

# Zero Energy Homes

Appalachian State University Energy Center  
*Adrian Tait*

## Understanding Greenbuilding

Green building is a trend that has been identified by the National Association of Home Builders' Research Center as one of the most significant developments in home building in the past three decades. "Green building is not an all or nothing endeavor, and includes land planning, site development, water conservation, energy efficiency, materials selection, and waste reduction. Building Greener, (2002). This type of building, a blend between energy efficiency, environmentally sound material selection, and resource wise advanced construction techniques has been an opportunity for many builders to capitalize on a trend that more and more makes sense both environmentally and economically.

The American Institute of Architects has also put sustainability at the top of their agenda. Calling for "every architect on every project to make sustainability a top priority", (Steidl, D., 2005.) Reports are beginning to demonstrate that green building is a smart move for companies to embrace both ethically and economically. In many cases an investment of only two percent of the initial cost of construction results in a life cycle savings of twenty percent of the initial cost, more than ten times the initial investment (Kats, 2003, Introduction).

Green building is a term used to describe construction practices that incorporate

sustainable materials, jobsite recycling, energy efficiency, renewable energy, careful site selection and utilization, and indoor environmental health. Some people have described green building as having shades to it. A "light green" building might be more efficient and make use of several materials that contain recycled content. A "dark green" building might use all the construction methods described above plus experimental techniques to reclaim unused energy within the building. Somewhere along the continuum is the "Zero Energy Home".

## ZEH : Renewable Technologies

Zero Energy Homes, sometimes called the zero energy buildings, are homes or buildings that combine a high degree of energy efficiency with the on-site production of renewable energy; the end goal being that the building creates the same amount of energy that it consumes. The U.S. Department of Energy (DOE) Building Technologies Program defines a net zero energy building as "a residential or commercial building with greatly reduced needs for energy through efficiency gains, with the balance of energy needs supplied by renewable technologies." NAHB Research Center. (2006).

This type of dwelling provides several important benefits, the first being that the utility bills can be significantly lower for the

homeowner. One zero energy home, built by a cooperative effort between the Appalachian State University Energy Office and the Catawba Valley Habitat For Humanity, has electricity bills averaging around \$42 per month, which includes the heating and cooling requirements. Some companies such as Advanced Energy of Raleigh, NC are now offering utility bill guarantee programs. The program, available to North Carolinians who meet the strict requirements, guarantees that heating, cooling, and electric bills will not exceed certain amounts, averaging between \$26-\$32, or else Advanced Energy



*ZEH built in Hickory north Carolina by Appalachian State University Energy Center and Habitat for Humanity.*

will pay the difference and pay to determine why the home is using more energy than it should be. Advanced Energy. (2006). Another benefit is that the since the home itself is producing and consuming an equal amount of energy the home is negating the need for a coal fired or nuclear fueled power plant to produce that amount of energy, thereby saving the emissions of carbon dioxide and other harmful pollutants.

ZEH projects have either been completed or are underway in areas around the country from New Mexico to New Jersey. Many different research organizations

are building these buildings including Oak Ridge National Laboratories (ORNL), Integrated Building and Construction Services (IBACOS), Habitat for Humanity, The National Association of Home Builders Research Center, and the US Department of Energy.

## **ZEH Off the Grid**

The concept of the ZEH has been around for many years. During the 1960's and 70's a home that produced its own energy and was not connected to the national utility grid was called an off grid home. These

homes are still built today but now builders and homeowners also have utility interconnection incentives available to them. This means that whereas in the past energy generated from photovoltaic panels or other on site renewable generation sources had to be stored in expensive batteries to be used when power was not being created, now excess power created can be fed onto the grid and many power companies offer interconnection agreements that buy power back. In North Carolina both Net Metering and NC Greenpower are available. NC Greenpower. (2006) The home can then draw from the grid when it is not producing power allowing the grid to act as a large battery.

Producing on site power from renewable energy is only one aspect of the ZEH. These homes work as a complex system where everything is interconnected, not just the utilities. ZEHs lower the energy needs of



*The Los Olivos Zero Energy Home (ZEH) in Livermore California*

the home by combining passive solar design with a small footprint and a tight envelope. This ensures that energy put into the home in the form of heating and cooling stays in the home.

