

zoning officials when trying to permit clustered housing in other towns in Vermont. Central heat and co-housing have been a stretch for some of the insurance companies to understand given the lack of risk in what we are doing, but we are insured.

The Dwellings

Our duplexes are like individual houses with each pair joined by a common porch-connector. The land has a natural spot for the homes: a south-facing slope just at the south edge of the large field, allowing for walkout basements and a good passive solar exposure. The north side has an accessible entrance into the first floor, forming the public side of each home. The south side is a more private, protected and sunny area.

We decided to use as much local wood as possible, though like most of our design decisions, just *how* much was left up to each owner. Our unit is all local framing lumber and board sheathing with 12 percent thick double 2"x4" walls and 2"x10" rafters—the largest easily available in local forests—built down to accommodate 16" insulation. About 20 percent of the lumber came from two acres we cleared for house sites.

The insulation is cellulose and we are using an air-tight drywall approach in most units. There are no vapor barriers in the wall, and I am monitoring exterior sheathing moisture content monthly in one unit with sensors provided by the engineer and building scientist, John Straube. The sensors are located on the inner surface of exterior sheathing in one dwelling, both low and high on the wall, on each orientation. So far this winter, moisture content has hovered in the low-to mid-20's on walls with little solar exposure and below 10 percent on sunny south wall areas. I draw from this data that the HRV's need to be run—both to keep the interior RH at acceptable levels for health and to avoid too much moisture diffusion through the walls. For more information about that please stay tuned.

We used Durisol foundations to pro-

vide excellent durability and insulation. We used their new 14" thick blocks for R-28 above grade and R-20 below. Thermotech fiberglass windows were used in most units, with R-5 overall insulative value and glass chosen for solar gain on the south (two Energy Advantage low-e layers in triple glass.) We used metal roofs for recycled content and recycling at the end of lifespan—with most homes using screw-down roofing and some going with standing seam. Materials choices varied with different owners. One house has foam sheathing with cellulose in the studs. One member is a skilled plasterer and is using clay plaster over wood lath in his unit! He'll help us plaster our Durisol inside. The plastered Durisol is an excellent hygric buffer, absorbing and releasing moisture in response to changing indoor conditions.

Energy Goals—Moving Toward Carbon-neutral

To meet our energy goals, we built on a relatively small scale. The exterior footprint of most units is 26'x30', with an indoor footprint of 24'x28'. To meet the 20K Btu/hr design heating load maxi-

mum, the units are super-insulated—R-5/20/40/60 (R-values for windows/earth contact/walls/roof) and are as air tight as possible. One unit tested at ~500 cfm-50, with an estimate 0.18 natural air changes per hour. The third unit built tested at 380 cfm-50 and is actually a larger unit. This is about 0.26 cfm-50/ft² surface area. Achieving this result was challenging with board sheathing, but the builders—Iron Bridge Woodworkers of Plainfield, Vermont—were conscientious. Some of the units have drain-water heat recovery and all have heat recovery ventilation. Most of the units have a woodstove to use more local heating fuel, and just for that hot source to back up to on a very cold winter day.

We installed a central wood pellet fired boiler (Tarm/Baxi Multi-Heat 4.0) with underground piping to supply heat and hot water to each unit. The boiler and the pellet bin are both located in the common building, which also houses a workshop space and an upstairs storage area. The pellet storage bin—after much discussion—ended up being site-built inside the common building, which saved us some overall cost. The pumping is



A few of the houses that make up the White Pine Co-Housing Units outside of Montpelier, Vermont. Photo taken in December of 2008.

from a central variable speed pump to save electricity. A 200 watt pump running continuously would require 1.7 kW of PV's to provide its annual electricity, so reducing pump watts cuts down on cost. A 1.7 kW array might cost \$15,000 of credits, with our \$400 controller that might cost one-third or half of that. (Again, stay tuned....)

