

## Six Ways to Think About Home Improvements

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The marketplace is starting to expect greater accountability and more sophisticated analysis when it comes to the long-term energy performance of homes. It's important that those of us on the supply side (i.e., contractors and designers) keep up with the needs and priorities of the demand side (i.e., homeowners and home buyers). The first step to meeting those evolving needs is to understand the range of strategies we have to choose from.

In my experience, there are six main ways of thinking about household energy-efficiency improvements:

- The most prevalent approach, which is to “do some stuff and hope for the best.”
- A somewhat more analytical approach, which is to calculate *payback period*—to think in terms of what's cost-effective.
- The next step up: “Do some stuff and *measure* what happens.”
- A more goal-oriented approach, which is to think in terms of *percent reduction*—a household sets a specific goal of, say, a 25% reduction from its current baseline energy usage.
- The approach of establishing specific *insulation and air-tightness standards*, and to work incrementally, over time, towards achieving those standards on a house-by-house basis.
- The ultimate goal-oriented approach of setting a specific target *energy budget*, analogous to a household financial budget. This differs from the percent reduction approach in that the goal is set independent of what the current baseline usage is.

In implementation, there are not always clear boundaries between these six approaches; they are not all mutually exclusive and in fact there is significant overlap between some. But they do represent distinct ways of thinking about energy improvements—six different places from which to start the conversation. Let me discuss them in order:

### *Level 1: Do some stuff and hope for the best*

This seems to be how most weatherization work is done these days. A homeowner has no clear idea of what his or her current energy usage is, or how it compares with similar houses in the neighborhood, but has a general sense that there are opportunities for improvement. She hires an insulation contractor, often through a utility-rebate program, and has some insulation work done. Maybe there's an improvement, maybe there isn't—nobody really knows for sure, because nobody's really keeping score.

Or say the homeowner has a kitchen renovation done. The contractor, being a savvy, up-to-date, “green” contractor, uses spray foam in the walls rather than fiberglass batts. Everyone assumes the extra cost was worth it, but no one knows for sure, because there's no attempt to compare pre-project energy usage with post-project energy usage, nor even

any attempt to assure by means of a blower door test that the spray foam was installed properly.

In my experience, this is how 90% of homeowners and contractors approach energy improvements, and this is why as a nation we're making such insignificant progress towards a more energy-efficient society: because, for the most part, we're flying blind.

### *Level 2: Payback period*

The next step up in analytical rigor from “do some stuff and measure what happens” is the payback calculation. For example, determining that it will cost \$1000 to upgrade my wall insulation, which will reduce my energy costs by \$100 a year, so my simple payback will be 10 years (\$1000 total cost, divided by \$100 annual savings, equals 10 years to recoup the cost). There is a range of tools available for this exercise; we use a simple spreadsheet developed by an energy consultant we work with.

The main problems with this approach are that “reasonable payback period” is a moving target based on the fluctuations of commodity prices; that fossil fuels have been consistently under-priced when all externalities are factored in, which situation is likely going to change in the not-too-distant future; and that the expected service life of home improvement projects is measured in decades whereas our ability accurately to predict energy costs is measured in days or weeks at best.

Let's say that we're planning your attic renovation, and determine that it will cost \$3000 extra to upgrade the rafter insulation from R-40 to R-60. At current fuel oil prices we estimate the payback to be 25 years, which doesn't sound like a good investment to you, so you take a pass on the upgrade. In five years, though, fuel oil prices have doubled; in ten years, they've tripled; and now that extra insulation seems like a much better idea, so you give us a call to see what we can do. Now, however, the upgrade is not going to cost \$3,000—it's going to cost \$20,000, because we have to remove all the drywall and insulation and start over.

Energy consultant John Krigger tells an anecdote about a similar if much larger-scale issue in Germany in the 1990s: After reunification, Germany embarked on a major project to add exterior insulation to the under-insulated masonry buildings in the former East Germany. They calculated that the most cost-effective approach would be to add 2” of exterior rigid foam insulation with a stucco coating. Half way through this massive undertaking, as Krigger tells it, they realized that the overall trend in energy prices actually made 4” of exterior insulation the most cost-effective—the marginal cost of the extra 2” of insulation would be relatively small compared to updated payback calculations. They were able to shift gears for the upgrades that had not yet been started, but it was too late for the buildings that had already been completed. Those buildings won't get another chance for a few decades, when they're next due for major exterior renovations.

### *Level 3: Do some stuff and measure what happens*

In this approach, you do your usual (ostensible) energy improvements, but you actually monitor whether or not those measures reduced household energy consumption. This obvious step is a surprisingly rare one.

In my experience, the easiest analysis is to track Btu consumption (from all energy sources) over time, and adjust the heating load component from season to season by means of Heating Degree Day (HDD) data. Predominantly cooling climates will need to track Cooling Degree Days (CDD). A detailed explanation of home energy performance measurement strategies is outside the scope of this article, but a good general introduction can be found at <http://www.homeenergy.org/consumerinfo/benchmarking-energy-usage.php>.

