Considerations in Building an Energy-Efficient House in SW Colorado

This paper summarizes some things every person interested in building an energy-efficient house in SW Colorado should consider. It is not meant to be an exhaustive list of things to consider; simply a list of important things to consider when designing and constructing a house around here.

Overriding Considerations

Consider desired extent of self-involvement in house heating and cooling; major savings can be realized with a little more involvement than simply adjusting a thermostat.

Consider maximizing locally abundant energy resources: sun (free), wood (low cost).

Site Considerations

Site should have southern exposure to passively collect solar energy (solar collection could be on any side of the house. Best from the standpoint of achieving other outcomes (like views through a lot of windows), the solar side should be the house's long south side. That side should have a lot of window area taking advantage of those south views. Should be fewer window areas to the east and west, and as few windows as possible on the north side.

Consider planting deciduous trees near the house and tall evergreens on the northwest to northeast sides of the house.

Added energy benefits if main living area(s) of house are on the south side of house and if the least used/inhabited rooms are on the north side of house.

Beyond that, house design is not particularly important as long as house design can incorporate passive solar aspect commensurate with the amount of solar mass for heat storage.

Also, a largely open area in the house, particularly on the south side to maximize the light and the views, facilitates heat distribution, equalizing the temperature throughout the area. A slab is an excellent means of incorporating thermal mass into a structure that has the benefit of distributing heat evenly and passively throughout the house.

Choosing Sources of Btus

Consider getting the house's needed Btus (for heating air and water) from renewable sources like the sun and wood as much as possible. ***Completely*** relying on renewable resources will be much more expensive than getting most of your Btus from renewable sources and relying on non-renewable sources for the rest.

Given that electricity may well be a renewable resource in the house's lifetime, consider electricity as the next most favored energy resource.

Other things being equal, use propane or natural gas for as little of your heating needs. (However, we prefer a gas range/oven.)

Foundations

A slab foundation is one of the best aspects to incorporate into a house design because the concrete mass of the floor functions as a uniform whole house ***thermal flywheel***. The idea of a

flywheel is that it stores energy to moderate swings in temperature. A flywheel works best if one isolates it from as many external sources of heating and cooling as possible. Therefore, the slab needs to be well-insulated ***both*** under and around it. Insulated concrete forms (ICFs) are suitable to use for foundation stem walls, particularly if they are supplemented by an additional 1-2" rigid insulation around the insides of the ICF. Before slab is poured, place and tape together 1.5-2" rigid insulation within the ICF perimeter (R-10 to 20).

House comfort ***all year*** is maximized to the extent the inside of house has an amount of thermal storage mass appropriate to store the solar heat passing through the house windows. Greater mass = greater temperature stability/constancy = greater comfort once desired temperature (e.g., 68-72 degrees) is achieved. Temperatures throughout the house need not vary by more than 5 degrees from high to low in any 24 hour period.

Slabs lend themselves to in-floor radiant heating (the best kind) and in-slab glycol-circulating radiant heat systems are excellent sources of house heating, ***However***, a well-constructed house may only need in-slab radiant heating in some areas of the slab floor, which saves money. (1. Most parts of the floor that get sunlight between November and March don't need in-floor radiant heat because the slab gets it from the sun. 2. Storage or other little-used areas of the house probably don't need in-floor radiant heat. 3. Bathrooms are most likely to benefit from in-floor radiant heat.)

One should strive to lower the house's heat requirements to preserve the heat energy (Btus) that's in the house. One should also strive to minimize the loss/escape of their house's heat energy. Lower heat loss means savings on the type and size of heating systems you have to use. You can estimate heat loss by calculating a house design's heat loss by doing energy modeling of the proposed design and construction of the house. Each house has a "design" heat load typically used to size the house's space heating unit (furnace) requirements. That way, one can determine the structure's rough heat loss and tweak various design and construction modifications.

Walls and Roof

Real simple: make walls (from top of foundation to peak of heated space as ***air-tight and well-insulated as possible***; no exceptions. Once inside the house, with all windows and doors closed, heat should not escape from house.

Walls with good and generous use of high-performance south-facing windows allow cooling night air from May to October to penetrate the house and re-charge the thermal flywheel slab, which is where the denser cool night air settles. If the house design incorporates a relatively high window, a chimney effect can be formed whereby warmer air leaves the house via high window and cool air comes in through the open lower windows.