The piping is a single supply and single return, with zone valves for each zone in each unit, including one zone for the domestic hot water tank. Each unit has a flow-setter to limit flow to 4 gpm (the 20,000 Btu/hr limit at a 10 degree temperature drop.) Each zone has an

“We set stringent energy goals for each unit—no more than 20,000 Btu per hour peak heating load.”

elapsed time meter in parallel with the zone to track usage, so that pellet usage can be allocated to each family. The stand-by and piping losses will be divided evenly between units, as each unit has the benefit of having the heat on line and the remaining usage will be allocated based on runtime and capacity of each zone. While this not nearly as accurate as Btu metering, it is about one-tenth the cost and achieves the goal of attaching cost to consumption.

Each family committed to eventually install renewable electricity roughly equivalent to their annual consumption. Two homes have PV's already—one with a 2 kW system, one with 3 kW, based on expected load. With Vermont's new group net metering law, PV's can be installed anywhere in the utility's territory and be allocated to a designated meter. The eastern-most unit has some shading from trees off the property, so those PV's may go on the common building, or those owners may opt to buy into a large community wind turbine at an optimal site within our utility territory. This is NOT



Cathedral ceiling drywall is put up before interior partitions are done, to reduce air leakage—drywall is the air barrier.

buying renewable energy credits (which I consider akin to buying papal indulgences)—it is paying the total cost for your share of the turbine that puts out your electricity needs.

Data on our energy use to date is very limited. The boiler ran to heat only one house from December 2008 until November of this year. From that period, I estimated the boiler stand-by and piping losses at about 8,000 Btu/hr, which would represent a total of about 4.5 tons of pellets per year, or about $\frac{3}{4}$ ton per

unit, or about \$200 per household. The annual useful heating fuel requirement for each unit is estimated between 27 and 31 million Btu of load, requiring about 2 to 2.5 tons of pellets, depending on hot water usage and size of the unit. (This assumes no wood stove use.) Ellen, a resident, reports that in her unit, the first one occupied, two hours of sun will carry the house for the day from passive gain and some into the night, depending on how cold it is.

Electricity consumption in the first

unit, occupied by a single person, is about 7 kWh per day, or about 2,600 kWh per year.

Transportation energy is the killer of carbon neutrality in rural areas. In my own work, I drive approximately 10,000 miles per year, and even with an efficient Honda getting an average of about 40 mpg, that's 250 gallons of gasoline or about 28 million Btu's per year of fossil fuel—about the same load as heat plus hot water for one of the units that we are providing with carbon-friendly wood pellets. While we are close to town and right next to the Town Trail for walking, biking or cross-country skiing into town, it is 4 miles and we almost always get in the car to get there. As time goes on, we hope to use a community intra-net to share shopping chores and reduce trips to town. We are an ideal distance for an electric

vehicle and one member is anxious to build one that could be PV powered!

The community is slowly coalescing as folks move in and the craziness of finishing construction and moving subsides—at least for four units. The garden area (200' x 150' !) has been plowed and topped with excess soil from the drive construction and is under the snow with a healthy winter rye crop. Our consensus process of decision making has served us well, and the diversity of ages within the group—from small children to 66 years—helps provide different perspectives. Settling out the selection of occupants had its share of hurt feelings as well as joyful moments and I have learned much from that. There are advantages and disadvantages of our smallness—member selection seemed more difficult with each family being such a big portion of the

total, but other decisions are easier to make, I believe. When I talk to other co-housers in larger communities, they often get a wistful look in their eye when I tell them how many we are. I look forward to seeing how the community develops over time and how the new edges wear off as we live this venture.

Andrew Shapiro of Energy Balance, Inc. has a goal to create high performance buildings that meet the needs of the occupants, the builders, and the earth and inspire visitors. He has provided energy and green building design consulting services for 25 years to a variety of clients, including owners, architects, engineers, developers, universities, and businesses. Andrew holds an engineering degree and is the co-director of the Vermont Energy Education Program. He can be reached at andy@energybalance.us.