

The Custom-Fit Retrofit

Tailor your home efficiency project to your climate, building

By **COLLIN TOMB**

Technical Review By **LINDA WIGINGTON**

Retrofitting existing homes is more expensive and complicated than designing for efficiency from the start. Every retrofit is different, with different strategies depending on the climate, the building features and the homeowner's goals. The key is to start with your objectives and then look for opportunities to reduce your load before investing in renewable energy supply.

Doug Parker, a Boulder County, Colo., sustainability examiner with 35 years' experience in low-energy housing, wants to insulate his household from rising energy prices as he looks toward a fixed retirement income. But home energy improvements pay off on many fronts. "Carbon dioxide reduction, lower energy bills and comfort — where these three things overlap, that's where you work," he says.

Linda Wigington is the founder of and special projects director at Affordable Comfort Inc. (affordablecomfort.org), which specializes in deep energy-reduction strategies for existing homes. She recommends three initial steps:

1. Be clear about your goals. Do you want energy bill savings, carbon emissions reduction, comfort, noise reduction or indoor air quality? Your solution will depend on your goals relative to the opportunities at your property. Sometimes your best option may be to move or to phase the project over

several years. A retrofit with a goal of passive survivability — the ability to maintain comfort through an extended loss of power — will take steps that would be ruled out in a plan designed for quick payback.

2. Identify your starting point. Analyze your utility bills and get an energy audit to figure out where your energy is going. Identify your assets and liabilities. Assets may include great solar potential, and liabilities could include lead-based paint or a gas oven with no exhaust fan.

3. Define and re-evaluate the thermal/pressure boundary. Ideally the boundary should clearly separate your home, mechanical systems and contents from the outside conditions (including the ground). Boundary confusion is a problem in many homes and can be clarified with a blower door test or, in some cases, a visual inspection. The thermal boundary usually should include heating equipment and exclude cooling equipment, attics and garages, but exceptions are common. The basement is usually within the home's thermal boundary — but often it is poorly insulated and a source of air-quality problems, so a retrofit may exclude it from the envelope.

Seize Opportunities

While the conventional wisdom is to implement energy-saving or energy-producing measures in order of cost-effectiveness, opportunity cost may be more important. If you're considering roof-mounted photovoltaics (PV), see if your roof needs a replacement that might include added insulation. If you are re-siding your home, take this opportunity to do drill-and-fill insulation and consider adding more insulation under the new siding.

Ironically, says Wigington, short-term steps to save energy can create barriers to achieving deep and sustainable reductions in energy usage. Energy-reduction efforts — particularly those addressing the building enclosure and mechanical systems — need to recognize the house as a system. Building durability, combustion safety, indoor air quality and energy usage are often intertwined. If you install a high-efficiency heating system before improving the building envelope, you may end up with an oversized system that performs inefficiently. An exhaust fan installed to improve air quality can cause a backdraft with gas-burning equipment not directly vented to the outside.

Tackle Conservation Before Supply

As more people come to view solar energy systems as the ultimate in green upgrades, it is easy to overlook the cardinal rule of high-performance building: conservation before supply. Energy efficiency can be much cheaper than PV or solar thermal energy, and it contributes more to comfort and other nonenergy benefits of green building. Efficiency is not sacrifice and scratchy sweaters; it is getting the same or better performance from a system with less energy.

Before Parker even sized his PV system, he did a complete efficiency retrofit, maintaining amenity at a fraction of the energy cost. By improving the building envelope first, says Wigington, you give yourself the greatest flexibility going forward. You can do with less renewable energy and maybe even a smaller heating and cooling system if your energy loads are much lower.

As mentioned, every retrofit will vary

Collin Tomb (collintomb@yahoo.com) is a business sustainability specialist at Boulder County Environmental Health, Boulder, Colo.

RETROFIT STEPS > *Every retrofit will vary depending on the climate, the building type and the goals of the occupant. Here is a common order of steps to consider.*

features and goals.

depending on the climate, the building type and the goals of the occupant. Here is a common order of steps to consider, proceeding from load-reduction efforts to renewable energy supply.

1) **Home energy audits** are available through some utilities and local governments and, more often, from private home performance contractors.

The audit should include energy bill analysis, an assessment of your appliances and mechanical equipment and a blower door test to find leaks in your building's thermal envelope. Many auditors now use infrared cameras to see heat entering and leaving a building.

Often auditors are trained to prioritize improvements by cost-effectiveness. Be sure your auditor understands that your goal is a whole-system view of the house, to make recommendations that move you in the right direction. Your auditor may also be able to recommend contractors to perform the work.

