The Nauhaus Chronicles: Anatomy of a Passive House

This is the second in a series of articles on a prototype project for a building system that I'm part of developing. We call it the Nauhaus (pronounced "now house"). To keep track of the series, or any of my columns, visit the Archive section at www.NewLifeJournal.com . For more information on the Nauhaus, visit www.thenauhaus.com .

Last month we established the need to drastically curtail our fuel burning addiction and that a pivotal step in our collective self-intervention will be increasing the efficiency of our buildings. This won't come as a surprise to the green building community as energy efficiency is the top talking point in lectures and biggest bullet point in advertising. The good news is that our buildings have gotten a lot more efficient over the last 20 years. The bad news is that we aren't going anywhere near far enough. The green building industry is still in the "low hanging fruit" stage which consists of spiffing up existing practices to squeeze out a modicum of improvement.

To get to carbon neutrality and save the world as we know it (yeah team!), we need to go a LOT farther. Fortunately, there are established road maps. In my June 2009 column, I discussed the best one I know: a certification program called Passive House. Buildings designed to this standard typically save about 90% on heating energy and, with conscious inhabitants, can reduce overall energy use 80% or more compared to their conventional counterparts built to code. Once you get to this low level of energy usage, you can make up the rest of the building's energy needs with a relatively small and therefore affordable renewable energy system, solar electricity (PV) for example.

This is a well established approach in Europe. In fact, the European Union parliament has proposed making it code by 2011. However, the standard is just catching on in the US with less than ten certified buildings on record here. The design of our Nauhaus prototype presently under construction in West Asheville has been pre-certified as a Passive House, which means if built it as designed and an air tightness test is passed, it will be certified.

Let's take a look at what that means. What's under the hood of a Passive House?

1. **Maximize free heating.** There are a number of free sources of heat available to all of us. The obvious one is the sun, but our bodies as well as lights and most appliances also give off heat. A Passive House is designed to take advantage of all of these. The first step is to choose a site that is open to the south to access winter sun. This is classic passive solar design with south facing glass giving sun access to interior thermal mass that stores solar energy. However, this can often be difficult to accomplish in the city where there are many obstructions. In our case, we

had to buy two lots and design two houses in tandem to insure that they both had good winter solar exposure. Harnessing body and appliance heat is easier to control and is accomplished by following steps 3 through 8 of this list.

2. **Maximize free cooling.** Free cooling in our climate means blocking the sun from entering the building during the summer and opening the house to both cooling breezes and night time cooler temperatures. We've accomplished this by carefully sizing roof overhangs, awnings, pergolas and porches to block the sun from entering the house when it's hot. We've also planned for cross-ventilation when it's not too humid to have windows open and our ERV (see below) can act as a whole house attic fan to bring in cool summer night time air.
3. **Build heavy.** Conventional wood-frame construction is pretty light. We need to add mass to our building in order to both store the winter solar heat AND the summer "coolth" that we access by opening windows at night in the summer when it's cool. We have massive floors of both concrete and compressed earth block made from dirt excavated on site. Our exterior walls are also massive, those few set in the ground are made of insulated concrete, the rest are a mixture of hemp fiber in a lime and cement binder called "hempcrete". In addition, a number of our interior walls will also be built of the site-made compressed earth blocks. (More on the hemp walls and earth blocks in a future column.)
4. **Insulate like crazy.** Passive in "Passive House" refers to elements that do their thing without consuming energy. Insulation is a great example. It's a workhorse. Once installed, it does its thing without further input. Contrast this to a furnace which costs money to buy and install and then continues to suck up the bucks with its insatiable need to burn expensive (and polluting) fuel. Insulating now saves money instantly on energy bills and keeps on saving throughout the life of the building. By conventional standards, our building is "super insulated". We're installing R-30 under the slab (code = R-5), R-38 in the walls (code = R-13), and R-62 ceiling (code = R-38).
5. **No thermal bridges.** A "thermal bridge" is basically a break in your insulation. For example, your typical fiberglass batt insulation in a wall is rated at R-13, but since it's interrupted by the wooden studs that hold up the roof, the true insulation value of the wall is about R-9. Our house is designed to have no significant thermal bridges, so our R-38 wall will really deliver R-38.
6. **High performance windows and doors.** Okay, now we've got an R-38 wall without thermal bridges. Installing typical windows and doors (about R-2) would be like putting big holes in our wall. That's why we're installing high performance doors and windows with values of at least R-7 and very low air leakage rates.

7. **Build airtight.** Insulation works by slowing the movement of heat. What's the point of installing all of that insulation if we're going to let heat sneak around it through holes in the building. Conventional houses loose about 1/3 of the energy used to heat and cool them through leaks. That translates into a cumulative hole big enough to crawl through. The more efficient the insulation, the larger effect these leaks have, so this effect is even more pronounced in our super-insulated design. For this reason, we'll have to build this house very tight. Our strategy is to combine good materials with careful installation. The hempcrete walls are a big help because they are thick and completely wrap the structural wood frame creating no gaps. Our windows give us a boost because they seal much better than typical windows. Finally, and most importantly, every juncture in the building has been carefully planned to allow excellent air sealing.
8. **Use energy recovery ventilation.** Of course, we need air to breathe. Since our building will be so tight, we can't depend on the typical strategy of letting air in through leaks around doors and windows, around outlet boxes, and other imperfections in the insulation layer of the building. Instead, we'll install an energy recovery ventilator (ERV). An ERV is a high efficiency fan that moves air through a heat exchanger. I'll explain the advantages of ERV's in a future column, for now suffice it to say that we're bringing in fresh air without the energy loss associated with air exchange through leaks.
9. **Make up the difference with renewable energy.** When all is said and done, these strategies will create a building that can literally be heated by the body heat given off by guests at a holiday party. By adding high efficiency lights and appliances and a conscientious lifestyle, we'll use less than 20% of the energy consumed by a conventional house of the same size. We plan to produce all of that energy and a sizeable surplus with a roof-mounted solar electric (PV) system. In other words, we're well on our way to the holy grail of a carbon neutral model for living…all on a little lot in West Asheville.

Next Month… Little Machines: Heating and Cooling a Passive House

Digital Glossary

Term	Web address
Carbon neutral	thenauhaus.com/nauhaus/summary.php#renewableenergy
Climate change	architecture2030.com/current_situation/science.html
Passive House	passivehouse.us
Passive solar design	thenauhaus.com/education/articles.php#passivesolar

Thermal mass	thenauhaus.com/blog/index.php/2009/04/the-problem-with-mass/
R-value	en.wikipedia.org/wiki/R-value_(insulation)
Renewable energy	en.wikipedia.org/wiki/Renewable_energy

Upcoming columns in the series

- heating and cooling a passive house
- breathable walls
- using local materials to build better buildings, reduce carbon emissions, and help the economy
- on-site self-sufficiency saves resources and takes pressure off municipal infrastructures