The Half Plan

by Gary Reysa

Reducing Your Carbon Footprint, Part Three: Defeating Drafts & Improving Insulation

Investing in energy-saving projects to reduce greenhouse gas emissions is a win-win situation—you can do something that is good for the planet and also earn a good economic return. Tap into these tips to make your home more comfortable, cut your utility bills, and decrease your household's carbon dioxide (CO_2) emissions.

An inadequately insulated and sealed home is especially vulnerable to both summer heat and frigid winter temperatures—*and* high cooling and heating bills. If your energy bills are going through the roof, your home's heat (or air conditioning) might be escaping there too—as well as through your walls, ceilings, floors, and ductwork.

Besides taking a big bite out of your budget, home heating and cooling can contribute considerably to greenhouse gas emissions. More than half of all U.S. homes use natural gas for space heating, and about 30 percent heat with electricity, which is generally provided by coal- or natural-gas-fired power plants. The result? According to the energy policy group Rocky Mountain Institute, thousands of pounds of CO_2 are released annually per household. (See the CO_2 emissions table for details on how your home energy use contributes to climate change.)

According to the U.S. Department of Energy (DOE), investing just a few hundred dollars in good insulation and home weatherization strategies can reduce your heating and cooling needs by up to 30 percent. Last year, my wife Joan and I took on the challenge of cutting our energy consumption—and related CO_2 emissions—by 50 percent. The five projects detailed here (out of the twenty we implemented) cut our bills by more than $500 each year—recouping the materials costs in the first year and preventing more than 1 ton of CO_2 from being released annually. (For tips on prioritizing your own CO_2 reduction plan, see the Footprint sidebar.)

Direct CO_2 Emissions by Source

Fuel Type	Output Rate (Lbs./KWH)
Coal-generated electricity	2.03
Petroleum-generated electricity	1.91
Natural-gas generated electricity	1.15
Coal	0.70
Heating oil	0.60
Propane	0.51
Natural gas (pipeline)	0.42
Hydro-generated electricity	0.04
Nuclear-power generated electricity	0.00
Fuelwood (if sustainably harvested)	0.00
Solar-electric/wind-electric	0.00

Source: Energy Information Administration/BP

*Table does not account for CO_2 produced during plant construction or decommissioning, equipment manufacturing, mining, or fuel processing.

Reduce Your Carbon Footprint

Reducing your energy use can pay off—both economically and environmentally. Follow these four easy steps to start saving.

1. Conduct a home energy audit and make a list of potential projects to reduce your household energy use. Many utilities will send out a technician, often for free, to assess your home's efficiency and provide a report and recommendations for efficiency upgrades. If you're off the grid, or your utility doesn't offer audits, you can hire a pro to perform an energy audit or do it yourself, using the online Home Energy Saver program (see Access).

2. Estimate the cost, energy savings, time and degree of difficulty, and greenhouse gas reduction for each project. For this article's projects, financial savings in fuel in the first year are based on the projected kilowatt-hours (KWH) saved, and multiplied by $0.079 per KWH—equivalent to my cost for propane, which we use to heat our home. The projected 10-year fuel savings assumes a 10 percent rise in fuel prices each year. Converting all nonelectrical forms of the energy to KWH will allow you to compare energy savings for electricity, transportation, and heating projects on the same basis. To estimate greenhouse gas savings for each project, I used the calculator at www.infinitepower.org.

Some handy conversion factors:

1 KWH = 3,412 Btu

1 gal. of propane = 92,000 Btu or 27 KWH

1 therm of natural gas = 100,000 Btu or 29.3 KWH

1 gal. of gasoline = 125,000 Btu or 36.6 KWH

1 gal. of heating oil = 139,000 Btu or 40.7 KWH

3. Prioritize projects according to CO_2 savings, and time, budget, and skill constraints.

4. Keep a file of your utility bills to review, so you can see what progress you are making. The bills also can be used to demonstrate your home's improved energy efficiency if you plan to sell it, and may be needed to claim rebates or tax credits.

The combined result of 100 million American families, each targeting a 20-ton reduction in CO_2 emissions, would reduce total U.S. CO_2 emissions by about 25 percent.

Dodging Drafts

A home's air leaks are often felt as drafts during cold weather, but infiltration can happen any time of year. Drafts around windows and doors are typically mistaken as a home's biggest energy drains, and homeowners are more prone to attack ones they can feel first. But in many homes, the most critical air leaks occur through the attic and basement.

In attics, leakage is likely to be greatest where walls meet the attic floor. Dirty insulation can give you clues for areas to seal, since it indicates that air is moving through. Seal the big "holes" first by stuffing garbage bags with loose-fill insulation that you can size to fit the spaces or, in less challenging situations, use a section of reflective foil or rigid foam insulation. Address smaller leaks with spray-foam insulation or caulk. Stuffing fiberglass insulation in openings is not effective, as it impedes airflow very little. Special techniques and materials should be used for sealing around furnace flues or other pipes that may become hot.