### **Applying Passive Solar**

Passive solar orientation is an aspect of the ZEH that is both simple and inexpensive. By orienting the home so that roughly 70% of the windows face within 20 degrees of due south, sunlight is allowed to enter the home during the winter months where the radiant heat can be absorbed by some form of thermal mass. Thermal mass can be created in many ways which include a concrete slab foundation, tromb walls, sunspaces with solid walls or concrete floors, or water storage tanks. The stored heat is then released into the home at night. Passive solar design can account for anywhere between 30 and 70 percent of the homes heating needs. When passive solar design is combined with a tight envelope the overall heating and cooling system can often be fitted with a smaller HVAC unit resulting

again in energy savings.

### **Sealing the Envelope**

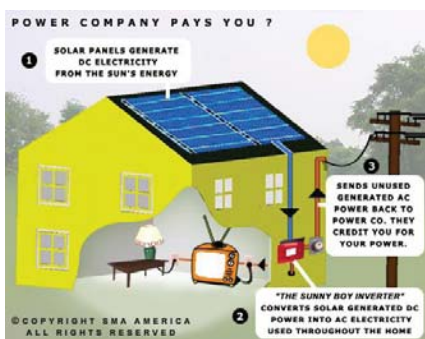
The envelope of the home is the barrier against air infiltration either into or out of the home. A tight envelope is achieved through the use of air sealing measures throughout the construction process. Taping around windows and doors, taping the seams in the moisture barrier or house wrap, caulking joints between parts of the house, ensuring insulation is continuous within the walls, floors, and ceilings. The relative tightness of the home can be measured with the use



*ZEH remodelled home in Califon, NJ*

of equipment which provides a measure of the amount of air that can leak through the envelope. A “tight” home has a rating of

3.5 air changes per hour or less when it is pressurized to 50 pascals. Verifying the air tightness of a home is a component of most of the green building programs currently in use. The other value of ensuring a home is airtight is summed up with the building scientist's mantra "build it tight, ventilate it right." Tight buildings must have ventilation provided to them. Leaky houses provide enough ventilation through leaks in the envelope; these typically come from the basement/crawlspace or the attic, both places where the air quality is questionable at best. A tight home must provide additional ventilation through the use of fans to ensure a continuous supply of fresh air. The fan cannot however simply blow outside air into the inside of the house. This would fill the house with cold winter air or hot humid summer air. The air should be first sent through an energy recovery ventilation system. An ERV processes the incoming air



through a system by which the outgoing air gives up its conditioned temperature to the incoming air, therefore saving the energy of heating or cooling this ventilated air.

## Slab or Crawlspace?

The foundations of ZEHs are most

commonly of the slab on grade type although successful ZEHs have also been built on crawlspaces and basements. If built on a crawlspace it should be sealed and insulated from the outside with a proper amount of conditioned air. With the addition of either a basement or crawlspace there can be a loss of thermal mass in the floor. Some builders overcome this by pouring concrete on the floor, usually two inches. However, this does add cost and time to the construction process. Slabs are the best choice for a ZEH because of the inherent thermal mass in the concrete slab.

## ZEH Walls

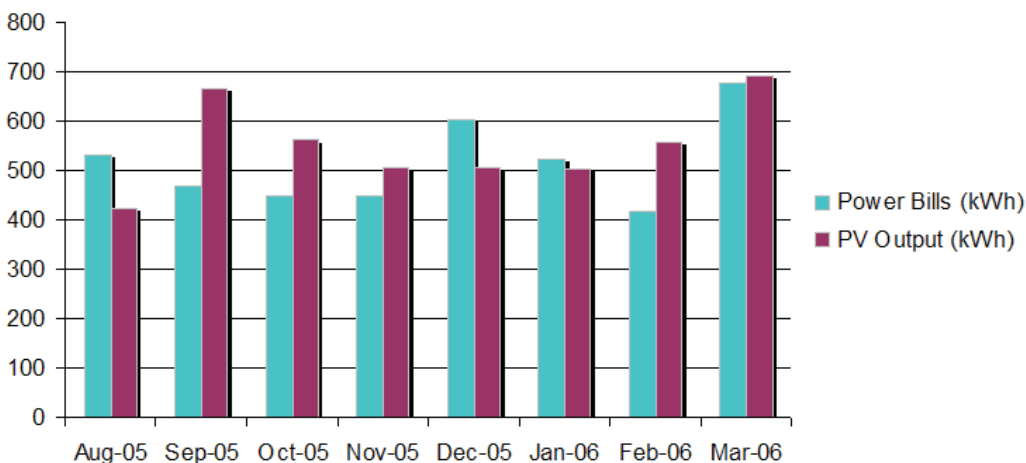
Within the walls of the ZEHs looked at; structural insulated panels are the most commonly used. These walls are prefabricated panels typically four feet by eight feet with either 4.5 inches or 6.5 inches of expanded polystyrene or polyisocyanurate insulation sandwiched between sheets of wood. SIPs are much easier to air seal than standard 2x4 or 2x6 walls, are easier and faster to install, and achieve better thermal performance than standard construction, while increasing interior space. The wall insulation in general among zero energy homes is R-21, either batts or spray foam. Ceilings and floors in the ZEHs are R-33 on average.

