



ENERGY SERIES: What is the Whole-House Systems Approach to Energy Efficiency?

The whole-house systems approach looks at the entire house as an energy system with interdependent parts. Like a human body, when one part functions poorly it affects the performance of the entire system. For instance, the benefits of an energy-efficient air conditioner are lessened when a duct system leaks, windows don't close tightly, the attic is uninsulated, and humid summer breezes are drifting in under the door.

The systems approach recognizes the interaction of windows, attics, foundations, mechanical equipment, and all other components and assemblies within the home. Changes in one or a few of these components can cause changes in how other components perform. If you recognize and take advantage of this fact, and apply appropriate advances in technology to the components, you can reduce your energy costs while improving your comfort. From a builder's or seller's perspective, an energy-efficient home is likely to be more marketable—especially if you can show the prospective buyers your low energy bills.

A Systems Approach to Home Renovation

WHY IS IT IMPORTANT?

Energy efficiency not only saves you money, it also saves natural resources. Take a look at your electric bill—just the electric part, not the fees for service, water, gas, garbage, taxes, etc. How many kilowatt-hours of electricity did you use last month? Generating that electricity typically uses nonrenewable resources like coal, natural gas, and oil. So although it's your home, it's everyone's environment. We all play a role in sustainability

and energy efficiency helps reduce the negative effects of burning fossil fuels by providing the same quality of services with reduced energy inputs and emissions. One study suggests greenhouse gas emissions associated with home energy use can be cut by 70% with current technologies (McMahon, et al., 2007).

Even water quantity and quality are related to energy consumption as it takes water to process fuels and generate electricity and it takes energy to withdraw, distribute, and treat water. New materials and technologies in home construction and remodeling mean you can live more comfortably and help the environment by reducing pollution and conserving natural resources.

WHERE DO I START?

We can begin by looking at the mechanical heating, cooling and ventilation system (HVAC) as it generally accounts for about half of the energy use in a home. Efficiency of the HVAC system controls both temperature and humidity within the home and is highly dependent on many of your homes structural features. Taking a step-wise approach to home renovation or equipment replacement will ensure that you get the most bang for your buck when it comes to thermal comfort and energy efficiency.

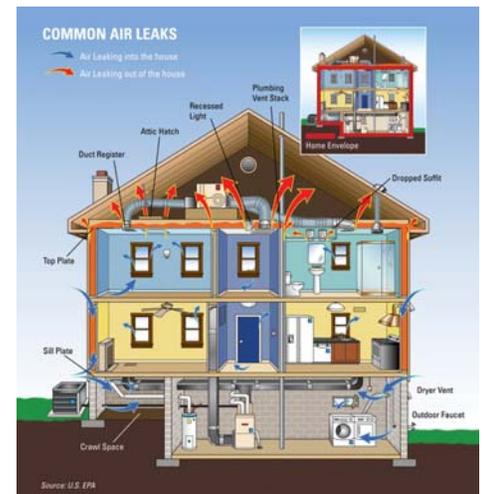


Figure 1. Common air leaks. Source: Air Seal and Insulate with ENERGY STAR.

AIR SEALING

Your home is constantly breathing or exchanging air with the surrounding outdoor environment. Unconditioned air is coming in while your conditioned air is flowing out. Generally the first place to start in creating an energy efficient living space is air sealing. This means sealing cracks and gaps around windows, doors, plumbing, electrical and venting penetrations so that you can control air exchange and ventilation. Sealing these leaks will mean that less unconditioned air makes it into your house and produces less load on your HVAC system. Start by using caulking and weatherstripping to seal air leaks. This is a low budget item that most homeowners can do. Table 1 and Figure 2 will help you determine where to look for leaks and the references below will give you more information on air sealing.

Sources of air leaks in a typical home

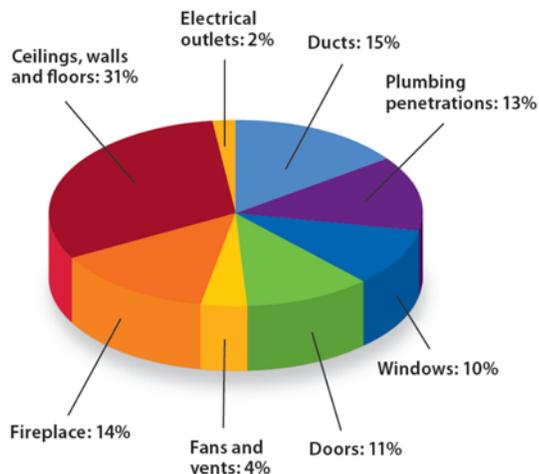


Figure 2. Sources of air leaks in a typical home. Source: Iowa Energy Center. Home Series-1: Home Tightening, Insulation and Ventilation

For more information on air sealing visit:

