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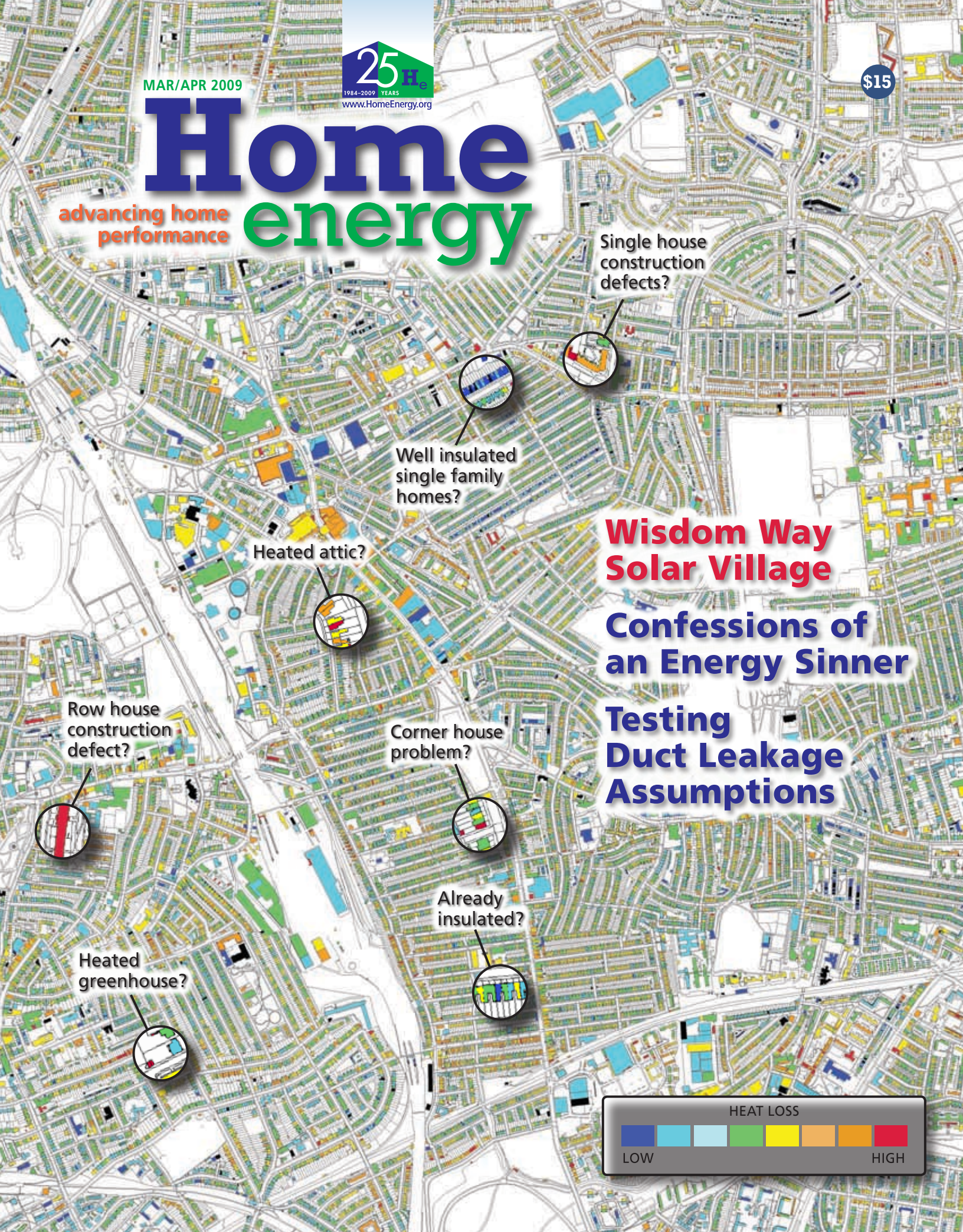

Wisdom Way Solar Village

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Wisdom Way Solar Village

A new community of affordable, sustainable homes moves toward zero energy.

by Robb Aldrich

In the western Massachusetts town of Greenfield, Rural Development, Incorporated (RDI) has completed the first affordable homes in the 20-unit Wisdom Way Solar Village. The solar-equipped homes will be certified through the Energy Star, DOE Builder's Challenge, and LEED for Homes programs (LEED Platinum certification is expected). More important than the certifications to homeowners will be the homes' performance; occupants are expected to save approximately $2,500 a year in energy costs.

