Building a Better, Greener Home

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As energy costs increase and people become more concerned about their impact on the environment, it would seem to be logical to focus some of our efforts on building better, more energy efficient homes. In the US, our homes and businesses account for half of our energy usage. By building more efficient houses, we reduce the energy they consume. This saves energy over the life of the building or the next 50 to 100 years.

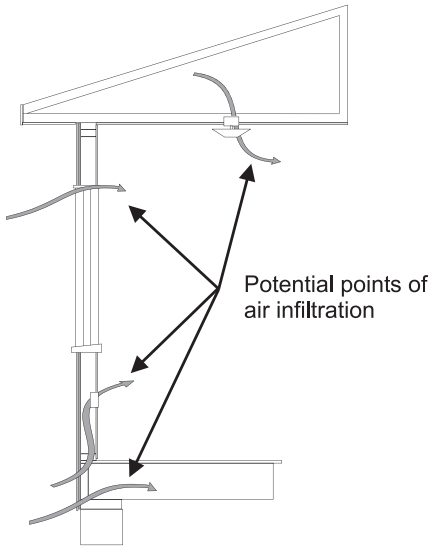
There are a number of ways in which we can greatly improve the energy efficiency of our homes. This document provides a list of things that can be done to build a better, greener home. Some of these items cost next to nothing while others do increase the total cost of the house. But, the increase in initial cost can typically be easily offset by the reduction in the energy cost over time.

The Building Envelope

Improving the energy efficiency of the building envelope probably offers the biggest return on investment. In the US, most new homes, even very expensive ones, are being built using the same methods that have been utilized for over 100 years.

2x4 frame construction is fine for building a reasonably strong house in an efficient manner. But, this type of construction is found lacking in a key area, energy efficiency. Since the wall cavity formed by 2x4 construction is only 3.5” deep, there is a limit to the amount of insulation that can be installed. Simply increasing the framing members to 2x6s adds another 2” of insulation to the wall cavity. This allows you to add 42% more insulation.

Wood framed buildings also suffer from thermal bridging. This occurs when heat more easily travels through the wood framing members, reducing the overall thermal efficiency of the wall system. Other building systems do not suffer from this problem to the extent that a stick framed building does. Adding a layer of foam sheathing to the exterior of the frame will further increase the energy efficiency of the building and reduce thermal bridging to some extent.



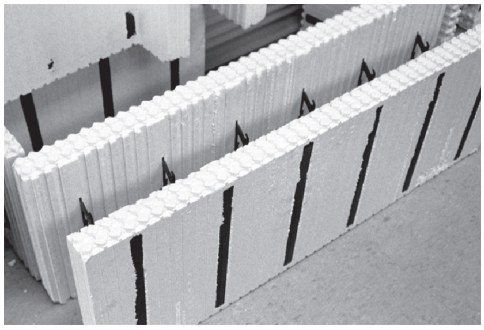
Another large contributor to energy loss with a wood framed building is air infiltration. Since a wood framed building is constructed with many parts, there are many cracks and crevices through which air can leak into and out of the home which is air infiltration. Materials such as house wrap can be used to help combat this issue, but it still remains a problem. Again, other building materials do not suffer this problem to the extent that wood framed buildings do.

Other building materials such as SIPs or ICFs offer energy efficiency increases. SIPs, or Structural Insulated Panels, are a composite material made of an inner layer of EPS or other foam with an exterior skin of OSB on each side. This creates a panel that is light, strong and very well insulated. The most common thickness is 6”, but they can be manufactured to almost any thickness desired. The thicker the foam, the more the insulation value of the wall. SIPs are typically used for wall and roof panels, but can be used as floor panels also. SIPs are cut to size at the factory and assembled at the job site to form the shell of the home. Since SIPs are made of large panels,

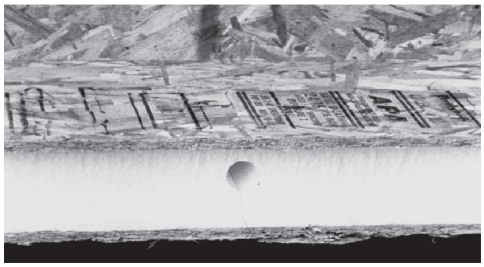
there are fewer areas for potential air infiltration compared to frame construction, further improving energy efficiency.

