Auditing Procedures and Tools to Extend Vision

By Larry Kinney, Boulder Colorado

Most buildings on our fragile planet use more energy than need be. However, identifying exactly where problems are and how to solve them practically is usually a matter of tedious detail. The process involves careful observation aided by data from fuel bills, monitoring instruments, insights from the people who use, manage, and maintain the buildings, and computer-aided analysis. The goal is to create healthier, more sustainable buildings.

Click to download back copies of the Boulder Green Building Journal. The Fall 2006 edition contains articles on energy auditing, tools, and radiant heating.

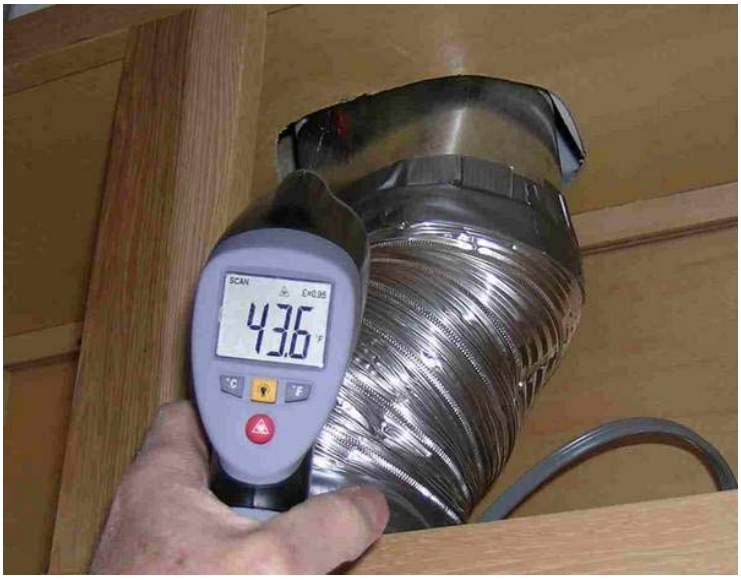
The artist, the pilot, and the physicist tend to see things from different perspectives, and although each may enjoy a beautiful sunset, they tend to ponder Mother Nature's splendor in ways that are conceptually distinct. When a professional energy auditor examines a building, he or she tends to see what others quite familiar with the building may not have noticed. It's a systematic kind of seeing

that envisions energy flow—conductive, convective, and radiative—into, out of, and throughout the building. The process is more than hunting and pecking; it is a key element in what is sometimes called "building science." Building science is in its infancy, but a number of principles are becoming clear, and observational techniques and associated instruments are being developed to advance the science. Much improved energy performance is becoming routine.

Analyzing Billing Data

Energy bills are very helpful in understanding patterns of energy use in homes and other buildings, so are an essential part of a thorough energy audit. They also help quantify energy savings achieved by a retrofit. The Green Geek column of the Summer of 2007 edition of the Boulder Green Building Journal describes my recent work analysts in developing a tool that substantially automates the process. Tools to Extend Vision. In the field, the energy auditing process makes use of a number of diagnostic tools to extend vision and aid in quantifying flow under a number of conditions, some of which the energy auditor creates himself. For example, the auditor routinely uses a "**blower door**"—a calibrated, variable speed fan—to depressurize a home. This enables determining its degree of air tightness and discovering leaks in the building's envelope and in its duct system.

Sometimes this process is made more precise by the use of an **infrared temperature sensor** that facilitates quickly determining temperatures on surfaces at some distance from the observer. The IR sensor in the picture shows a cold air leak close to the duct of an ventilation fan in a kitchen cabinet. Leakage from such unobvious places is difficult to find with the unaided eye.



When he sees a spider web on a sill plate above a foundation wall, the energy auditor suspects air leakage is lurking—for air movement can bring lunch to a wily web weaver. Temperatures of delivered air and water are measured, as are systems that produce and control their flow. The photo on the right shows a simple **weir**. It measures water flow without the need of a watch, enabling a good decision to be made on whether to recommend replacing the shower head with one that is more efficient.

Conveyance mechanisms like ducts and pipes are checked for leakage. The photo on the right shows a "**duct pan**" which is placed over a supply or return grille when the blower door is depressurizing the home. If the reading on the digital manometer indicates a pressure of more that several pascals, there is air leakage to the outside of the building's envelope that surely results in energy waste and perhaps discomfort as

well. Ducts that show the greatest pressure readings are usually closest to the leaks, a powerful aid in the sealing process the audit will recommend.