RDI has been a pioneer in developing and building affordable, efficient, sustainable homes in western Massachusetts. Building on the lessons learned from RDI's home in Colrain, Massachusetts (see "Toward an Affordable Zero-Energy Home," *HE* Sept/Oct '08, p. 16), RDI began plans in 2007 for a community of near zero energy homes in Greenfield. Once again, RDI worked closely with engineers at Steven Winter Associates (SWA) and architects at Austin Design to plan the community. Located on Wisdom Way, the project was named Wisdom Way Solar Village.

The Village consists of ten duplexes (20 dwelling units total), including two-, three-, and four-bedroom homes. Eighteen of the 20 homes are for sale; 2 will be fully accessible and will be rented to residents with disabilities. All of the homes are visitable by people with wheelchairs. The first duplex was completed in November 2008; other duplexes will be completed at the rate of approximately one every two months (see "Key Energy-Saving Features").

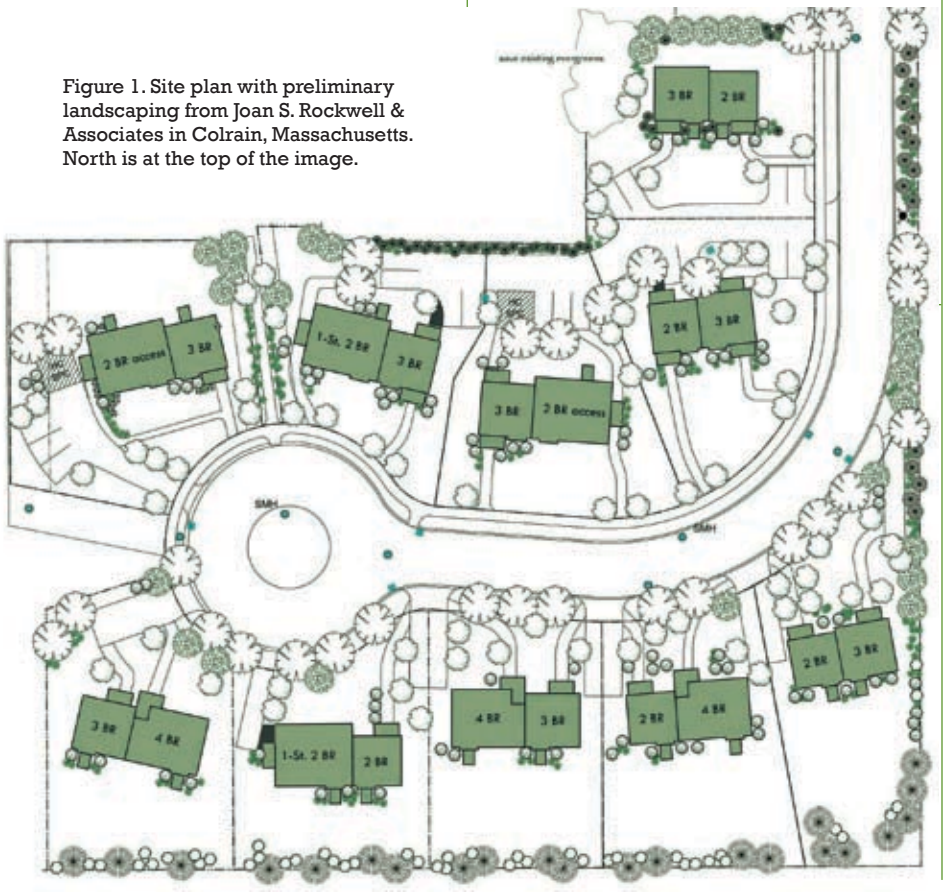

Figure 1. Site plan with preliminary landscaping from Joan S. Rockwell & Associates in Colrain, Massachusetts. North is at the top of the image.