Air leakage in basements is most common where the concrete or block foundation wall comes in contact with wood framing. For optimal energy savings, fill gaps or cracks between the sill plate and foundation, at the bottom and top of rim joists, and around any penetrations. Use silicone or acrylic latex caulk to seal gaps or cracks less than 1/4 inch and expanding spray foam for gaps between 1/4 inch and 3 inches. In new construction, rolls of foam sill-seal should always be used between the foundation and the mud sill to eliminate air infiltration.

I addressed both the attic and basement in my home, and weather-stripped around windows and doors. And although the savings for this project are difficult to estimate, the low up-front cost of the project and its results are worth any time and money spent. Preventing air infiltration and improving a home's insulation offers a terrific payoff in a home's energy performance—one that you will definitely see reflected in your reduced heating and cooling bills. (For details on calculating energy savings, see Access.)

Project 1: Sealing Gaps & Cracks

Up-front Cost: $50

DIY Labor: 8 hrs.

DIY Difficulty: 4 (on a scale of 10)

Annual Energy Savings: 1,980 KWH

First-Year Energy Cost Savings: $156

Projected 10-Year Savings: $2,493

Annual CO_2 Reduction: 1,009 lbs.*

*Based on reduction of propane used for home heating; 0.51 lbs. CO_2 released per KWH equivalent.

Improving Insulation Overhead...

The DOE provides minimum R-value recommendations for homes based on climate, heating source, and the type of space needing insulation (attics, basements, or walls). Definitely consider exceeding these levels—known as "superinsulating"—for maximum energy efficiency. (For DOE recommendations, see Access.)

If you have a limited budget, experts recommend adding insulation in areas, such as attics, where it can be done most easily—and usually, least expensively. The existing insulation in my 12-year-old home's attic was about 10 inches of loose-fill fiberglass, which provides about R–2.2 per inch, for a total of R–22. For our climate here in Bozeman, Montana, the DOE recommends attic R-values of 49 or greater, so our attic was woefully underinsulated. Making matters worse, according to Oak Ridge National Laboratory studies, loose-fill fiberglass under cold conditions can lose as much as half of its nominal R-value due to convection currents in the insulation.

Before I invested in insulation, I used the Insulation Upgrade Calculator to estimate the savings (see Access). Measure the depth of the existing insulation in your home carefully and input the corresponding R-value—it will make a big difference in the savings you calculate. (If your attic is uninsulated, the Notes section on my Insulation Upgrades Calculator Web page can help you estimate the R-value.)

Based on the Calculator's results and local practice, we added 7 inches of blown-in cellulose insulation over the existing fiberglass loose-fill insulation to raise the R-value in the attic to about R-47. We decided to use cellulose because it has a higher R-value per inch than fiberglass, and does not allow the internal convection currents that reduce R-values in fiberglass insulation. We also feel that cellulose is an environmentally friendly choice, since it's made primarily from recycled paper products.

Before starting your project, be sure to properly seal around all penetrations, including pipes, conduit, and ducts—it will save you lots of work, and the itchy mess of digging through inches of insulation, afterward. Also be careful to avoid blocking vents and can-style lighting fixtures.

Project 2: Amending Attic Insulation

Up-front Cost: $256

DIY Labor: 6 hrs.

DIY Difficulty: 3 (on a scale of 10)

Annual Energy Savings: 1,593 KWH

First-Year Energy Cost Savings: $126

Projected 10-Year Savings: $2,006

Annual CO_2 Reduction: 812 lbs.

Insulating the attic saves 812 lbs. CO_2 per year

Insulating the crawl space saves 558 lbs. CO_2 per year

...And Underneath

According to the DOE, insulating crawl spaces and underneath floors can save an additional 5 to 15 percent on heating costs. The 25- by 15-foot, 4-foot-tall crawl space that occupies about a quarter of our home's footprint was originally vented to the outside. The floor above the crawl space was also uninsulated. By sealing the vents and laying a polyethylene moisture barrier over the dirt floor, we converted the crawl space to a conditioned space and boosted the efficiency of our furnace and ducts, which run through the crawl space. All the joints in the polyethylene are overlapped and sealed. Two-inch-thick rigid foam insulation is attached to the inside of the concrete walls, and the rim joists are insulated with rigid foam and fiberglass batts.

In our situation, this strategy is more effective than insulating the floor above the crawl space. First, it's less work. It also reduces the possibility of moisture problems developing in the crawl space, eliminates any plumbing freezing issues, and keeps the furnace and ductwork in a conditioned space that experiences fewer temperature extremes.

Project 3: Insulation in the Underbelly

Up-front Cost: $210

DIY Labor: 8 hrs.