Appliances are also measured for electric energy use, typically using inexpensive **watt hour meters** like the one shown. Click here to download a brief brochure on how to use this tool to measure appliance energy use. For example, measuring the energy use of refrigerators can enable making good decisions on whether it is cost effective to replace them with more efficient models. (Modern ENERGY STAR-rated refrigerators often use over three times less electric energy than their older counterparts.) This meter is also useful in measuring "phantom loads" in a home such as those from small battery chargers or electronic equipment which uses energy even when switched off.

Observations and **analyses of bills** suggest still other measurements and circumstances to observe until the auditor is satisfied that a useful level of understanding of what works well—and what needs improvement—is achieved. Then a set of suggested retrofit measures is compiled with costs and likely paybacks (and other consequences, like health and safety) identified.

The auditor routinely checks for gas leaks (using an electronic **sniffer** like the one shown) as well as for poor or corroded electrical wiring connections between the circuit breaker box and outlets. The **circuit tester** pictured works like a stress-test EKG by putting a 15 amp load on a circuit for a few milliseconds while measuring the voltage drop due to the load. A five percent or more drop suggests the need for remediation.

Useful Results

The good news is that there are usually a number of opportunities to save energy cost effectively while improving performance and comfort, extending the lifetime of the buildings, and lowering energy costs. In some cases, the rising price of energy—as well as cash incentives for certain energy efficiency measures—combine to make particular retrofits especially economical.

The challenge in providing cost effective shelter is to figure out what really should be done to effect useful improvements (while avoiding those which are less likely to be effective)—then ***produce high-quality retrofits, verifying that savings are indeed achieved and craftsmanship is at a high level.***

It's not easy to get it right. However, the benefits of much improved energy performance and accompanying improvements in comfort, safety, health, and longer life of the structure make the enterprise worthwhile.

Teaching the Craft of Energy Auditing

I have been involved in energy auditing for over three decades. We've worked on many buildings from small apartments to large commercial and industrial buildings and casinos. Along the way, we have developed auditing procedures that enable

understanding buildings so that a good work plan can be developed that upon being implemented saves as much energy as cost effectively as possible—while safeguarding health, safety, and indoor air quality.

My principal interest these days is to teach others the craft of energy auditing—and to consult on particularly intriguing energy auditing jobs. Some practical wisdom on the subject in contained in "Residential Energy Auditing Techniques." It describes techniques we have developed over the years as well as tools we have found useful in extending vision. It also includes an extended checklist.

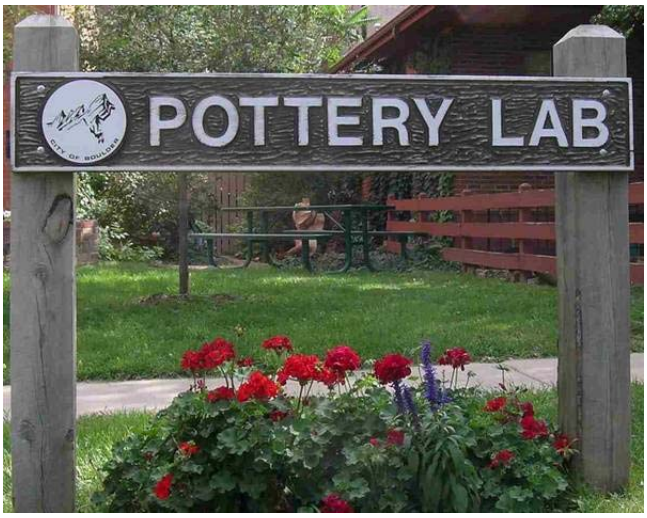
References to the document that may be downloaded here include reports on Lighting, Ducts, Windows, and Refrigerators.

Recent Energy Auditing Work

We recently completed extensive energy audits on over 40 buildings in **Indian Country.** These cover six tribal lands in seven states from the desert of Arizona and Nevada to the cold country in South Dakota.

Performed for the Council of Energy Resource Tribes in Denver under a grant from the U.S. Department of Energy. Here is an interesting slide presentation on energy auditing

findings in casinos.



Sometimes energy auditors are asked to look at particular issues in a building such as the heating system or windows. The **Boulder Pottery Lab** is an example of a building in which we were asked to do an analysis on energy-saving opportunities associated with windows. As we examined the structure, we discovered that many other problems dominated energy issues in the building.

The resulting analysis was put into slide form and used in briefing a committee in Boulder charged with historic preservation. Click here to download a copy of the presentation.