- *Weatherize Your Home—Caulk and Weather Strip*. National Renewable Energy Laboratory (NREL). US Department of Energy. <http://www.nrel.gov/docs/fy01osti/28039.pdf>

- *Home Series-1: Home Tightening, Insulation and Ventilation*. Iowa Energy Center. <http://www.iowaenergycenter.org/wp-content/uploads/2012/03/HomeSeries1.pdf>
- *Caulking and Weatherstripping*. Energy Efficiency and Renewable Energy (EERE): Energy Savers. <http://energy.gov/energysaver/articles/caulking>
- *Air Seal and Insulate with ENERGYSTAR*. http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_sealing

Ductwork

Leaky ductwork can cause major loss in energy efficiency. Leaky ductwork dumps your conditioned air in undesirable places; like in your attic or underneath your house. That means that you are paying to heat or cool the outdoors. In addition, when your cool air goes out, hot humid air comes in through air gaps to take its place. This puts twice the strain on your HVAC and makes your ductwork a prime target for an energy efficiency upgrade. First, visually inspect your ductwork for gaps or disconnected runs.

Use mechanical fasteners to secure ducts, then mastic sealant to seal gaps, and then insulate to prevent radiation loss.

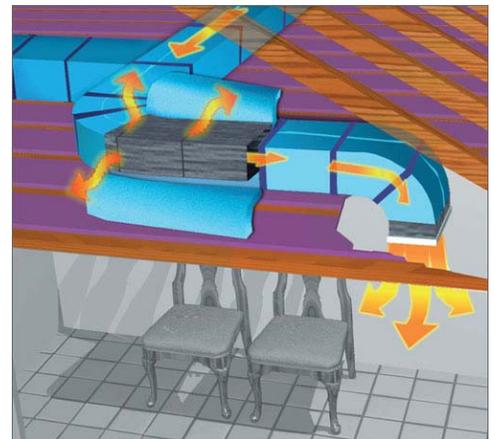


Figure 3. Ducts.

For more information on ductwork visit:

- *Energy Efficient Homes: The Duct System*. University of Florida IFAS Extension. <http://edis.ifas.ufl.edu/FY1024>
- “Ducts.” EERE: Energy Savers. <http://energy.gov/energysaver/articles/tips-air-ducts>

INSULATION

The next step for your efficient home is insulating. Roof temperatures can reach over 140°F so first target attic insulation. In the southeast the attic insulation level should be at least R-30. Wall and floor insulation are generally less important. Due to their high cost and lower impact implement other efficiency measures and consider other options before addressing walls and floors. One exception may be homes with raised wood floors and crawlspaces. If your elevated wood floor feels cold or drafty during the winter consider adding insulation. In addition, some home features, such as slab on grade foundations may actually reduce HVAC load in cooling dominated climates. See <http://energy.gov/energysaver/articles/insulation-materials> for more information on insulation levels recommended for your area and building location.

WINDOWS

The most important consideration for improving the efficiency of windows is air sealing (as previously mentioned). Once windows are properly sealed using caulking and weatherstripping, shading is the next step. First consider adding exterior shading on the east, west and south sides using properly placed trees, awnings, tinted window film, or solar screens. Exterior shading has the most benefit as it blocks solar radiation from entering the home while still allowing light to enter the home. Next consider using blinds or drapes to shade the home from the interior. Interior shading options stop solar radiation near the window, limiting heat gain in the home but also limiting day lighting. If your windows are unable to be properly sealed, or if you are considering replacing windows for functionality or aesthetic reasons, consider using energy efficient windows.

Windows are a big ticket item in home renovation and can drastically improve comfort and energy

performance. Replacing old windows with double pane, low-e windows can be a major benefit but remember that proper, air-tight installation is as important as the window itself. If you are going to replace windows, it should be done before HVAC replacement as window efficiency plays a large part in heating and cooling load calculations that determine the size of your HVAC equipment. Better windows could mean that you will need a smaller HVAC unit.

For more information on windows visit:

- *Air Seal and Insulate with ENERGYSTAR.* ENERGYSTAR.
http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_sealing
- *Energy Efficient Homes: Windows and Skylights.* University of Florida IFAS Extension.
http://edis.ifas.ufl.edu/document_fy1045

HVAC

The best way to ensure that your home continues to perform at peak energy efficiency is to perform regular HVAC maintenance. This includes steps that you can take such as replacing air filters often, cleaning condenser coils, straightening coil fins, and cleaning condensate lines. The resources listed below can help you with these tasks. There are other steps that need to be taken by a qualified HVAC technician such as checking refrigerant levels, testing for refrigerant leaks, checking the air flow and testing the electrical controls.

