Principle Components of Energy Efficient Homes

Energy Efficient Homes are Money Saving Homes

Designing and building an energy efficient home that conforms to the many considerations faced by homebuilders can be a financial challenge but the results have proven it is the best way to save in the long run. Any house style can be made to require relatively minimum amounts of energy to heat and cool, and be comfortable and healthy. But it is easier now to get your architect and builder to use improved designs and take special consideration in their construction methods. Even though there are many different design options available, they all have several things in common: a high R-Value; tightly sealed thermal envelope; control ventilation; and lower than usual heating and cooling bills.

Some designs are more expensive to build than others, but none of them need to be extremely expensive to construct. Recent technological improvements in building elements and construction techniques, and heating, ventilation, and cooling systems, allow most modern energy saving ideas to be seamlessly integrated into any type of house design without sacrificing comfort, health, or aesthetics. The following is a discussion of the major elements of energy efficient home design and construction systems.

Thermal Envelopes

A thermal envelope is everything about the house that serves to shield the living space from the outdoors. It includes the wall and roof assemblies, insulation, windows, doors, finishes, weather-stripping, and air/vapor retarder's. Specific items to consider in these areas are described below.

Wall and Roof Assemblies

There are several alternatives to the conventional stick-built, (wood framed) wall and roof construction that are now available, and they are growing in popularity every day. They include:

Optimum Value Engineering (OVE). This is a method of using wood only where it does the most work, thus reducing costly wood use and saving space for insulation. However, workmanship must be of the highest order since there is very little room for construction errors.

Structural Insulated Panels (SIP). These are generally plywood or oriented strand board (0SB) sheets laminated to a core of foam board. The foam may be 4 to 8 inches thick. Since the SIP acts as both the framing and the insulation, construction is much faster than OVE or it's older counterpart, "stick framing". The quality of construction is often superior too since there are fewer places for workers to make mistakes.

Insulated Concrete Forms (ICF). These often consist of two layers of extruded foam board (one inside the house and one outside the house) that act as concrete forms. This is a well proven method but not as fast to construct as walls formed with aluminum concrete forming systems - Integrated Insulated Concrete Wall (IICW) systems.

Aluminum Forming / Insulated Walls

A variety of foam insulation products are now integrated into the cast-in-place (CIP) concrete wall forming process, which implement aluminum forming systems. These insulation systems include patented devices that secure the foam in place as part of the concrete wall setting process. Included as part of the steel reinforced concrete center, this insulation and wall forming process reduces more man-hours than any other CIP process. Resilient CIP Integrated Insulated Concrete Wall (IICW) systems easily exceed code requirements for tornado and hurricane prone areas.

Insulation

An energy-efficient *"performance"* home has much higher insulation R-values than required by most local building codes. For example a typical house in Kansas or Missouri might have haphazardly installed R-11 fiberglass insulation in the exterior walls in R-19 in the ceiling, and the floors and foundation walls may not be insulated. A similar, but well-designed and constructed house's insulation levels would be in the range of our R-22R to R-30 in the walls (including the foundation) and R-50 to R-70 in the ceilings. Carefully applied fiberglass batt or roll, wet-spray cellulose, or foam insulation will completely fill wall cavities.

Air/Vapor Retarders

Sometimes these two things can do the same job. How to design and install them depends a great deal on the climate and what method of construction is chosen. No matter where you are building, water vapor condensation is a major threat to the structure of a house. In cold climates, pressure differences can drive warm, moist indoor air into exterior walls and attics. It condenses as it cools. The same can be said for very Southern climates, just in reverse. As the humid outdoor air enters the walls to find cooler wall cavities it condenses into liquid water. This is the main reason why some of the old buildings in the South that have been retrofitted with air conditioners now have mold and wood-rot problems. These issues are a perfect example of why insulated concrete homes are preferred over wood *"stick-built"*.

Regardless of your climate, it is important to minimize water vapor migration by using a carefully designed thermal envelope and sound construction practices. Any water vapor that does manage to get into the walls or attics must be allowed to get out again. Some construction methods and climates lend themselves to allowing the vapor to flow towards the outdoors. Others are better suited to letting it flow towards the interior so that the house ventilation system can deal with it.

Airtight drywall approaches and other simple methods to control air and water vapor movement in a residential building lead to significant positive results. The systems rely on the nearly airtight installation of sheet materials such as drywall or gypsum board on the interior as the main barrier and carefully sealed foam board and or plywood on the exterior unless of course the walls are concrete in which case there does not absolutely have to be an additional interior or exterior product.

Foundations & Slabs

Foundations and slabs should be at least as well insulated as the living space walls. Uninsulated foundations have a negative impact on home energy use and comfort, especially if the family uses the lower parts of the house as a living space. Also, appliances that supply heat as a byproduct, such as domestic hot water heaters, washers, dryers, and freezers, are often located in the basement. By carefully insulating the foundation, walls, and floor of the basement, these appliances can assist in heating the house. As mentioned above, concrete homes can easily be insulated and follow the same guidelines.

Windows

The typical home loses over 25% of its heat through windows. Since even modern windows insulate less than a wall, in general an energy-efficient home and heating dominated climates should have few windows on the north, east and west exposures. A rule of thumb is that window area should not exceed 8-9% of the floor area, unless your designer is experienced in passive solar techniques. If this is the case, then increasing window area on the southern side of the house to about 12% of the floor area is recommended. In cooler dominated climates, it is important to select east, west, and south facing windows that provide a "low solar heat-gain coefficient". A properly designed roof overhang for south end facing windows is important to avoid overheating in the summer in most areas of the continental United States. At the very least, Energy Star rated windows or their equivalents, should be specified according to Energy Star's regional climatic guidelines.

