There's a lot more to say about this topic, which we can explore in-depth here in the future.

10 Ventless gas fireplaces are a liability. Manufacturers like to call these "vent free," suggesting you're being liberated from a burden by not having an exhaust vent. I think it's essential for people to know that they're actually missing something important when they go with a ventless gas appliance. Yeah, the gas industry lobby is powerful enough to have kept them legal this long, but these things can be dangerous.

Here are the main reasons why ventless gas fireplaces should be avoided:

- Even when working perfectly, they put a lot of water vapor into the house.
- Drafts, fans, candles, and tight houses can mess up the combustion process.
- Many homeowners don't understand how to operate or maintain them.

They may have fancy technology built into them now (oxygen-depletion sensors and catalytic converters), but the bottom line is that the risks can outweigh the benefits. It's not that hard to build a chase and cut a hole to install a direct-vent model, so why take the risk.

Allison Bailes owns Energy Vanguard, a home-performance and training firm in Decatur, Ga.