ICFs or Insulated Concrete Forms are another high efficiency building option. ICFs are essentially hollow foam blocks that are assembled at the job site to form walls. Once the walls are complete, they are filled with concrete. The concrete provides the structural part of the wall and the foam on each side provides the insulation. Most ICFs have between 5" and 5.5" of insulation. The concrete in the middle of the wall acts as a thermal mass that buffers temperature fluctuations of the building, adding to the overall efficiency. Since ICFs are filled with a continuous layer of concrete, there is virtually no air infiltration through the wall. These factors make ICF homes very energy efficient. Additional advantages of ICFs are the strength of the wall system and sound deadening. The steel reinforced concrete inside the ICF wall makes them the strongest common building material available for a home.

Insulated Concrete Form



Structural Insulated Panel



Regardless of what type of wall system you choose, make sure that all the cracks and crevices open to the outdoors are caulked well. Caulking is really cheap but can save you a lot of money by reducing heat loss.

In addition to the walls, you also need to consider the insulation below the floor and above the ceiling.

In many homes, there is no insulation below the floor whether the home is built on a concrete slab, over a crawl space or with a basement. If the home has a slab floor, insulation should be placed below the concrete before it is poured. The typical method is to use 2" of foam sheets below the slab. This insulation helps to keep the slab floor from transferring your heating dollars to the ground below. A crawl space or unfinished basement is typically cooler than your living area. Heat will also transfer to these cooler areas below the house, causing your HVAC system to replace it. Adding insulation below the floor will reduce this heat transfer. If you have a finished basement with a slab floor, it should have insulation below the slab just like any other area with a slab floor.

The attic of your home should also be well insulated. Most areas have requirements that specify the R-value of your attic insulation. It is also important that care is taken to carefully seal any areas of potential air infiltration into the attic. Since heat rises, the warm air in your home will try to escape through any small openings into the attic. Problem areas include around light fixtures and electrical or plumbing penetrations. These areas can be sealed individually or all at once. One option is to apply a thin layer of expanding foam to the floor of the attic (on top of the ceiling wall board) and then to add a thick layer of fiberglass or cellulose insulation above it. The foam seals all the air leaks and the other material provides the bulk of the insulation. Or you could use expanding foam for all the attic insulation, but this does increase your costs.

To verify rate of air infiltration of your home, you can have a blower door test performed to help identify any remaining air leaks. A blower door is a device that is temporarily installed in an exterior doorway. This device has a fan that pushes a known quantity of air into the house. The technician can then determine how much air is leaking from the building and where the leaks are. The goal of a blower door test is to identify and eliminate any large areas of air infiltration that can reduce the efficiency of the house.

The HVAC System

Most homes built today have some form of HVAC system, which stands for heating, ventilation and air conditioning. The most common type of system utilizes forced air for both heating and cooling. The contractor who installs the HVAC system calculates how large it must be to meet the peak demands of the house.

It is very important that the system not be too large for the home. An HVAC system that is too large will do what is called short cycling. When an oversized system turns on for either heating or cooling, it will only run for a few minutes before it shuts off because the home has reached the required temperature. The next time the system is called on, again it will only run for a few minutes. To be efficient, an HVAC system needs to run for an extended period of time. This is especially important in the air conditioning mode. One function of air conditioning is to remove excess moisture from the air inside the home. If the HVAC system is short cycling, it has no chance to remove this moisture. A properly sized system will run for a longer period and do a much better job of removing moisture.

Besides having a correctly sized HVAC system, additional energy savings can be gained with a dual speed system. Most HVAC systems only have one speed, they are either on or off. A dual speed system has two speeds or half speed and full speed. Most of the year, you do not need the full capacity of your HVAC system. The full capacity of your system is typically only required on the coldest winter and the hottest summer days. Except for days with extreme temperatures, you need less HVAC capacity. A dual speed system provides you with this capability. The half speed option allows the system to run more efficiently for longer periods of time and consumes less energy. Of course a dual speed system does cost more than a single speed system, but over time, your energy savings will more than offset the extra cost.

