

Home Energy Efficiency and Health Improvement

“Always do efficiency first!” Paul Westbrook, The Joy of Efficiency

This presents a sequence for making your home more energy efficient, healthy and economically viable. Different homes and climates create unique situations, so there is no one-size-fits-all solution. However, there is a cost effective sequence that starts with the least expensive/most effective improvement and moves thru the more expensive up-grades. Generally, these projects have a high ROI because they are substituting relatively small capital expenditures to eliminate on-going fuel bills.

Energy conservation is the starting point for sustainability because 1KW used in your home requires 3.5KW of generation. You may be a do-it-yourselfer, or use an independent energy inspector (HERS, Home Energy Rating System, or Building Performance Institute, BPI) to assess your home. Below is a check list along with explanations of key features of the different systems you might choose.

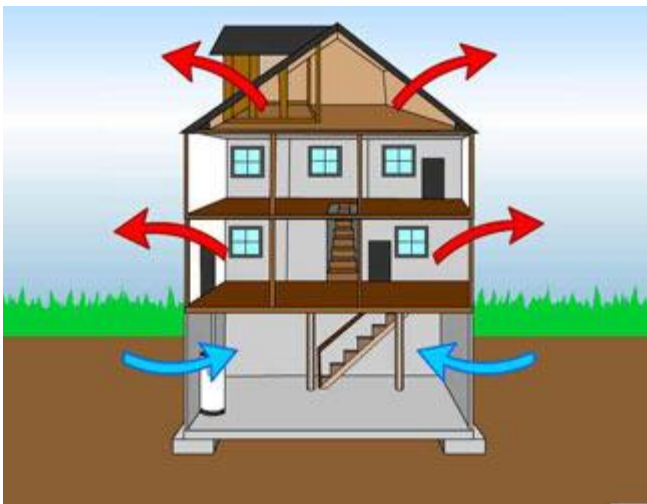
Low Hanging Energy Fruit:

The 3 easiest and most cost effective improvements are 1) proper insulation and sealing of the living space, 2) LEDs in routinely used lighting; and 3) properly maintained and operated mechanical systems.

1. Encapsulate your crawl space, basement and attic, if possible. This has the effect of turning them into semi-conditioned spaces. Lack of crawl space encapsulation or a poorly sealed basement is a major source of energy inefficiency. However, encapsulation requires humidity monitoring, or control.
2. Attics can be sealed or vented, but vented attics can be a major source of loss for conditioned air, if the living space is not properly sealed and ventilated.
3. Poorly maintained and operated mechanical equipment (HVAC, pumps, HWH, etc.) are the third largest wasters of energy in the home.

Ventilation – the Critical Health Problem

Basically, making your house into a thermos bottle produces the best energy efficiency and is current best practice. However, this approach requires good, mechanical ventilation and may not be cost effective for your home. In a sealed roof/crawl space/basement system the home should have a humidity sensor, a connection to your conditioned air, or a dehumidifier to avoid mold.



THE STACK EFFECT: AIR ENTERS LOW, EXITS HIGH

Ventilation and air quality is critical to health. Ventilation solutions are climate specific. Home air may have many impurities such as pollen, volatile organic molecules (VOMs), CO₂, CO and radon. Ductless gas heaters, or improperly operated gas ranges are a major source of indoor pollutants. (Yes, open gas flames in the home are not as healthy as previously thought and must be properly vented). Homes with young children and breathing compromised occupants should consider newly developed active air quality sensor controls for their ventilation system.

Most homes use old ventilation systems that simply open a vent to the outside for a fixed amount of time each day and use the big fan on your HVAC to blow air thru the house. This is energy inefficient (because it exhausts your conditioned air regardless of need), might suck in more pollutants, and can cause air pressure changes (negative, or positive air pressure forces conditioned air out of the home). The best energy efficiency and most healthy ventilation comes from an energy or heat recovery ventilation system (ERV, HRV). These ventilation systems are most often included in a replacement of existing HVAC systems. Proper ventilation takes expertise to understand and install.