KEY ENERGY-SAVING FEATURES

The homes in Wisdom Way Solar Village have the following energy-saving features:

- Double 2 x 4 walls are filled with 12 inches of dense-blown cellulose (R-42).
- Attics are insulated with 14 inches of loose cellulose (R-50).
- Triple-pane windows have a U-value of 0.18.
- There is a sealed-combustion gas-fired heater in each unit.
- Each unit has an efficient exhaust-only ventilation system.
- All lighting is provided by CFLs.
- Refrigerators and dishwashers are Energy Star rated.
- 2.8 – 3.4-kW PV systems (depending on unit size).
- Solar water heating with sealed combustion, tankless gas auxiliary water heater.

Project Team

RDI saw real value in assembling a design team very early on in the project—even before the land was acquired. In addition to several people from RDI (the builder and developer), the design team included architects, a civil engineer, a landscape architect, a mechanical engineer, a lawyer, the solar contractors, a plumber, an electrician, the site and foundation contractors, a utility representative, a home energy rater, and other specialists as needed. Not every member of the team attended every meeting, but having this group of committed professionals willing and able to address problems and meet as needed was critical to the project's success. The team has continued working together to address concerns and resolve issues as construction has progressed.


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The first duplex at Wisdom Way Solar Village near completion.

Site Planning

Site planning is one of the most important—but often overlooked—elements in designing communities of high-performance homes. This infill site was a level field with very few trees or other obstructions. The design team met very early in the process to consider:

- creating a neighborhood rather than a typical suburban development;
- providing open space for gardening and recreation;
- incorporating utilities and roads efficiently;
- orienting all homes to the south to allow for passive and active solar;
- landscaping in ways that would not cause detrimental shading; and
- making the community accessible to people with disabilities.

The site plan finally approved by town officials is shown in Figure 1. The ten duplexes are sited to ensure solar access for all homes. Open space is preserved in the northwest corner of the site, and a narrow strip on the western edge of the block (which is shaded by tall trees to the west) is also left open. SWA worked with RDI and Joan Rockwell, the landscape architect, to specify maximum mature heights for plantings so solar access to homes would not be compromised now or in the future.

Building Construction

The community will consist of

- four two-bedroom, one-story homes (1,137 ft^2 gross), two of which are fully accessible;
- four two-bedroom, two-story homes (1,140 ft^2 gross);
- nine three-bedroom, two-story homes (1,390 ft^2 gross); and
- three four-bedroom, two-story homes (1,773 ft^2 gross).

Basement

All homes have full, unconditioned basements. The first-floor joist bays are insulated with blown cellulose at 11.5 inches for approximately an R-40 insulation value. While SWA often recommends insulating foundation walls rather than the floors above basements, RDI determined that insulating the floors was less costly and more practical. Energy modeling showed that R-18 rigid foam insulation (3 inches of polyisocyanurate) adhered to the walls would be necessary to achieve the same energy performance as the R-40 floors. The blown cellulose was considerably less expensive and simpler to install. In many areas, foil-faced polyisocyanurate foam is approved for this application and can be left exposed. At this site, however, local code officials could have required that the foam be covered with drywall, further increasing the cost.

Above-Grade Walls

One of the key features in the prototype home in Colrain was the double-wall construction (see Figure 2, p. 27). This is being repeated at Wisdom Way Solar Village. First, the exterior, load-bearing, walls are framed in, using 2 x 4s at 16 inches on center. Carpenters then enclose the entire envelope (wall sheathing, roofing, windows, and doors). Once the home is enclosed, a second 2 x 4 wall is framed in 5 inches inside the exterior wall. Fiber-reinforced polyethylene is stapled to the inner studs, and the entire 12-inch wall cavity is filled with dry-blown cellulose insulation at densities of approximately 3.4 pounds per cubic foot.