Another important issue with the HVAC system is the location of the air distribution ducts. The ducts for your system should be located inside the temperature controlled envelope of the home. The ducts should never be located in a non-conditioned attic space. Non-conditioned attic spaces experience extremes of heat and cold. Even though ducts placed in an attic space may have a small amount of insulation around them, you lose a lot of the energy when heating or cooling energy is transferred to the non-conditioned area.

The joints in the ducts of the HVAC system should be sealed to prevent air leakage. A special mastic compound is commonly used for dealing the joints in the ducts. Typical “duct tape” is not an acceptable method. After a year or so, the adhesive on the duct tape will fail and you will have leaking ducts.

Windows and Doors

If you are building a highly efficient house, it makes sense to use good quality windows and doors.

In regard to doors, there are typically solid wood doors and doors made from either fiberglass or steel with some type of insulation material in the middle. The solid wood doors are beautiful but generally require more upkeep since they are a natural material. Fiberglass or steel doors lack the natural beauty of wood, but they do generally require less maintenance and offer better insulation qualities.

As far as windows, you have a few more choices. Windows are typically made of wood, fiberglass, vinyl or aluminum. You can also get wood windows that are clad on the exterior with aluminum giving you the advantage of a durable exterior finish while keeping the beauty of wood inside. Beyond the style of any specific window, the most important things to consider are their energy efficiency and the maintenance they will require. Commercial aluminum windows are typically much less energy efficient than residential windows.

The energy performance of doors and windows is typically expressed as the U-value. The lower the U-value,

the better the thermal performance. Builder grade windows generally have a U-value of around .35. Higher quality windows will have a U-value of .30 or better. The same goes for doors, there are many available that have a U-value of .30 or better. Your windows and doors are one of the weakest points in the thermal envelope of your home. Cheap windows and doors will reduce the energy efficiency of your home and cost you money every time you pay your utility bill.

Beyond the energy efficiency of your windows and doors, you and/or your designer need to pay attention to the quantity and direction your windows and doors face.

Since windows and doors have the lowest insulation value of any part of your house, the more of them you have, the less energy efficient your house will be.

Doors and windows can also impact the energy efficiency of a house by their location in relation to available sunshine. We all know that the sun rises in the east and sets in the west. In the US, the winter sun will shine through south facing windows, helping to warm the interior. During the summer, the sun is at a steeper angle in relation to the ground and will not shine into south facing windows with properly designed overhangs.

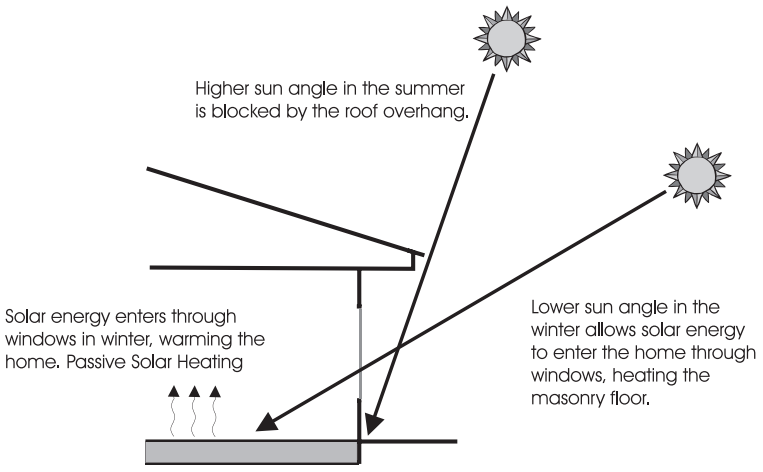
Windows facing east or southeast will typically capture the morning sun at all times of the year. This may or may not be a good thing. You typically do not want the sun warming the interior of your home on a hot summer day. West facing windows pose additional problems. They will typically capture sunshine during the hottest part of a summer day. This heat gain will cause your HVAC system to work that much harder to keep things cool.

You can protect your east and west facing windows with shades or awnings to help reduce heat gain. You can also take advantage of trees to provide shade in required areas.

Passive Heating and Cooling

Your home can also be more energy efficient by taking advantage of passive heating and cooling. Passive heating and cooling is simply heating or cooling our homes using no mechanical means.