HVAC and Thermal Basics

- Historically HVAC and energy efficiency investments typically are sold on the lowest first cost, dramatically increasing the homeowners total cost of ownership (and home CO₂ levels) over time. Be careful to understand the energy penalties for low first costs.
- Thermal energy can't be created or destroyed, it can just be transferred, or transformed. This has significant implications for heating and cooling – you can 1) use natural heating/cooling effects like shading, window exposure, etc. (this is known as Passiv Haus design and is often the most cost effective), 2) convert electrical, or gas energy into thermal energy and move it or 3) move existing thermal energy. The chosen method(s) determines energy efficiency.
- Gas heaters, boilers and furnaces are much cheaper to operate per btu because of the gas. However, because methane is much more environmentally destructive than CO₂ and so much gas leaks (as much as 15%), plus burning gas creates unhealthy and potentially lethal fumes, environmentalists are urging the phase out of gas.
- A heat pump uses refrigerant compression to remove, or add heat from the air, or water and add / eliminate heat from your home (conditioned air). A heat pump is many times more efficient than resistance heating. However, heat pumps lose efficiency at extreme temperatures. For this reason, in more extreme northern or southern applications, energy recovery ventilation (ERV) and/or geothermal HVAC becomes much more economical.
- Water moves thermal energy (heat, or cooling) 61 times more efficiently than air (your old radiant system is many orders of magnitude more efficient at moving heat than forced air). Variable refrigerant flow mini split systems get their efficiency from using refrigerant to move energy rather than forced air. However, these systems require circulating refrigerant thru your house.
- Heat pump technology has radically improved, so that now 25 SEER systems are available.

HVAC comes in several forms – some quite old:

- Fireplaces – while an attractive heat source, can be a source of volatile organic compound air contamination, if not properly vented and completely isolated from the living space (avoid ventless). A chimney can be major source of heat loss.
- Gas heaters, boilers, furnaces.
- Heat pumps – use a compressor with refrigerant to extract heat and move the heat, or cool to where it needs to go. Heat pumps may be water to water, water to air, air to water or air to air. Therefore, they are used for forced air, radiant or geothermal systems. The lower the temperature swing between the source of the heat/cool and the use temperature for the thermal energy the more efficient the thermal exchange is.
- Geothermal heat pumps – need a ground loop (a tube filled with water) that is immersed in water or the earth, or that ends in open water to provide energy transfer from the radiant exchange (like an ice cube melting in water to come to one common temperature). The improved efficiency comes from exchanging heat with the more moderate earth or water temperatures that swing less than the more extreme swings of outdoors air temp. Instead of trying to dump excess heat into 90°F outside air, it's transferred to the water pipe that may be 65 - 70° year round underground. Geothermal is

more expensive first cost, but it is the most efficient, cleanest, safest form of heating and cooling. And over time it has the lowest cost of ownership.

- Variable refrigerant flow (VRF) units - are relatively inexpensive and efficient, use refrigerant circulating in pipes thru the building to transfer heat/cool to air handling units where a coil uses it to heat/cool air. They are based on compressor and refrigerant heat extraction - similar to mini splits.
- Mini Splits - are heating and cooling systems that allow you to control the temperatures in individual rooms or spaces (as do VRFs). Mini-split systems have two main components -- an outdoor compressor/condenser and an indoor air-handling unit(s). These are cheap first cost but usually fairly expensive to operate (except for the VRF units). The ductless versions must be vented properly and introduce air quality risks.
- Resistance heat – most inefficient, but often cheapest first cost. Uses electric resistance thru a coil to convert energy to heat.
- Evaporation cooling tower – uses evaporation to cool circulating water (commercial applications)..
- Boiler – uses gas or oil to boil water. Older boilers are inefficient and polluting because as much as 40% of the heat is exhausted thru the flue. Modern boilers capture as much as 95% of the heat. These still burn fossil fuels and are more polluting than electric heat pumps.
- Gas forced air heater – gas flame used to heat air. Gas is significantly “dirtier” than electricity.
- Radiant heating is more efficient than forced air. Modern systems use PEX tubing embedded in the slab when it’s poured for both heating and cooling. A heat pump is used as the heating and cooling source.

