

# WHOLE-HOUSE SYSTEMS APPROACH TO ENERGY EFFICIENCY

## Introduction

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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, attic insulation is insufficient, 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: Why Is It Important?

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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.<sup>1</sup>

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.

## A Systems Approach: Where Do I Start?

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Begin by looking at the major mechanical component, the heating, ventilation and air conditioning (HVAC) system, 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 home's 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.

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<sup>1</sup> McMahon, 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. <http://www.climate-science.gov/Library/sap/sap2-2/final-report/default.htm>

## Step 1: Air Sealing

Your home is constantly breathing or exchanging air with the surrounding outdoor environment. Unconditioned outdoor air comes in while conditioned indoor air flows 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 weather-stripping to seal air leaks. This is a low budget item that most homeowners can do. Figures 1 and 2 will help you determine where to look for leaks and the following references will give you more information on air sealing.

For more information on air sealing visit:

- Iowa Energy Center. *Home Series 1: Home Tightening, Insulation and Ventilation*. <http://www.energy.iastate.edu/homeseries/tightening.htm>
- U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE). Energy Savers: Your Home. “Caulking and Weatherstripping.” [http://www.energysavers.gov/your\\_home/insulation\\_airsealing/index.cfm/mytopic=11260](http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11260)
- U.S. Environmental Protection Agency/U.S. Department of Energy, ENERGY STAR. “Air Seal and Insulate with ENERGY STAR.” [http://www.energystar.gov/index.cfm?c=home\\_sealing.hm\\_improvement\\_sealing](http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_sealing)
- *Weatherize Your Home—Caulk and Weather Strip*. 2001. National Renewable Energy Laboratory (NREL). US Department of Energy. <http://www.nrel.gov/docs/fy01osti/28039.pdf>

**Sources of air leaks in a typical home**

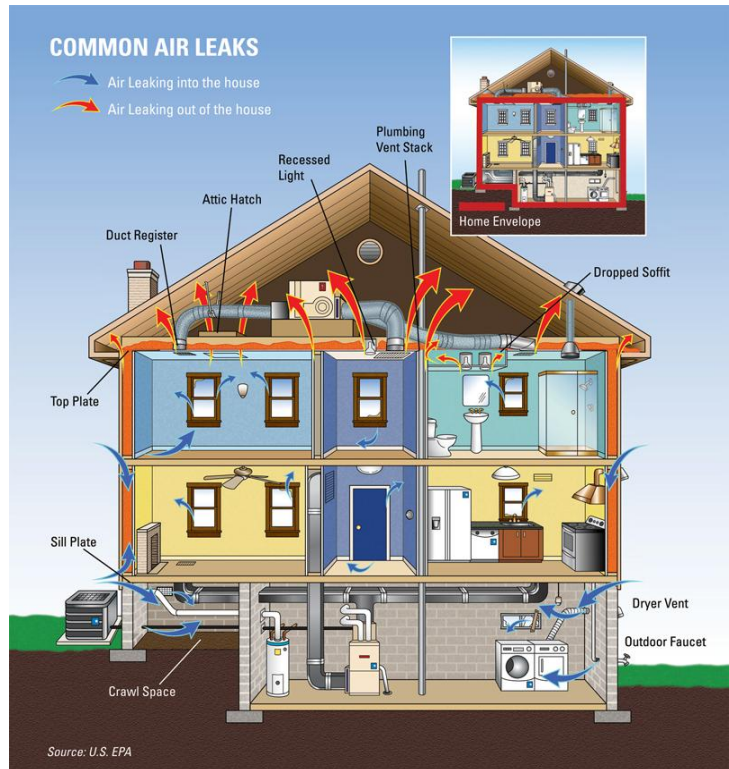
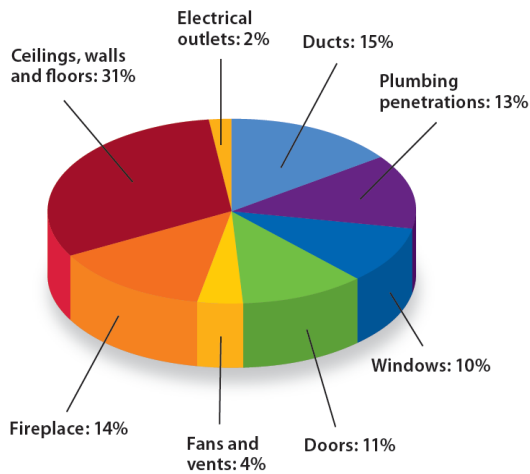


Figure 1 Sources of air leaks in a typical home. Source: Iowa Energy Center. Home Series 1: Home Tightening, Insulation and Ventilation.

