Building Performance and System Thinking

David Keefe
Vermont Energy Investment Corporation
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"So, what do you do for a living?"

Most people can answer this question in one or two words. They're a carpenter, or a stockbroker, or a dentist, or a realtor. Those of us who try to improve the performance of buildings have a harder time of it. Some of us come from specific sub-trades (insulation or heating, or whatever). But we're not just insulators or heating contractors. We want the buildings to work. We want them to be healthy, and comfortable, and durable, and efficient. We want them to perform, and that requires looking at the big picture.

We are part of an emerging trade. Without a name that's recognizable, we need a whole paragraph to explain what we do. Recently, some of us have begun using the term "building performance" (or perhaps "home performance"). This is as good a description as any. It implies that we are primarily trying to make the assembled system function as well as possible. Some of us do this with blueprints or plans. Some of us attempt this as part of building something new. Some of us try to do it with education. Some of us analyze existing buildings. Some of us fix them.

The common ground here is that building performance professionals are focused on making things work. That requires understanding the various components in a home and how they interact. We may not know every detail about each component, but we try to understand as much as possible about how they all work together (or don't).

Part of this has to do with measuring things. Lots of things have performance ratings, and lots of them don't perform as rated in individual situations. So we measure temperatures, and flow, and pressure, and carbon monoxide, and oxygen content, and relative humidity, and whatever else we need to measure in order to figure out what's actually happening, as opposed to what the label says.

Why do we even need a "building performance" sub-trade? Doesn't the general contractor handle the big picture? In the good old days, when building materials and methods were comparatively simple and changed very little from generation to generation, it was easier. But that's no longer the case. We use many materials now that didn't even exist when our parents and grandparents were building things. The appliances are more sophisticated. We have tight buildings with big fans. We have many more chemical contaminants, and the biological problems seem to be getting worse too. Things are getting complicated fast.

Where's the owner's manual?

When we buy a car, or a piece of sound equipment, or the latest electronic gadget, we get a manual with it. This makes sense because these are complicated assemblies that should be operated properly. A house is more complicated than any of these. It's the biggest purchase most of us make. It's also where we spend the most time. And yet we typically get no operating instructions with it. Why is that?

When an auto manufacturer decides to create a new car, they put teams of designers on the task. These teams have specific jobs. One team might work on the car's chassis, one on the motor; another designs the interior, etc. But the teams don't do their jobs alone. The people who design the suspension talk to the teams working on the motor, or drive train, or brakes, or whatever. They know what the other person is doing, and they factor that information into their job. During the process, someone looks at the overall design and makes sure that the things will work together. That's not the way we usually build houses.

Typically, the way house construction goes is more like this: Someone decides the overall shape of the building, and then his or her role in the process is over. Someone else decides the details of the framing and perhaps the finished surfaces. Someone else may think about insulation and air sealing. Or no one brings it up, and the insulation ends up being whatever is the standard procedure for the subcontractor, and the air sealing is ignored. Someone else decides what electrical devices to install. Someone else selects and installs the heating, cooling and domestic hot water equipment. Someone else picks out the ventilation (if there is any). For the most part, these people don't talk to each other.

The end result of this process is not a designed assembly, but a collection of parts thrown together. The reason there's no owner's manual is that there isn't anyone to write it. There is no individual, or group of individuals, looking at the big picture. Everyone focuses on their little piece and typically ignores any possible links between their work and the rest of the stuff in the house. But the interactions are important.

- If the water heater backdrafts when it's operated with the clothes dryer and kitchen exhaust on, whose fault is that? Is it the fault of the people who built the shell tight? Is it the fault of the electrician who installed the clothes dryer? Is it the fault of the person who installed the kitchen fan? Is it the fault of the contractor who put in the water heater? What about the architect, or the insulation contractor, or the person who decided that the chimney would be built, thereby encouraging the installation of a natural-draft device? If you ask any of these people, they will typically respond that their piece is done correctly. They are often right. But the system doesn't work correctly, because no one has anticipated how things may interact. It's not anyone's job.

- Most builders in cold climates have to deal with callbacks due to window condensation. They sometimes end up in a three-way dispute between the

homeowner, the contractor, and the window manufacturer's representative. The homeowner is angry about water on the glass and black stains on the sills, the windows are blamed for defects, and the contractor doesn't know what to do. The window rep says the windows aren't to blame (that's usually correct). The homeowner simply knows that things aren't working and wants them fixed. The contractor often doesn't understand that the key to this situation lies in the links between construction-related moisture, occupant activity, surface temperatures, and ventilation. The new house often simply needs fresh air in order to dry out, but that's not obvious to anyone.

- There's lots of mold around these days. It's always been around (and always will be), but we have more of it in our homes than we used to. Part of it has to do with increased indoor humidity. But it also has to do with it being harder for building assemblies to dry out. Air conditioning can be a major factor. And we build with more mold-friendly materials than we used to. You may know an awful lot about mold and still not have a clue why it is growing in a particular spot. For that, you might need to understand air tightness, insulation, condensation, forced air systems, occupant behavior, capillarity, spillage, etc, etc, etc.

Just as new homes can have problems due to unanticipated interactions, existing homes can suffer as a result of work performed without consideration for possible side effects. Some of these happen quite a lot.

- One standard retrofit for existing attics is to install additional insulation and add ventilation, but do no air sealing. This sometimes can increase the fuel bill and rot the roof. The increased ventilation allows more airflow from the house, increasing the heat loss. With that air goes more moisture to the attic, where it condenses on the now colder roof sheathing. This unanticipated, and undesired result is due to not understanding how the system works.

- Air sealing an un-insulated house can create moisture problems by raising the relative humidity without warming up the surfaces. Air sealing without attention to ventilation can do the same thing.

- Air sealing in buildings that contain combustion equipment can cause that equipment to fail. People or programs that routinely seal up buildings without looking at the combustion equipment risk sooner or later harming someone with flue gas. Installation of ventilation equipment can do the same thing.

- If a working chimney is retired, a ventilation device has been removed. Most heating contractors don't think of this, because they are only looking at heating. If a basement is air sealed, combustion air has been removed. Most shell contractors don't think of this, because they are only looking at the shell. If a clothes dryer is installed in a combustion zone, a safety hazard may have been created. Most appliance installers don't think of this, because they are only looking at appliances.

- Indoor air quality problems are source problems, but they aren't always treated that way. The guiding principle of "eliminate, separate, ventilate" is often ignored, and ventilation (the least effective option) is chosen automatically.

- Problems in homes are sometimes treated with no consideration of the occupants. Human activity is a powerful influence on building performance, yet some building professionals routinely do their work without ever asking what the people do. This time, it's the human part of the system that is ignored or misunderstood. If a world-class ventilation system is installed and the occupants shut it off because they don't understand why it should run, it's worthless.

Buildings are more complicated than ever before. The materials are more complex, more misunderstood, and in many ways more sensitive. We put more appliances and devices in than we used to. Many of them are bigger than they used to be. Homeowners tend to have higher expectations than in the past. Yet we still combine materials and equipment, hit or miss, and assume they will work. If we want a house that "works as a system", we need more thinking and better planning.

Paying attention to the interactions and the overall building performance allows us to design and construct buildings that work, buildings that are durable, safe, healthy, comfortable and efficient. System thinking also makes it possible to fix existing problems effectively without surprise side effects. If we don't take time to understand the connections, we're just guessing.

Contact Information:
David Keefe
Manager of Training Services
VT Energy Investment Corp.
P. O. Box 221
Fairfax, VT 05454
Home office: (802) 849-6399
Email: davidkeefe@verizon.net