Given that the windows in an air-tight house are closed almost all of the time from November to April, need to bring fresh outside air into house on a regular or periodic basis. Best idea is to use a whole-house air-to-air heat exchanger/ventilator to exhaust winter moisture from bathrooms and supply make-up outside air to the living area of the house (costs about $1,500).

One of the best tight house techniques is ***polyurethane*** SIPs as house walls and roof. Polyurethane SIPs and spray foam is almost twice as effective an insulator as polystyrene SIPs and spray foams. (1 inch = R6 or 7) Polyurethane SIPs achieve high insulation values and excellent air tightness because their sections are often cam-locked together, foam-to-foam.

2x6 conventional frame construction less good, but okay as long as polyurethane spray foam is used to fill the 2x6 wall cavities and the truss areas of the roof use at least 15-18" of cellulose.

Regardless of the construction type used in the house you build, consider YOUR responsibility to seal all cracks in the envelope of the house using expanding polyurethane spray foam in those orange cans. In my 2,000 sq. ft. house, I used about 40 large cans of it. Better to spray too many cracks than not enough.

Windows

Strongly consider all triple-paned windows. All windows should have R-5 or higher insulating capabilities (hard to achieve w/o three panes of either glass (heavy) or two of glass and the middle pane of plastic. Gases couldn't hurt, but may escape some in transit or over time.

Strongly consider using windows with different performance characteristics on different sides of house.

Strongly consider using the most solar heat retardant windows on the west side of the house to keep heat from house in summer. Heat from sun on winter afternoons is not appreciable compared to afternoon and evening heat of summer sun!

Incorporate windows on west, east and south sides of house to efficiently collect outside night air.

The best sealing windows are casement and awning types.

Roofing

Consider metal "energy star" roofing. Reflects 20-80% of sun's heat. Important contributor for keeping house cool ***all day*** in summer using night air to recharge mass of slab floor.

South eave of house should be 24-30" wide to maximize receiving the sun's heat when the house needs heat/Btus and keeping the sun out when the house does not need heat. Width of east and west eaves are far less important from heating/cooling standpoint, but are usually kept the same for appearances.

Know that there are formulas to determine the proper amount of attic venting. Do not skimp on attic venting because such venting is a key summer cooling strategy.

True fanatics may also use outside, eave-hung blinds to reduce heat from summer morning or afternoon sun. Inside cellular window shades are a more conventional approach to reduce heat, but they are less effective because the heat is allowed to enter the inside of the house. However, interior shades and exterior blinds are not mutually exclusive techniques.

Water Heating

Consider an appropriately sized on-demand water heater; one that's no larger than what's needed 90-95% of the time. Hot water circulation uses electricity, but electricity can be renewably generated. If hot water circulation is used, the hot water should be circulated only several times a day.

Space Heating

Consider an appropriately-sized wood stove for supplemental heating in a large living area. Correct sizing (Btu output) for the house design heat load is very important to prevent overheating

in the house. On sunny winter days, the woodstove need only be used after sunset for 4-5 hours. On cold, cloudy days, stove may be used all day. Since the house will be nearly air-tight, the combustion air for the wood stove must be supplied via an outside vent and duct directly to the stove's combustion chamber. In doing so, cold air can be used for the fire instead of already warm interior air.

Range Vent Fan

Kitchen vent fans MUST be used in airtight houses. Vent fans MUST vent range air to outside the house. Do not skimp on kitchen vent fans. Buy a fan that costs at least $300 and is both ***powerful*** and ***quiet***. Outside damper of exhaust ducting must close securely.

Washing

Hi-efficiency front-loading washers are worth the cost considering how much electricity and water they save over their lifetime.

Line-drying clothes saves a lot of electricity and gas. Consider an outdoor location that's relatively close to the washer.

Lighting

From the house design, anticipate both the need and purpose of artificial lighting in the house. General/mood versus task, etc. Use fluorescent lights as much as possible in house for all but regular needed task lights, and use halogen lights elsewhere.

Solar lights for outside walkways are a cost-effective alternative to low-voltage lighting, although little-used but effective broad area outside lighting should probably be halogen.