An airtight, superinsulated wall is a key component of an extremely efficient home in northern climates. While there are several ways to achieve excellent wall performance (such as using SIPs or rigid foam sheathing), the double-wall method (with R-values above 40) works well for RDI for two reasons:

- The homes are designed with double-wall construction in mind. The perimeter of the home is basically rectangular, with very few interruptions (each Wisdom Way home has one box bay). Using double-wall construction on more complicated plans, with more dormers, angles, and bays would take longer and cost more.
- RDI employs a core group of carpenters who are building all the homes. RDI does not have to rely on (or train) outside framing contractors for this specialized job.

Attic

Roofs are constructed with manufactured trusses. Vented attics incorporate full soffit and ridge vents and full insulation baffles at every truss bay. Homes are insulated with 14 inches of loose-blown cellulose for an R-value of 50 or greater.

Windows

RDI has typically used insulated, vinyl-framed, low-e windows from Paradigm Windows. Paradigm also manufactures a triple-pane window with a U-value of 0.18 Btu/ft^{2}hr°F and a solar heat gain coefficient (SHGC)


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Double walls before (left) and after (right) the cellulose insulation was installed.

of 0.23. Ideally, RDI wanted to find windows with a higher SHGC—at least for the southern elevations. The search for an affordable window with higher solar heat gain—while keeping the low U-value—was not fruitful. Paradigm Windows did, however, offer to provide double-pane windows with the low-e coating on surface 3 (on the inside window in order to block heat loss). This raised the SHGC to 0.37 and provided a U-value of 0.26. The final specifications for windows at the Village are shown in Table 1.

Table 1. Window Choices

ORIENTATION	DESCRIPTION	U-VALUE (Btu/ft²hr°F)	SHGC
South	Double-pane, low-e on surface 3	0.26	0.37
North, East, West	Triple-pane, low-e on surfaces 2 & 5	0.18	0.23

Heating and Ventilation

Because of the superb envelopes, the design heat loads of the units are less than 12,000 Btu per hour. Given this very small load, RDI chose a very small, simple heating system—a sealed-combustion, natural gas-fired unit heater located in the central area on the first floor of every unit. The heater is Monitor Products model GF1800. The capacity of the heater is 10,200 Btu per hour on low fire and 16,000 Btu per hour on high fire; annualized fuel utilization efficiency is 83%. In previous projects, RDI's standard heating system has been an Energy Star boiler (either gas or oil) fueling hydronic baseboard convectors. The unit heater system saves RDI approximately $4,500 in costs and helps offset the cost of the double-wall construction.

SWA has discussed comfort at length with RDI. Because of the superior envelope, design loads in the bedrooms (at 2°F outdoor air temperature) will be approximately 2,000 Btu per hour. SWA believes that internal gains within the bedroom, along with conduction and convection from other parts of the house, will provide adequate comfort. Preliminary estimates show a temperature differential of 4°F or less between upstairs and downstairs, though the occupants' habits will play a significant role in determining the actual differential.

To reduce this differential, and to improve ventilation performance, SWA has worked with RDI to design a very simple air distribution system. This system is described below. To keep occupants comfortable while showering, each bathroom with a shower will contain a 500W electric-resistance heater. Each heater will be wired to a crank timer, which will switch it off automatically after a set period of time.

Like most RDI homes, the Wisdom Way houses will have an exhaust-only ventilation system. In the primary bathroom (the one with a shower), a Panasonic WhisperGreen exhaust fan is programmed to run continuously to meet the whole-building ventilation requirements of ASHRAE Standard 62.2-2007 (30–60 CFM, depending on the unit). The fan can boost to high speed (80 CFM) for an adjustable amount of time when the bathroom is in use.

Exhaust-only ventilation is a common, affordable choice for small homes in northern climates, where A/C and duct systems are not always installed. For RDI—which develops affordable housing for many first-time homeowners—it has the additional appeal of requiring very little maintenance. From an energy standpoint, new exhaust fans with efficient, electronically commutated motors (ECM), such as the Panasonic WhisperGreen, typically use 5 to 11 watts. With such low power consumption, the overall energy and operating costs of these exhaust-only systems can be lower than operating costs of some heat recovery or energy recovery ventilating systems.