Figure 2 Common air leaks. Source: Air Seal and Insulate with ENERGY STAR. [http://www.energystar.gov/index.cfm?c=home\\_sealing.hm\\_improvement\\_sealing](http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_sealing)

## Step 2: Ductwork

Leaky ductwork can cause a major loss in energy efficiency. Leaky ductwork dumps conditioned air in undesirable places; like 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 (Figure 3). Second, use mechanical fasteners to secure ducts. Third, use mastic sealant to seal gaps. Finally, insulate ducts to prevent radiation losses.

For more information on ductwork visit:

- Porter, Wendell A., Hyun-Jeong Lee, and Kathleen C. Ruppert. *Energy Efficient Homes: The Duct System*. 2008. University of Florida IFAS Extension. <http://edis.ifas.ufl.edu/FY1024>
- U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE). Energy Savers: Tips on Saving Energy and Money at Home. "Ducts" <http://www1.eere.energy.gov/consumer/tips/ducts.html>

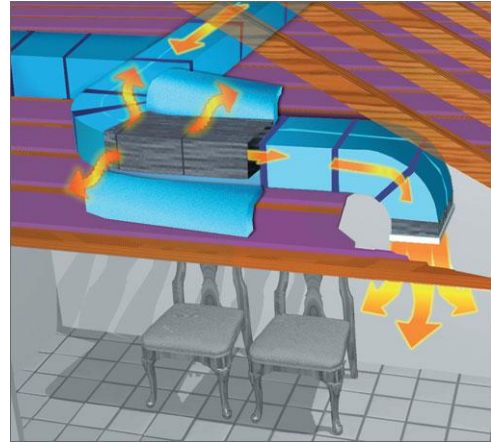


Figure 3 Ducts. Source: U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE). *Energy Savers: Tips on Saving Energy and Money at Home*. "Ducts" <http://www1.eere.energy.gov/consumer/tips/ducts.html>

## Step 3: Insulation

The next step to improve your home's efficiency is insulating. Roof temperatures can reach over 140°F so target attic insulation first. In the southeast, aim for attic insulation levels of R-30 or higher. Wall and floor insulation generally offer a lower return on their retrofit investment. Due to their high cost and lower impact, consider other efficiency measures before adding insulation to 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. Other floor types, such as slab on grade foundations, may actually reduce HVAC load in cooling dominated climates. See <http://www1.eere.energy.gov/consumer/tips/insulation.html> for more information on insulation levels recommended for your area and building location.

## Step 4: 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 weather-stripping, 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. Next consider using blinds or drapes to shade the home from the inside. Interior shading options stop solar radiation near the window, limiting heat gain in the home but also reducing 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 but can significantly improve comfort and energy performance. Replacing old windows with double pane, low-e windows can be a major benefit. However, 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 system.

For more information on windows visit:

- Hammer, Marie. *Window Management for Energy Conservation*. 2003. University of Florida IFAS Extension. [http://edis.ifas.ufl.edu/document\\_fy548](http://edis.ifas.ufl.edu/document_fy548)
- Ruppert, Kathleen C., Wendell A. Porter, and Hyun-Jeong Lee. *Energy Efficient Homes: Windows and Skylights*. 2008. University of Florida IFAS Extension. [http://edis.ifas.ufl.edu/document\\_fy1045](http://edis.ifas.ufl.edu/document_fy1045)
- U.S. Environmental Protection Agency/U.S. Department of Energy, ENERGY STAR. “Air Seal and Insulate with ENERGY STAR.” [http://www.energystar.gov/index.cfm?c=home\\_sealing.hm\\_improvement\\_sealing](http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_sealing)

### **Step 5: 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 frequently replacing air filters, cleaning condenser coils, straightening coil fins, and cleaning condensate lines. The resources listed below can help you with these tasks. Other steps that should be taken by a qualified HVAC technician include checking refrigerant levels, testing for refrigerant leaks, checking the air flow and testing the electrical controls. This process is called commissioning and ensures that your HVAC is at peak performance so that your home is comfortable and efficient. If your HVAC system is too old or run down to benefit from regular maintenance, consider upgrading to a newer, higher SEER system.