2) **Appliances and electric efficiency** are your lay-up for carbon emissions reduction. Where it is derived from fossil fuels, electricity is the dirtiest form of power. For every kilowatt-hour (kWh) you use in your home, 2.2 kWh are lost in generation and transmission. Always install a programmable thermostat and replace your incandescent bulbs with CFLs, which use 60–75 percent less electricity. Your



CENTER: BELLA ENERGY; CLOCKWISE FROM TOP RIGHT: SETH MASIA, I STOCKPHOTO; HONEYWELL; JOHN BULIK OF SOLARTEK ENERGY OF DENVER INC.; JOHN BULIK OF SOLARTEK ENERGY OF DENVER INC.; BELLA ENERGY; US DOE

Energy efficiency can be much cheaper than PV or solar thermal energy, and it contributes more to comfort and other nonenergy benefits of green building.



COLLIN TOMB

Doug Parker wanted to insulate his Boulder, Colo., home from rising energy prices as he looks toward retirement. His efficiency retrofit maintains amenity at a fraction of the energy cost.

auditor can let you know which of your appliances is using more than its share of energy.

3) **The building envelope** comprises several key components.

Air sealing is usually one of the first recommendations for older homes. The thermal pressure boundary is generally located at the level of the finishes — drywall, trim and flooring — with the insulation and moisture barriers behind. Old homes often leak at a rate of 1.0 natural air changes per hour, meaning that you pay for inside heating or cooling to offset outside temperatures once every hour. Much of the leakage may be occurring around attic hatches, bath fans, recessed lights and top plates at the ceiling. These should be sealed in the attic before more insulation is piled on top of them.

Insulation is often performed in tandem with air sealing. There is a law of diminishing returns with greater insulation (“R-value”), so identify the least-insulated parts of the house and improve them first. Blown cellulose or fiberglass fills gaps and, if installed at high enough density, as in a wall cavity, reduces the



ISTOCKPHOTO.COM

Audit programs nationwide have shown how difficult it is for homeowners to move beyond the audit to implementation. Some local entities have responded. Home Performance with Energy Star, for instance, is working with utilities to connect homeowners with certified contractors.

air infiltration that occurs between the batts of conventional insulation. You can blow insulation in attics, or into walls through “drill and fill” from outside or inside, depending on what kind of holes you want to patch. Rigid insulation, applied to the wall sheathing, reduces heat loss through studs and headers. Evaluate your floor or your crawlspace/basement to make sure insulation is continuous around your thermal boundary in a heating-dominated climate.

Use as much insulation as you can fit; space will be the limiting factor in many of these locations.

Windows, doors and skylights are where the cost-effectiveness of greater insulation generally comes into dispute, as a high-tech window replacement is expensive and can have a payback as long as your mortgage. Consider moveable insulation that fits tightly against the window frame. If heat loss from windows is causing you to crank your thermostat, comfort alone might justify the expense. Skylights have traditionally been energy losers, but the new tubular skylights



ISTOCKPHOTO.COM

provide daylighting with minimal energy loss.

4) **Heating and cooling systems** are typically oversized in older houses. If you are tightening and insulating your house, you may get away with a significantly smaller system or a different type of system altogether.

Parker subjected his system to a “duct-blast” test and found that it leaked almost as fast as the test fan could blow. After sealing all his accessible ductwork, he divided his house into four zones, each controlled by a programmable thermostat. He replaced his 80 percent-efficient furnace with a 95 percent-efficient one “right-sized” for his home through calculations in the Air Conditioning Contractors of America *Manual J* (acca.org).

He addressed his cooling problem with a 14 SEER air conditioner. It was not the most efficient one available, but he had his utility install a “savers’ switch,” allowing the utility to turn off the compressor for 15-minute intervals during peak hours. It saves him as much energy as a more expensive air conditioner, and he says he doesn’t notice when it goes off.

If you already have a baseboard electric system or if your furnace is inefficient and your ducts are outside the thermal envelope, look into air-source or ground-source electric heat pump options. They can be ductless, and they pair well with PV. They increase the efficiency of electric heating to the point at which it competes with natural gas in terms

A deep energy retrofit that moves beyond quick fixes to fundamental load reduction and renewable energy supply has paybacks that go beyond dollars.

of carbon emissions. A small or medium-sized home can be comfortable with one or two “mini-split” units, depending on the climate and the home’s heating needs.

