The Energy Transition: Religious and Cultural Perspectives

with Larry L. Rasmussen, Normand M. Laurendeau and Dan Solomon, "Introduction to 'The Energy Transition: Religious and Cultural Perspectives,'" Normand M. Laurendeau, "An Energy Primer: From Thermodynamics to Theology," William B. Irvine, "Overcoming Energy Gluttony: A Philosophical Perspective," Anne Perkins, "Conservation: Zero Net Energy Homes for Low-Income Families," R.V. Ravakrishna, "Sustainable Energy for Rural India," Fletcher Harper, "Greening Faith: Turning Belief into Action for the Earth," Drew Christiansen, S.J., "Church Teaching, Public Advocacy, and Environmental Action," and Larry L. Rasmussen, "Energy: The Challenges to and from Religion"

CONSERVATION: ZERO NET ENERGY HOMES FOR LOW-INCOME FAMILIES

by Anne Perkins

Abstract. The Wisdom Way Solar Village in Greenfield, Massachusetts is a zero net energy mixed-income, mixed-ability subdivision/condominium of 20 solar homes. It stands as an ethical response to climate change in that it demonstrates that homes in the northern United States can be built to use almost no fossil fuel for heat or electricity and to use very little water. It also demonstrates that small groups of people can learn to work together and to enjoy the benefits of living in a small community.

Keywords: affordable housing; community; deep energy retrofit; funding; HERS; homeowner education; LEED; zero net energy

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It is estimated that the energy used in buildings in the United States is 48% of all the energy used each year, thus contributing almost half to the annual CO_2 emissions. This number includes residential, institutional, commercial, and industrial buildings (Mazria 2007). If such energy use is dramatically reduced, the impact in reducing global warming could be significant. Growing out of this understanding, a movement to build and renovate homes such that they produce as much energy as they use has taken hold in the United States and Europe. Known as Zero Net Energy (ZNE) buildings, the number of such buildings is slowly increasing.

In addition, in the United States there are many programs to build or renovate affordable homes for low-income persons to rent or purchase. In 2004, Rural Development, Incorporated (RDI) based in Turners Falls,

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Massachusetts, became involved in the construction of "near" ZNE homes. With the financial assistance of many private and public organizations, they completed several stand-alone scattered site homes in rural Franklin County, and a 20 home subdivision/condominium known as the Wisdom Way Solar Village (WWSV). This paper will focus on the Solar Village, both in terms of the techniques used to achieve ZNE (and Leadership in Energy and Environmental Design [LEED™] Platinum) for each home and also on the building of the village community that was accomplished. In the IRAS Statement on Energy and Climate Change quoted in Rasmussen, Laurendeau, and Solomon (2011), two of the statements are as follows: "Whereas peak oil and global warming will disproportionately affect the most economically vulnerable members of our global community"; and "The majority of environmental refugees arising from climate change are currently and will continue to be the global poor." Although cognizant that the poor in the U.S. are not nearly as poor as those in sub-Saharan Africa, for instance, and that no one weather-related incident can be attributed to the climate change brought on by high levels of CO_2 in the environment, a mobile home park in Greenfield near to RDI was devastated and ultimately destroyed by flooding of the Green River. All of the low-income residents had to be evacuated in the middle of the night and then to find new homes. This took place in the weeks following the devastation of hurricane Katrina in the Southern United States that impacted poor people so powerfully. Even in the United States then, the poor suffer more than others. As the cost of heating oil and gas has risen, providing homes for low-income families that have little or no fossil fuel costs gives them some measure of economic security.

The Technical Details

The WWSV was the result of a collaborative effort. Once the excellent solar site was secured, an integrated design team met in several sessions to discuss site design possibilities as well as actual building designs. Team members included two architects, a landscape architect, a utility representative, a mechanical engineer, a civil engineer, a Home Energy Rating System (HERS) rater, future homeowners, suppliers, trades people (plumber, electrician, insulator, site contractor, foundation installer), and RDI staff, including four carpenters. Involving all of these actors from the beginning allowed for excellent design as well as "buy-in" as work progressed. Team members knew one another and whom to talk to as issues arose.

The 4.7-acre site is unique. It is on sandy soil with excellent solar access in an area of work force housing in the town of Greenfield, Massachusetts. The site is surrounded on three sides by an apartment complex and a cemetery. The fourth side has three houses, thus the village sits in the center and feels self-contained. Although several site designs were considered, Greenfield zoning regulations led to a design of 20 homes in 10 duplexes with one road that serves to enter and exit the village. The team reluctantly accepted a 26-foot road width, which they believed was wider than necessary leading to unnecessary asphalt use. It allowed the road to become a public way, however. This designation caused the Town of Greenfield to assume the expenses of maintenance and snow plowing. The ideal of "green building" was compromised for this pragmatic reality.