In the Wisdom Way houses, SWA has worked with RDI to incorporate a simple air distribution system; this system will circulate fresh air and help equalize air temperatures, throughout the home. Each home will contain an additional Panasonic WhisperGreen fan that will "exhaust" air from the ceiling of the first floor and distribute 20–25 CFM of air to each bedroom. SWA, in conjunction with

the National Renewable Energy Laboratory, will use tracer gas tests to evaluate ACH throughout the homes.

Lights and Appliances

RDI participates in an Energy Star program sponsored by the local utility (Western Massachusetts Electric Company). As part of this program, RDI receives screw-in CFLs, which are installed in all fixtures throughout the homes. Refrigerators and dishwashers provided by RDI are also Energy Star rated.

Water Heating

Most of the energy used to heat water will be provided by solar-thermal systems. Flat-plate solar collectors are mounted on the south-facing roof of each home, and a propylene glycol antifreeze solution is circulated between the collectors and a heat exchanger located in a storage tank in the basement. A direct-current pump circulates the glycol; the pump is powered by a dedicated PV module (with a differential temperature controller). Auxiliary water heating in each home is provided by a sealed-combustion, natural gas-fired, tankless water heater installed in the basement near the solar tank.

As the photos show, south-facing roof space is very limited in these homes. Three- and four-bedroom houses have three 29 ft^2 solar-thermal collectors; two-bedroom houses have two collectors. RDI's original plans called for solar-thermal systems to provide part of the space-heating load as well as the water-heating load. However, this would have required one or two additional solar-thermal collectors, and there was simply no room for them on the roof.

Typical Wall Section from Austin Design

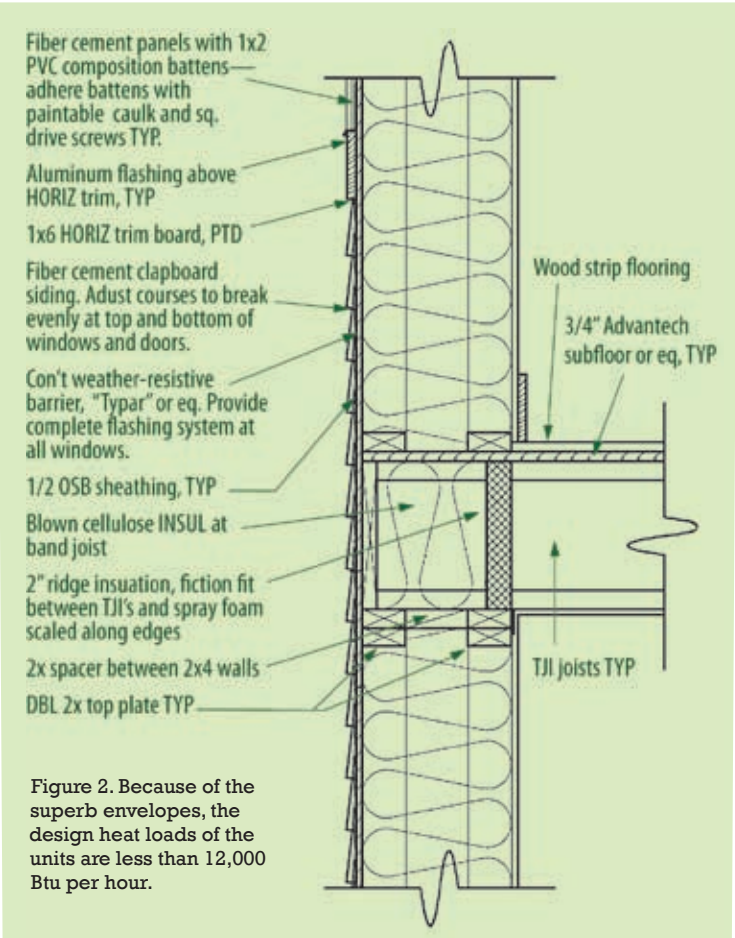

Figure 2. Because of the superb envelopes, the design heat loads of the units are less than 12,000 Btu per hour.