5) **The selection of a water-heating system** depends on the frequency and amount of your hot water use. No matter what system you select, insulate your pipes and keep your shower enclosed so you’re comfortable at a lower water temperature. Also consider installing a demand pump if you have to wait for hot water; the average American family wastes 10,000 gallons of water a year just waiting for it to get hot.

For electric water heating, insulated plastic tanks last longer and lose less heat than traditional steel tanks. Air-source heat pumps are available to fit on standard tanks, and they improve on the efficiency of ordinary electric resistance. Tankless systems can be efficient where long draws of hot water are required, but be sure to check on yearly maintenance costs. Integrated systems combining space heating with water heating can be a way to justify the expense of a very high efficiency water heater. If you’re installing a ground-source heat pump, an attachment called a desuperheater will heat your hot water as well.

6) **Solar heating** is great for domestic hot water, particularly in nonfreezing climates. In freezing climates, solar thermal panels must be equipped to drain back to the tank and/or must contain a glycol-based heat-exchange fluid. Traditionally, the plumbing and maintenance costs of retrofit solar thermal systems have limited their adoption, but that may be changing as incentives remove cost barriers

Online Resources

Affordable Comfort Inc., for deep-energy-reduction and home-performance resources: affordablecomfort.org

Building Performance Institute Inc., for BPI-accredited contractors: bpi.org

Building Science Corp., for information, consulting and seminars: buildingscience.com

Database of State Incentives for Renewables and Efficiency, including federal incentives: dsireusa.org

Energy Star Home Improvements, with step-by-step projects: energystar.gov website at tinyurl.com/ytnhxb

FindSolar.com, for information and local solar professionals: findsolar.com

GreenBuildingAdvisor.com, green home resources: greenbuildingadvisor.com

Home Performance with Energy Star, for local efficiency audits: energystar.gov website at tinyurl.com/yd4cgm

“Carbon dioxide reduction, lower energy bills and comfort — where these three things overlap, that’s where you work.”

— Doug Parker, Boulder County, Colo., sustainability examiner

and stimulate the industry to standardize systems and maintenance. Even though a solar thermal system didn’t fit into his home economics, Parker says you should always pre-plumb for a system that may become practical sooner than you think.

7) **Photovoltaics** are in the spotlight as rebates make them more affordable. Don’t buy more modules than you need to cover your loads. Most utilities that pay for overproduction offer only wholesale rates, so don’t think of your house as a power plant just yet. Find solar resources and local professionals at FindSolar.com.

Moving from Audit to Implementation

“It’s a better investment than the stock market right now,” says Parker, referring to the energy savings he is already reaping from his improvements. Remember that simple pay-back analyses usually don’t account for the cost of borrowing money, the lifetime of equipment purchased and the many noneconomic benefits of the improvements.

Rebates and incentives for efficiency and renewable energy are better than ever. Many utilities have ratepayer-funded demand-side management (DSM) initiatives, like the util-

ity-operated “savers’ switch” on Parker’s air conditioner. Howard Geller, executive director of the Southwest Energy Efficiency Project (swenergy.org), says these incentives are worth every penny: “The cost to save energy is 2–3 cents per kilowatt-hour, while any new energy source such as coal, natural gas, wind or solar costs at least two to three times as much.”

Utility and government rebates and tax incentives for renewable energy and efficiency are growing rapidly nationwide. In addition, districts like Berkeley, Calif., and Boulder, Colo., are pioneering bond-funded loan programs that tie the cost of green retrofits to the property they benefit.

Federal tax credits can make projects more affordable than you think, too. The economic stimulus law approved earlier this year increased the tax credit for efficiency upgrades to 30 percent, with a maximum combined credit of \$1,500 for installations made in 2009 and 2010. In addition, renewable energy system installations are eligible for a 30 percent tax credit. See details at dsireusa.org.

After cost, the single biggest obstacle to home energy retrofits is the hassle of arranging the work. Some local entities have responded by developing installation programs that improve homes while creating jobs. Home Performance with Energy Star is another efficiency program intended to follow intention with implementation (energystar.gov website at tinyurl.com/yd4cgm). It connects homeowners with certified contractors, and in many cases, it has separate auditors who identify tasks at the beginning and inspect them at the end.

One thing is certain about an energy remodel: It will pay back at a higher rate as time goes on, making it a great investment compared to cosmetic finishes that depreciate with each passing trend. Parker, for one, feels more secure in his low-energy home. “We like the notion of passive survivability,” he says. “The power could go down and we’ll still be warm.” **ST**