For more information on HVAC visit:

- *Energy Efficient Homes: Air Conditioning.* University of Florida IFAS Extension.
<http://edis.ifas.ufl.edu/FY1026>
- *Air Conditioning.* EERE: Energy Savers.
<http://energy.gov/public-services/homes/heating-cooling>
- *Heat & Cool Efficiently.* ENERGYSTAR.
http://www.energystar.gov/index.cfm?c=heat_cooling hvac

LIGHTING/APPLIANCES

Lighting and appliances should be replaced as needed with more energy efficient options or models. These do not contribute as greatly to the systems upgrade approach but can produce dual benefits. Initially their individual energy consumption is reduced. In addition, they may produce less heat therefore reducing cooling load on your HVAC system. One example is switching to compact fluorescent lighting. If you replace a 60 watt incandescent lamp with an equivalent compact fluorescent lamp energy use is reduced by 78% and waste heat is also reduced by 75%. This will hold true for appliances such as refrigerators, clothes dryers and water heaters.

For more information on lighting and appliances visit:

- *How Compact Fluorescents Compare with Incandescent*. EERE: Energy Savers: Your Home. <http://energy.gov/public-services/homes/saving-electricity/lighting>
- *Lighting*. EERE: Energy Savers. <http://energy.gov/energysaver/articles/tips-lighting>
- *Energy Efficient Homes: Appliances in General*. University of Florida IFAS Extension. http://edis.ifas.ufl.edu/document_fy1032
- *Appliances and Home Electronics*. EERE: Energy Savers. http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10020

References and Resources

See the following publications for more information about the whole-house systems

approach, the importance of realizing your home is a system, and the changes that you might be able to make to your home to improve both energy efficiency and occupant comfort:

- McMahan, J.E., M.A. McNeil, and I.S. Ramos. 2007. Chapter 9: "Buildings," in *The First State of the Carbon Cycle Report (SOCCR): The North American Carbon Budget and Implications for the Global Carbon Cycle*, A.W. King, et al., Editors. National Oceanic and Atmospheric Administration, National Climatic Data Center. Asheville, NC, USA. pp. 95-102.
- Amann, J., Wilson, A., and Ackerly, K. 2007. *Consumer Guide to Home Energy Savings*. 9th Edition. American Council for an Energy-Efficient Economy. Washington, D.C.
- Taylor, N.W., Kipp, J., and Ruppert, K.C. 2008. *Energy Efficient Homes: Incentive Programs for Energy Efficiency*. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. <http://edis.ifas.ufl.edu/FY1033>
- U.S. Department of Energy. *Energy Efficiency Pays: Systems approach cuts home energy waste and saves money*. Office of Energy Efficiency and Renewable Energy. http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/26290.pdf
- U.S. Department of Energy. 2003. *Whole-House Energy Checklist: 50 Steps to Energy Efficiency in the Home*. Office of Energy Efficiency and Renewable Energy. <http://www.southface.org/factsheets/WH-Energy%20Checklist%20GO-10099-766.pdf>
- U.S. Department of Energy. 2009. *Whole-house Systems Approach*. Office of Energy Efficiency and Renewable Energy. <http://energy.gov/energysaver/articles/whole-house-systems-approach>

Table 1. Steps to look for air leaks.

Though every situation is unique, the best general approach includes the following steps in roughly this order:

Step	System Component	Strategy	Impact
1	Doors, windows, walls, floor, and ceiling	Weatherize and seal any holes or gaps in building envelope	Improves air barrier by reducing air leakage
2	Heating / air conditioning (HVAC) ductwork	Seal and insulate ductwork	Improves air barrier by reducing air leakage
3	Attic insulation	Improve / replace to R-value recommended for your area	Improves thermal barrier by increasing insulation function
4	Windows	Replace single-pane metal framed windows with double-paned low-E wood or vinyl framed alternatives	Improves air and thermal barriers by reducing air leakage and reducing solar heat gain
5	Heating / air conditioning (HVAC) system	Service existing HVAC system and/or upgrade to properly sized SEER 14 or higher HVAC system	Improves heating and cooling efficiency
6	Water heater	Replace old inefficient model with modern ENERGY STAR alternative	Reduces water heater energy consumption
7	Lighting	Replace high wattage bulbs (such as incandescent and halogen) with low wattage alternatives of comparable lumen value (such as compact fluorescent and LED)	Reduces lighting energy consumption and unnecessary heat load to indoor spaces
8	Ceiling fans	Install ENERGY STAR ceiling fans in commonly occupied rooms	Reduces load on HVAC system by improving occupant comfort
9	Appliances	Replace old inefficient models with modern ENERGY STAR alternatives	Reduces appliance energy consumption

Many utility companies offer free or low-cost audits, as well as incentive and rebate programs for many of the above recommended steps. In addition, you may be eligible for state or federal tax credits when you purchase certain energy efficient components. See the Database of State Incentives for Renewables & Efficiency (<http://www.dsireusa.org>) and federal tax credits for energy efficiency (http://www.energystar.gov/index.cfm?c=products.pr_tax_credits) for additional information.

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