Solar-Electric Systems

With funding from the Massachusetts Technology Collaborative, and its Green Affordable Housing Initiative, RDI is able to install a PV system on every dwelling unit. Three- and four-bedroom homes will have 3,420W PV systems, and two-bedroom homes will have 2,850W systems. Over the course of a year, the larger systems will generate approximately 3,750 kWh; the smaller systems will generate 3,125 kWh. Building America analyses show that in a three-bedroom unit, the larger system will provide 77% of the home's electrical needs. With conscientious homeowners, however, the percentage could be much higher; SWA expects that many homes will have 100% of their electricity provided by the PV system. RDI plans to record electricity generation and consumption in the homes when occupied.

Energy Costs and Benefits

SWA used EnergyGauge USA v2.7.03 (EGUSA), an hourly energy simulation tool, to model the energy performance of a three-bedroom home. Performance of the solar-thermal system was modeled with F-Chart software, and PV generation was calculated using the PVWatts tool. This three-bedroom unit is a midsized home for the development, and it is also the most common, accounting for 9 of the 20 homes. Wisdom Way homeowners can expect to spend approximately $2,500 less each year for energy when compared to the "baseline" home. The baseline home is modeled to reflect mid-1990's construction practices according to the Building America Benchmark definition. SWA and RDI plan to work with homeowners to collect actual energy consumption data when the homes are occupied.

RDI's costs to build above code are harder to determine. While costs of components (such as triple-pane windows) are simple to calculate, there are many costs associated with building techniques, and with the installation of advanced systems, that are difficult to quantify. Working with RDI, SWA has calculated the approximate incremental costs of installing advanced energy systems—that is, the costs above typical code construction. These costs are shown in Table 2.

Table 2. Approx. Incremental Construction Costs

SYSTEM	INCREMENTAL COST
Envelope	$7,000
HVAC	$(4,500)
Lights & Appliances	$300
Solar Water Heating	$10,000
Photovoltiacs	$25,000
Total	$37,800

In looking at Table 2, it is important to note that these are the costs before any incentives, rebates, or grants. RDI did receive considerable support from the state of Massachusetts, from utility programs, from the federal

government, and from other sources. For the affordable homes in the development, total incremental cost of energy features is approximately $10,000 after subsidies. The moderate-income and market rate units received somewhat less support.

It is also noteworthy that the two solar systems account for the lion's share of the total incremental cost. While RDI received substantial support for the solar systems, the table highlights the relative costs of efficiency versus renewable energy. Before incentives, efficiency is far less costly (and more cost-effective) than renewable energy.

Finally, it is worth noting that the simple heating system—together with the elimination of a boiler—led to substantial savings in the cost of the HVAC system.

Selling Homes

Of the 20 homes in the development, 11 are reserved for low-income buyers (income below 80% of median); 5 are reserved for moderate-income buyers (income between 80% and 110% of median); and 2 will be market rate for any buyers. The remaining 2—the accessible units—will be owned by RDI, and will be rented to people with disabilities.

RDI has been conducting monthly or bimonthly meetings with prospective home buyers for over a year. Meetings have served to inform potential buyers about some of the key features of the homes. The meetings have also provided RDI with feedback about what home buyers value in a home and in a community. The market rate homes are priced below $250,000; for a full list of prices, visit RDI's Web site. With the down-turn in the housing market, RDI claims that while homes are not selling as quickly as planned, they are selling. RDI credits the homes' performance, the community setting, and affordability as the biggest selling points.

The project has also inspired others in the area—architects, affordable housing developers, and market rate builders—to examine similar construction techniques, and to reach for excellent levels of home performance.

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For more information:

To learn more about Rural Development, Incorporated, go to www.ruraldevelopmentinc.org.

The Building America program is a DOE initiative focused on cost-effective pathways to zero energy homes. To learn more, go to www.buildingamerica.gov.

Steven Winter Associates, Incorporated, is an architecture and engineering firm focused on energy efficiency, accessibility, and sustainability. SWA has offices in Norwalk, Connecticut; New York, New York; Washington, D.C.; and Boston, Massachusetts. To learn more, go to www.swinter.com.

Austin Design, Incorporated, has provided architectural services for several RDI projects. Its Web site is www.austindesign.biz.