## Windows and Doors

Windows and doors within a ZEH must adhere to tight guidelines for efficiency and thermal performance. By keeping windows on the western, northern, and eastern sides

of the home to a minimum heating and cooling losses can be lowered. Windows are one of the least insulated areas in any home and easily lose more energy than they allow in. Windows should have an insulating U value of .30 or better and a solar heat gain coefficient under .4 for hot climates, and above .55 for cold climates. Chiras. (2004). Doors are also typically an energy leak. These should have an R value of at least 5 or greater for exterior doors.

Achieving optimal energy efficiency is a crucial factor in these homes. So much so that after the large gains from insulation, air sealing, and passive solar design are



accounted for then astute designers begin to look for gains in areas that often achieve only small additional benefits. These measures include specifying high efficiency appliances, connecting appliances and systems together to utilize wasted energy, and making use of some of the newest technologies. High efficiency appliances include those certified as energy star. Systems that can be tied together to gain efficiency include recovering water heat from

shower drains and refrigerator condenser coils. Typically, additional energy savings from these measures are in the two to five percent range.

## Getting the Most from Your ZEH

The reality of Zero Energy Homes is that user behavior has a lot to do with whether or not the house actually reaches a net zero energy status. Of all the homes surveyed for this report only one home has actually achieved a greater energy production than consumption; the ZEH built in Hickory, NC.

With energy consumption as of March 2006 at 3442 KWH and energy production at 3724 KWH the Hickory home is actually putting more energy into the grid than it uses. Taking into consideration that the summer months when production from the photovoltaic panels will peak has

not yet been recorded this house may well be one of the first to live up to its name. This house is currently being used as the office space for the Catawba Valley Habitat for Humanity so it is unsure if residents of the home would use more or less power

Thus user behavior has much to do with these homes achieving a net zero energy usage. It is imperative that homeowners be trained on how to make the best of these

high performance homes. Understanding how to make efficient use of the passive solar design, appliances, and home systems is critical. “To really get to net zero energy, a certain amount of prudent practice in everyday habits is going to have to be part of it”, says Jeff Christian, director of the Building Technology Center at Oak Ridge National Laboratories. Griscom. (2005)

*The reality of Zero Energy Homes is that user behavior has a lot to do with whether or not the house actually reaches a net zero energy status.*

## **Tax Incentives**

On the other end of the equation is how much energy production the photovoltaic panels are capable of. With the price of this technology coming down slowly and demand for panels so high it is simply a matter of paying more up front to install more panels. Currently the incentives for renewable energy in North Carolina are making it more attractive than ever to invest in this expensive technology. The state is now offering a tax deduction of 35% of the installed cost of the system. This coupled with the 30% federal tax deduction equates to the government offering a 50% sale on PV systems.

The size of the home also has much to do with how efficient it is. Smaller homes require less heating and cooling. All of the homes surveyed for this report were between 1000 and 1600 square feet. Not only does this smaller size allow a more efficient overall system it can also allow more money to be budgeted towards the details in the home. This can create a more interesting and personalized space that has been called the “not So Big House”. Susanka. (2001). By sizing the square footage of the house

down it also affords more money to put into higher quality systems such as the HVAC, ERV, and PV.

## **So what will it take to get more of these homes built?**

A new study by the NAHB Research Center predicts that with a 30% tax incentive for building these homes, ZEHs will make up 67% of the new housing starts by the year 2050. This prediction finds the household energy usage leveling off by 2030. Without adoption of ZEH technologies energy usage continues to increase as new homes are added. This study finds several things that are important to achieving integration in the marketplace. Active utility participation, market acceptance from homebuyers and homebuilders, and financial incentives from government are all crucial for ZEHs to reach a critic mass of acceptance and usage. NAHB Research Center. (2006).

As energy prices continue to rise and consumers look for ways to save money; houses that achieve the measures of air sealing, insulation, and efficiency will be more in demand.