Once you start keeping score in this way, you'll be able to figure out over time what works best, what works a little, and what works not at all. Building on that knowledge base, you'll be able to start setting more specific targets with your clients, and backing those targets up with established past performance.

#### *Level 4: Percent reduction*

With this strategy, we calculate your baseline usage and work out what an aggressive (but not unrealistic) reduction would be. Say your house is using 60 KBtu per square foot per year and we know, from past experience with similar projects, that in the course of your whole-house renovation we can bring that down by 25%—to 45 KBtu per square foot per year—without stretching your project too much. That 25% sounds pretty good—*is* pretty good, in fact, by the standards of what's going on in your marketplace—so everyone is happy. (We find that using a HERS index as a metric is the most effective way to design to a percent reduction, since each one-point reduction in your HERS score represents a 1% improvement; for more information on HERS scoring go to: [www.natresnet.org](http://www.natresnet.org).)

The good news with this approach is that you know you're making progress that you can quantify. The bad news is that the degree of progress may be completely arbitrary or insufficient. If all houses reduce their energy usage by 25% in the next ten years, we'll certainly all be better off—but will we be *enough* better off?

#### *Level 5: Specific construction standards*

It can be complicated, time-consuming, and costly to do all the analysis required to design to a percent reduction or a specific energy target on a project-by-project basis. A crude but generally effective approach might instead be to establish specific insulation, air-sealing, and mechanical equipment efficiency standards that you try to achieve on all your projects (the building code approach to energy standards), and then periodically verify that those are the “right” standards by measuring actual energy performance on a range of projects over time (a step not really covered by building codes).

One way to set those quality standards would be as follows: Say you decide you want your projects to reach a HERS index of around 50 (prior to any “credits” for PV or solar thermal)—or 50% of the anticipated energy usage of a code-level home. You'd calculate what levels of insulation, air-sealing, and mechanical efficiency it takes for a representative project to reach that score. This exercise will yield a pretty good set of “draft standards” for you to start working with on all your projects, and you can fine-tune those standards over time as you gain more data about actual energy consumption of those projects.

In our climate region (5600 degree days) there's some growing initial consensus (still to be tested over a wide range of homes) that the following are useful target standards (and they happen to yield a HERS index of around 50, pre-renewables):

- R-10 basement floors
- R-20 basement walls
- R-40 above-grade walls
- R-60 roofs
- U-0.20 windows
- Less than 1.0 ACH @ 50 as tested by a blower door
- High-efficiency whole-house ventilation

It would usually not be realistic to think that you could reach these levels of insulation over the course of just one renovation project. Such standards can, however, be an extremely useful framework for an incremental strategy—a “master plan” for a house, whereby these standards would be reached over time as various parts of a house are improved, repaired, or replaced. This sort of framework, though not without challenges, will likely minimize potential regrets about missed energy opportunities.

#### *Level 6: Set a target energy budget*

The ultimate strategy towards energy-efficiency improvements is that of a target energy budget. A target energy budget represents an attempt to calculate how much your household energy usage *should* be based on some overarching goals, which can range from the personal to the global. Some such goals might include the ability for your house to weather an extended power outage (what Alex Wilson of Environmental Building News calls “passive survivability”) or the ideal of a net zero energy house, all the way up to national energy independence or long-term atmospheric carbon stabilization.

With this approach, you establish your target goal, and then figure out the most cost-effective way to get there, so the target goal drives what's cost-effective, not vice versa—an important shift in thinking.

Let's say your goal is a net zero energy house. You calculate what the building site can produce over the course of a year from PV and solar thermal, and that becomes your energy budget for the house. In this case, it might be 17 KBtu per square foot per year—and that becomes the budget you design to.

If, less aggressively, your goal is a house that can be safely inhabitable for up to a week with no power, you might be able to settle for a “zone” of the house that can be operated on 17 KBtu, but the rest of the house might be closer to 35 KBtu.

At the opposite end of the spectrum, you might be motivated by the goal of a 2000-Watt Society ([http://en.wikipedia.org/wiki/2000-watt\\_society](http://en.wikipedia.org/wiki/2000-watt_society)). A 2000-watt society means that your individual (per capita) energy budget is about 17,500 kWh per year for all activities—work, transportation, food, entertainment, housing, etc. Given this overall budget, you might do some calculations and decide that your household energy budget should be about 12 KBtu per square foot per person. (Full disclosure: It's really hard to do this sort of calculation with any sort of mathematical rigor, but it can be an eye-opening intellectual exercise, and we have to start somewhere.)

In fact, the Passive House approach to home design ([www.passivehouse.us](http://www.passivehouse.us)) is based on a similar approach: It sets a very low budget for household energy usage based on estimates of what a world-wide sustainable per capita household energy budget might be, and then provides the tools to help you design to that budget.

Some of these ways of framing conversations with our clients about household energy goals may at first glance seem difficult, impractical, or hopelessly idealistic. Ultimately, though, I think you'll find, just as I am finding, that they are no harder to work through than all the other challenges we've faced. It's just one more adaptation to a changing marketplace—and we're all getting really good at such adaptations these days.