Our forefathers knew about passive heating and cooling. They did not call them this, but they took advantage of them just the same. They simply designed their homes to take advantage of the suns heat in the winter and to allow cooling breezes to flow through the home in the summer. We had forgotten many of these features with the advent of mechanical HVAC systems.



South facing windows

Passive heating involves allowing the suns energy to enter and warm the home during the cooler winter months. This is also called solar heat gain. The home should be oriented with the long axis oriented east to west. This orientation allows for windows to face due south for maximum solar gain. Windows facing southeast or southwest will also allow solar heating, but at a slightly less efficient level. If the roof overhangs above your south facing windows are properly designed, little of the suns heat will enter the home during the summer. There does need to be a balance regarding the number of windows on the south side of the home. Too many windows will allow in

too much energy causing the house to overheat, even on the coldest days.

The type of windows you utilize can also make a difference. With the advent of low-E windows, you can choose how much of the suns energy you allow into the home. Some windows will block most of the thermal energy from the sun while others will allow some of the suns energy to enter the home. Pay attention to the solar heat gain coefficient (SHGC) of the windows you buy. The SHGC is expressed as number between 0 and 1. The lower the SHGC number, the less of the suns energy will be allowed through.

Different areas can utilize windows with different SHGC ratings. If you live in the north, you may want the maximum solar gain and windows with a higher SHGC rating. If you live in the south and do not need much passive heating, windows with a lower SHGC rating would be appropriate.

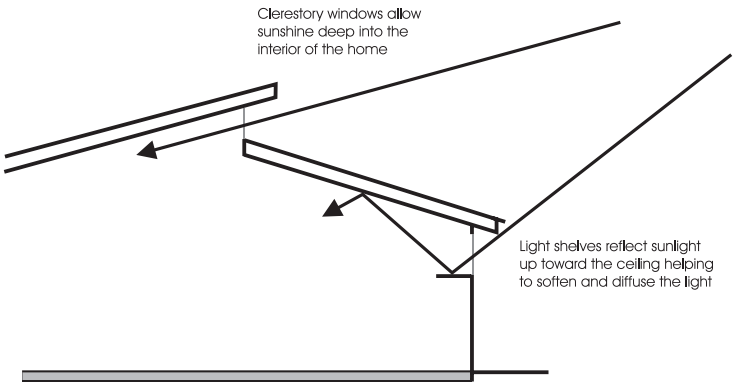
Passive cooling involves designing the house to promote a natural flow of cooling air through the building. A typical design incorporates windows close to the floor and some type of vent or outlet in the ceiling. The low windows allow cooler air, preferably from a naturally shaded area to enter the home and warmer air to rise out through the roof. This takes advantage of warmer air rising and exiting at the roof.

Daylighting

Daylighting is simply using natural light to illuminate the home. If ample natural light enters the home, the need to use artificial light during the daytime is reduced or eliminated, reducing energy consumption. The key with daylighting is to admit enough light to make people feel comfortable, but the incoming sunshine should not be enough to cause the temperature in the room to increase.

There are a number ways to increase the amount of daylight into all parts of the home. Again, the home should be oriented lengthwise on an east-west axis. You want to take advantage of sunlight from the south and north as much as possible. Utilizing daylight from the east or west is problematic because of the angle of the sun as it rises and sets. Windows on the south side can be shaded in the summer to admit light but not heat. Windows on the north side of the building will admit light but rarely cause a problem with glare.

Clerestory windows or windows mounted at the top of the wall, near the ceiling, are common configurations to get natural light into the interior of the building. Clerestory windows are typically a row of small horizontal windows located in the upper portion of the roof. Like other windows in the home, clerestory windows will admit light at all times of the year, but can also admit direct sunshine during the winter months to provide passive solar gain. Either clerestory or high mounted windows might utilize a light shelf. A light shelf is simply a horizontal shelf located just below the window opening. The light shelf reflects the incoming sunlight back up to the ceiling. This helps to further disperse and soften the light.



A light monitor is another way to enhance daylighting. A light monitor is essentially a box mounted on top of the roof with a window facing either south or north. A south facing window would be shaded by the overhang to block direct sunshine during the summer. Like a clerestory window, sunlight enters the light monitor and is reflected down into the room below. Light diffusing shades are sometimes used with a

light monitor to further disperse the sunlight.