In general, the best ceiling windows are awning and casement styles since these often close tighter than sliding types. Metal window frames should be avoided, especially in cold climates. Always seal the wall air/vapor diffusion retarder tightly around the edges of the window frame to prevent air and water vapor from entering the wall cavities.

Air-Sealing

A well-constructed thermal envelope requires that insulating and ceiling be precise and thorough. Ceiling air leaks that exist everywhere in the thermal envelope can significantly increase energy costs. Good air-ceiling alone may reduce utility costs by as much as 50% when compared to other houses of the same type and age. Homes built in this way are so energy – efficient that specifying the correct size heating and cooling systems can be tricky. It is important to follow strict guidelines when choosing systems. Rules-of-thumb system sizing is often inaccurate, resulting in oversizing, wasteful operation, and unnecessary increased utility bills.

Controlled Ventilation

Since an energy efficient home is tightly sealed it's often also important and fairly simple to deliberately ventilate the building in a controlled way. Controlled, mechanical ventilation of a building reduces air moisture infiltration and thus the health risks from the indoor air pollutants. It also promotes a more comfortable atmosphere and reduces the likelihood of structural damage from excessive moisture accumulation.

A carefully engineered ventilation system is important so devices such as furnaces, water heaters, clothes dryers, bathroom and kitchen exhaust fans properly and easily exhaust air from, and depressurize a tight house if all else is ignored. Natural draft appliances such as water heaters, woodstoves, and furnaces may be "back drafted" by exhaust fans and lead to a lethal buildup of toxic gases in the house. For this reason it's a good idea to only use "sealed combustion" heating appliances wherever possible and provide make-up air for all other appliances that can pull air out of the home.

Heat recovery ventilators (HRV) or energy recovery ventilator's (ERV) are growing in use for control ventilation in tight homes. These devices salvage about 80% of the energy from the stale exhaust air and then deliver that energy to the fresh entering air by way of a heat exchanger inside the device. They are generally attached to the central forced air system but they may have their own duct system.

Other ventilation devices such as through-the/wall and or "trickle" vents may be used in conjunction with an exhaust fan. They are, however, more expensive to operate and possibly more uncomfortable to use since they have no energy recovery features to pre-condition the incoming air. Uncomfortable incoming air can be a serious problem if the house is in a northern climate, and they can create moisture problems in humid climates. This sort of ventilation strategy is recommended only for very mild too low humidity climates.

Heating and Cooling Requirements

Houses incorporating the above elements should require relatively small heating systems (typically less than 50,000 BTU/hr even for very cold climates). Some have nothing more than sunshine as the primary source of heat energy. Common choices for auxiliary heating include radiant in floor heating from a standard gas fired water heater, a small boiler, furnace, or electric heat pump. Also any common appliance that gives off waste heat can contribute significantly to the heating requirements for such houses. Masonry, pellet, or wood stoves are also options, but they must be operated carefully to avoid “back drafting”.

If an air conditioner is required, a small (6000 BTU/hr) unit can be sufficient. Some designs, like the ACT houses in arid Davis, CA use only a large fan and the cooler evening air to cool down the house. In the morning the house is closed up and it stays comfortable until the next evening.

Beginning a Project

Houses incorporating the above features had many advantages. They feel more comfortable since the additional insulation keeps the interior wall temperatures very stable. The indoor humidity is better controlled and drafts are reduced. A tightly sealed air/vapor retarder reduces the likelihood of moisture and air seeping through the walls. Insulated concrete homes are also extremely quiet when compared with insulated “stick built” homes because of concretes dense makeup.

There are some potential drawbacks with well insulated stick built homes. They may cost more and take longer to build, not only because of the added cost of the insulation, not only because of the added cost of the cost to install the insulation, but due to the escalated cost of lumber in 2021. Concrete homes on the other hand integrate the insulation as part of the construction process, thereby dramatically reducing the man hours when compared with conventional wood home construction methods. Another reason for additional costs when including insulation in “stick built” homes is that unskilled labor requires special training if they have no experience with these systems. Since there is currently a major shortage of labor in the US construction industry, skilled labor is hard to find. When building concrete homes, less labor is required due to the all-in-one process of forming the walls with the insulation all at once.

Before beginning a home building project, carefully evaluate the site and its climate to determine the optimum design and orientation. You may want to take the time to learn how to use some of the energy related software programs that are available to assist you. Prepare a design that accommodates appropriate insulation levels, moisture dynamics, and aesthetics. Decisions regarding appropriate windows, doors, heating, cooling, and ventilating appliances are central to an efficient design. Also evaluate the cost, ease of construction, the builders limitations, and building code compliance. Some schemes are simple to construct, while others can be extremely complex and thus expensive.

An increasing number of builders are participating in the federal government's Building America and Energy Star Homes programs, with promote energy-efficient houses. Many builders participate so that they can differentiate themselves from other competitors. Construction costs can vary significantly depending on the materials, construction techniques, contractor profit margin, experience, and the type of heating, cooling, and ventilation systems chosen. However, the biggest benefits from designing and building a money saving, energy-efficient home is its healthy environment, superior comfort level and lower operating costs. This relates directly to an increase in its real estate market value.