For more information on HVAC visit:

- Porter, Wendell A., Hyun-Jeong Lee, and Kathleen C. Ruppert. *Energy Efficient Homes: Air Conditioning*. 2008. University of Florida IFAS Extension. <http://edis.ifas.ufl.edu/FY1026>
- U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE). Energy Savers: Your Home. “Air Conditioning.” [http://www.energysavers.gov/your\\_home/space\\_heating\\_cooling/index.cfm/mytopic=12370](http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12370)
- U.S. Environmental Protection Agency/U.S. Department of Energy, ENERGY STAR. “Heat & Cool Efficiently.” [http://www.energystar.gov/index.cfm?c=heat\\_cool.pr\\_hvac](http://www.energystar.gov/index.cfm?c=heat_cool.pr_hvac)

### **Step 6: Lighting and Appliances**

Lighting and appliances should be replaced as needed with more energy efficient options or models. Though these are smaller contributors in a systems upgrade approach, they can produce dual benefits. First, they offer reduced direct energy consumption with each use and in standby mode. In addition, they may produce less heat therefore reducing cooling load on your HVAC system. This applies to most appliances such as refrigerators, dishwashers and water heaters. One example is switching to compact fluorescent lighting. If you replace a 60 watt incandescent lamp with an equivalent compact fluorescent lamp direct energy use is reduced by 78% and waste heat is also reduced by 75%.

For more information on lighting and appliances visit:

- Lee, Hyun-Jeong, Kathleen Ruppert, Wendell Porter, and Travis Prescott. *Energy Efficient Homes: Appliances in General*. 2008. University of Florida IFAS Extension. [http://edis.ifas.ufl.edu/document\\_fy1032](http://edis.ifas.ufl.edu/document_fy1032)
- U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE). Energy Savers: Your Home. “How Compact Fluorescents Compare with Incandescents.” [http://www.energysavers.gov/your\\_home/lighting\\_daylighting/index.cfm/mytopic=12060](http://www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=12060)

- U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE). Energy Savers: Tips on Saving Energy and Money at Home. “Lighting.”  
<http://www1.eere.energy.gov/consumer/tips/lighting.html>
- U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE). Energy Savers: Your Home. “Appliances and Home Electronics.”  
[http://www.energysavers.gov/your\\_home/appliances/index.cfm/mytopic=10020](http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10020)

## Overview

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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](http://www.energystar.gov/index.cfm?c=products.pr_tax_credits)) for additional information.

## Additional References and Resources

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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:

Amann, J., Wilson, A., and Ackerly, K. 2007. *Consumer Guide to Home Energy Savings*. 9<sup>th</sup> Edition. American Council for an Energy-Efficient Economy. Washington, D.C.

Taylor, N.W., Kipp, J., and Ruppert, K.C. 2008. *Energy Efficient Homes: Easy Steps to Improving Your Home's Energy Efficiency*. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. [http://edis.ifas.ufl.edu/document\\_fy1028](http://edis.ifas.ufl.edu/document_fy1028)

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 and Renewable Energy, Office of Building Technology, State and Community Programs. March 1999. "Energy Efficiency Pays: Systems approach cuts home energy waste and saves money." Technology Fact Sheet DOE/GO-10099-746.

[http://apps1.eere.energy.gov/buildings/publications/pdfs/building\\_america/26290.pdf](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/web/resources&services/publications/technical\\_bulletins/WH-Energy%20Checklist%20GO-10099-766.pdf](http://www.southface.org/web/resources&services/publications/technical_bulletins/WH-Energy%20Checklist%20GO-10099-766.pdf)

U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE). 2009. Energy Savers: Your Home: "Whole-house Systems Approach."

[http://www.energysavers.gov/your\\_home/designing\\_remodeling/index.cfm/mytopic=10370](http://www.energysavers.gov/your_home/designing_remodeling/index.cfm/mytopic=10370)

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### About the Florida Energy Systems Consortium (FESC)

The goal of the consortium is to become a world leader in energy research, education, technology, and energy systems analysis. Specific goals include:

- Coordinate and initiate collaborative interdisciplinary energy research among the universities and the energy industry.
- Share research results with a wide audience, including the science community, media, business, governments, and industry.
- Assist in the creation and development of a Florida-based energy technology industry.
- Provide a state resource for objective energy systems analysis.
- Develop education and outreach programs to prepare a qualified energy workforce and informed public.

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