Hot Water Uses Approximately 11% of Home Energy

- Add Insulation to your existing water heater tank and hot water piping. That’s a quick, cheap way to improve an existing tank system.
- On-demand hot water has become popular and saves energy by not heating a tank that will cool over time. For one, or two person households, or those with intermittent hot water needs these can be relatively efficient even though they use inefficient resistance heating.
- HVAC heat pumps can have reversing valves to take waste heat off of the a/c cycle, or use the more efficient heat pump to generate hot water. This can be efficient for larger use applications although it is more expensive first cost than conventional hot water heaters.
- Solar hot water works very well, especially in southern latitudes. With added insulation for the tank, the water can remain hot for days even in cloudy weather (11% of the average HH energy requirement). This also shifts peak load off for solar photovoltaic users and reduces energy rates for those with peak determined distribution rates.

Plug Load

Plug load represents about half of the average home energy use. In the future these will become much more efficient by being artificial intelligence operated. Power strips are just beginning to have sensors to determine if devices are connected to chargers and automatically turn off.

Future Tech

The future holds major improvements for home energy and HVAC systems. In the next five years we’ll see that:

- Smart monitoring will give homeowners accurate information on efficiency investments and projected savings through improvements. This will fuel a significant market shift from buying home equipment on lowest first cost to buying to minimize total cost of ownership.
- Appraisals are beginning to have energy efficiency addendums that support the home sellers case for charging more for a more energy efficient home.
- Variable speed fans and compressors will more commonly be used in HVAC systems to use less energy and move air at the most efficient pace also improving zone controls.
- Air quality sensors will control ventilation systems to improve indoor air quality.

- Membrane HVAC that uses forcing water thru a membrane to generate heat and cool will become affordable. Early examples are reported to be up to 90% more efficient.
- A.I. controlled ground source heat pumps will reduce the size requirement (and cost) of geothermal heating and cooling.
- Variable refrigerant flow has recently succeeded in the market because of good efficiency and it is relatively low cost. This is likely to become more common in the U.S. market.
- Artificial intelligence controls will much more efficiently operate home equipment as an entire system rather than the current siloed operation of individual systems. This will eliminate a number of problems resulting from poor operation and maintenance of equipment..

Now You Are Ready to Consider Solar PV

Solar PV prices are 10% of what they were 20 years ago! If you have gotten this far and have achieved a truly energy efficient (and healthy) home you have also radically reduced the size and cost of a photo voltaic energy system for your home. The reduced energy requirement lets a solar system meet your household energy needs (and even potentially charge your electric car) at a much lower cost. This is key to making solar affordable. Because solar installers often do not sell energy reduction services and equipment, you need to make certain your home is efficient.

Unfortunately, in some locations utility company resistance to individual solar photovoltaic along with climate limitations has resulted in a patchwork quilt of economic desirability depending on the exact location. Consequently, a local installation expert will be required to navigate local economics.

As a vision, would it be really attractive to have paid for your lifetime energy bill when you complete paying your mortgage? This is called "The Willy Sutton Sustainability Strategy." It should be economically feasible in most of the U.S. now.

Conclusion

Many if not most U.S. homes are due for an energy upgrade and modern technologies are increasingly cost effective. In many states politicians and regulators are listening to the popular demand for clean, sustainable, cost effective energy. Sustainability begins with home efficiency, and we should be moving quickly to a future where energy has already been paid for by making the proper investments to become efficient and to generate renewable energy locally. The industrial revolution was driven by the improved productivity from substituting capital for labor. We live in a world of abundant, if not excess capital. The move to sustainability is achieved by substituting capital for on-going fossil fuel payments. We invite you to make a profitable investment in a lower cost, cleaner future by considering these options.

To create you own energy plan, you can go to:

<https://www.energystar.gov/campaign/assessYourHome>