DIY Difficulty: 4 (on a scale of 10)

Annual Energy Savings: 1,094 KWH

First-Year Energy Cost Savings: $86

Projected 10-Year Savings: $1,377

Annual CO_2 Reduction: 558 lbs.

Dealing with Ductwork

In buildings with forced-air heating and cooling systems, the network of ducts in a home's walls, floors, basement, attic, and ceilings carries conditioned air to the rooms. Most systems, unless they're relatively new, are uninsulated or insulated improperly. Uninsulated and leaky ducts translate into energy and dollars down the drain. Studies indicate that conduction losses and leaks from the average ducted air distribution system reduce overall system efficiency by about 30 percent.

Insulating and sealing ducts is especially important if they are located in unconditioned, unheated spaces. Minor duct repairs are generally easy to do yourself. First look for sections that should be joined, but have separated, and then look for obvious holes. Seal your ducts with Underwriters Laboratories (UL) certified mastic to ensure a long-lasting bond. Insulating ducts in a basement will make the basement colder, so if both ducts and the basement walls are uninsulated, consider insulating both. To help prevent condensation on cooling ducts, make sure that a well-sealed vapor barrier exists on the outside of the insulation. In most climates, use duct wrap insulation of R-4 or R-6.

I spent about $20 to seal all the ducts I could get at with duct mastic, and insulated the remaining uninsulated ducts in the attic and crawl space. This easy and inexpensive project more than triples its original investment in savings in less than a year. My cost-savings estimations are conservative—your savings may be much more depending on the condition of your duct system.

Project 4: Sealing Ductwork

Up-front Cost: $20

DIY Labor: 4 hrs.

DIY Difficulty: 3 (on a scale of 10)

Annual Energy Savings: 940 KWH

First-Year Energy Cost Savings: $75

Projected 10-Year Savings: $1,184

Annual CO_2 Reduction: 479 lbs.

Window Wrapping

Leaky, single-pane windows, and even double-pane units, can lose lots of heat and make heating bills soar. Most of us have tried the hair-dryer-and-shrink-wrap plastic window seal, which helps stop infiltration. But an easier (and somewhat cheaper) method for reducing heat loss through window glazing is to provide additional insulation. I had read about bubble-wrap being used in greenhouses to reduce winter heat loss, and decided to try it on some of the windows we don't need to open during the cold months.

I found that bubble-wrap packing material can be an inexpensive improvement for window efficiency. Being an engineer with a new infrared meter to test, I measured windows with and without bubble wrap, and determined that the wrap adds about R-1 to the windows.

Installation is easy and quick—simply cut a sheet of wrap to match the glazing, mist the glazing with water, and smooth the bubble-wrap over the window. Usually, one spray is enough to secure the bubble-wrap to the window for the full heating season. Although the bubble-wrap distorts the view, it still allows ample daylight to pass through.

At the end of winter, you just pull the bubble-wrap off, roll it up, and save it for next year. This simple solution is very cost effective—payback is usually less than one heating season—and is worth doing even if you plan to do something fancier in the future.

Project 5: Bubble-Wrapping Windows

Up-front Cost: $38 (or free)

DIY Labor: 3 hrs. (there's a little learning curve the first time)

DIY Difficulty: 2 (on a scale of 10)

Annual Energy Savings: 955 KWH

First-Year Energy Cost Savings: $75

Projected 10-Year Savings: $1,202

Annual CO_2 Reduction: 487 lbs.

A Step in the Right Direction

When Joan and I officially began the Half Plan, we decided to tackle the projects that offered the most energy savings per dollar spent for our climate, house, skills, and habits. After only two years, the savings have been phenomenal.

From simple projects like these, which require little to no up-front investment, to bigger investments, such as replacing our car with a hybrid-electric Toyota Prius, we'll save about $4,600 in energy costs and prevent 20 tons of CO_2 from being emitted—*every year.* Of course, as electricity and fuel prices continue to climb, our financial savings become even greater. And that's a (half) plan we can really get behind!

Access

Gary Reysa, Build It Solar Projects • www.builditsolar.com • Details on energy savings calculations

"The Half Plan—Reducing Your Carbon Footprint. Part One: Thermal Gains," Gary Reysa, *HP118*

"The Half Plan—Reducing Your Carbon Footprint. Part Two: Trim Your Waste Line," Gary Reysa, *HP119*

Carbon Calculators

Infinite Power • www.infinitepower.org/calculators.htm

Safe Climate • www.safeclimate.net

Project Evaluation Links/Software:

DOE Recommended Insulation Levels • www1.eere.energy.gov/consumer/tips/insulation.html

Home Energy Saver • http://hes.lbl.gov/ • Online DIY home energy audit

Insulation Upgrade Calculator • www.builditsolar.com/References/Calculators/InsulUpgrd/InsulUpgrade.htm

Online Insulation Assessment: ZIP-Code Insulation Program • www.ornl.gov/~roofs/Zip/ZipHome.html