Sun tubes are yet another option for admitting natural light. A sun tube is a special reflective tube and cover that mounts in the roof. The sun tube captures sunshine and directs it down the tube and into the home. These are useful for dark bathrooms and hallways. Sun tubes do not admit a lot of light but do help in areas that would otherwise be dark.

You want to avoid the traditional skylights. Skylights admit large amounts of sunshine and heat into the home during the summer months. This direct sunshine can increase the interior temperature of the home, causing the air conditioning system to work harder and consume more energy.

Designing your home for adequate daylighting can reduce your energy bills from lighting and possibly reduce your heating bills in the winter by providing some passive solar gain.

Energy Efficient Appliances and lighting

Some appliances use more energy than others. Typically, the less expensive models use the most energy.

You can reduce your energy consumption by purchasing better quality, more efficient appliances. Energy Star rated appliances are generally the most energy efficient.

One appliance that can make a big difference is the clothes washer. Front loading washers use less than half the water of the standard top loading models. This reduces the amount of water used as well as the amount of water that must be heated for washing. In addition, they spin the cloths faster and remove more water from them before they go to the dryer. Less water in the cloths means less drying time and more savings still.

Chances are the few dollars extra you pay for a high efficiency appliance will be recouped over its life.

About 20 to 25 percent of all energy used by a home is used for lighting. If you utilize more efficient types of lighting, you can reduce your overall energy consumption.

The incandescent light invented by Thomas Edison has been great for the past 100 years but has never been very efficient. Of the energy used by an incandescent bulb, only about 10% is converted into visible light while the remainder is turned into heat. Today, there are number of lighting options that use less energy.

Halogen lights use about 20% less energy than incandescent lights. Halogen lights are typically small, have high intensity and are available in a number of forms: desk and floor lamps, surface mount lamps, track lights and canister style lights. They also are available in a number of wattages. One drawback to halogen lamps is that they get very hot.

Compact fluorescent lamps or CFLs are another lighting option. CFLs use about 75% less energy than an equivalent incandescent light. So, a 60 watt equivalent CFL will only use about 14 watts of electricity. CFLs are not quite as flexible as halogens in that there are a limited number to light styles and wattages available and most of these cannot be used in conjunction with a light dimmer. But, CFLs do use much less energy and they can last many times longer than incandescent bulbs.

An emerging lighting technology is LEDs or light emitting diodes. LEDs have been around for many years in electronics and more recently in flashlights. But, many manufacturers are working on bulbs that we can use in our homes. LEDs hold great promise because they will use a fraction of the energy of other lighting types and they will last even longer still. Look for LEDs to become a viable option in the near future.

Making some good choices in your appliances and lighting can save you energy and money on every utility bill.

Solar Water Heating

Heating water consumes about 15 to 20 percent of the total energy used in the typical house. In most areas, adding a solar panel to your roof to help heat your potable hot water will reduce your overall energy usage.

Solar water heating setups are typically active systems, requiring a pump and thermostatic controls to turn the system on and off. The pump and control can be driven off of standard line current or they can be run off of a photovoltaic (PV) solar panel that can produce the electricity. The beauty of a system that runs off of solar energy is that it uses no energy and produces heat. The PV powered system does cost more though.

Summary

This is a relatively short list with a lot of parts. But, there is great potential to dramatically reduce energy usage of your home without sacrificing comfort or convenience. By taking more dramatic steps, you can reduce your energy usage even more.

If you choose to use some of these energy saving options, you should check and see if you are eligible for any government sponsored tax incentives. At this time, there are tax incentives on geothermal heating and solar water heating systems. There are also incentives for Energy Star rated homes once the homes energy efficiency has been verified by a certified technician.

You may also want to implement additional solar options in the future such as PV electrical generation capability. As more PV systems are sold, their cost will come down and they will become even more economically viable. To prepare for this prospect, you might do a few things to make your home “solar ready”. You can work with your electrician to add a couple un-used conduits from the mechanical room to a convenient location on or near the roof. An access panel near the roof might also be a good idea. You also need to leave a little spare space in your mechanical room for the additional power conversion components of the PV system. These steps cost very little, but will make it much, much easier and cheaper to add a PV system to your home at some point in the future.