The team was united in believing that it is most important to lower the energy use of a building and to take advantage of passive solar gain before adding renewable energy systems. Only then is it going to be feasible to get to ZNE. The duplexes were designed to take advantage of the sun, both for solar gain in the windows and for solar panels—photovoltaic (PV) panels for electric generation and thermal panels for water heating. Thus, the buildings were oriented on the site with a long east-west axis. Using techniques developed for RDI by Austin Design, Incorporated, in an earlier home, the walls were all 12″ thick. The carpenters built the exterior wall first. Once the roof was on and the building was sealed from the weather, the inside walls were built. Both walls were 2 × 4–16″ on center with 0.25″ plywood gussets to connect the two walls at the fenestration points. These walls were later filled with 12″ of dense pack cellulose for an *R* value of 43. *R* is a measure of thermal resistance, with the higher the number, the better the resistance.

A raised heel truss was used for the roof, allowing for 15″ of blown cellulose for an *R* 50. The basement ceilings were also insulated with cellulose for an *R* 40. It should be noted here that insulating the cellar walls is preferable from an energy perspective, but the cost would have been considerably more. The team frequently had to make such choices.

The windows in the homes are also unique. The team chose to use a vinyl-framed triple-pane window with a low-emissivity coating (low E) and krypton gas with an *R* value of 5.5 for the north, east, and west windows. The south façade windows are double pane with low E and argon gas for *R* 3.8. Because Greenfield, Massachusetts is an area that needs heat about 8 months a year, while only needing air conditioning (AC) perhaps 2 weeks a year, the team chose to have the window manufacturer flip the glazing in the frame for the south windows such that the low-E coating causes the heat to be reflected back into the house instead of out. The south windows also have a higher Solar Heat Gain Coefficient than the triple-pane windows on the north, east, and west. It is very challenging to find such windows that are appropriate for northern climates in the United States due to the fact that most construction in the United States is in the southern states where AC is in demand. Such windows are available from Canada with the environmentally preferable, but also more expensive, fiberglass frames.

In addition to the windows and the insulation, the RDI carpenters were very careful to seal the homes such that the air exchanges were very low, typically 1.15 air changes per hour at 50 Pascals. This was accomplished with low-density foam or caulking around all of the fenestrations as well as the foundation to sill and sole plate to deck joints. A blower door test was done midconstruction to show any weak points.

"Seal it tight, ventilate it right" is a mantra of the energy efficient housing movement. Pollutants (primarily water) must be removed from air-tight homes, and fresh air must be introduced. An exhaust-only system was used in the WWSV homes, which ranged from 1100 to 1700 square feet of living space. A quiet Panasonic™ WhisperGreen bath fan (Panasonic Corporation of North America, One Panasonic Way, Secaucus, NJ 01094) was installed in each main bathroom. It runs at 30 cubic feet per minute (cfm) continuously and is raised to 80 cfm when bathing. It uses only 6 watts of electricity. In addition, there are quiet fans in all secondary bathrooms that vent to the outside, range hood fans that vent to the outside, and passive soffit and ridge vents on the exterior.

In an unusual feature, another quiet WhisperGreen fan was installed in the ceiling of the main living area and ducted to the bedrooms. This is for air distribution, not for ventilation. However, it has the residual effect of distributing heat as well. Buyers are taught to leave bedroom and bathroom doors open most of the time for air and heat distribution.

These features all combined to require very small heating loads in the homes. The design-heating load became less than 12,000 British thermal unit per hour (Btu/hr) when the temperature was 2°F outside. A typical boiler will produce 100,000–150,000 Btu/hr, while a typical condensing boiler will produce 16,000–46,000 Btu/hr and a typical condensing furnace is rated at 37,700–58,000 Btu/hr. Thus, a central heating system did not make sense to install because it would have been oversized. Instead, one natural gas room heater sufficed for the whole home at much less cost. Although only 83% efficient, the sealed combustion heater supplies a low of 10,200 Btu/hr and a high of 16,000 Btu/hr. The main bathroom also has a small electric resistance baseboard heater for bathing that is set on a timer so it cannot inadvertently be left on and waste electricity.

Researchers from the National Renewable Energy Laboratory in Golden, Colorado, came to the WWSV to test how well the whole house was working. They learned that the bedrooms were so well insulated and sealed that the heat of a 100-watt incandescent light bulb, or a computer, or a television set, or even a person, could increase the room temperature significantly. Thus, if the owner wanted to go to bed in a warm room, a small appliance turned on for 15 minutes would suffice (U. S. Department of Energy [DOE], 2010).

The homes have very low electric loads as well. The appliances are all Energy Star or natural gas, and the lighting is almost 100% compact florescent. With PV systems ranging from 2.85 kilowatt (kW) for two-bedroom homes or 3.42 kW for the three- and four-bedroom homes, most occupants are not paying electric bills. The PV systems were sized according to the modeled loads.

The WWSV also participated in several programs that define energy efficiency and "greenness." The Massachusetts New Homes for Energy Star™ inspected each of the homes after they were insulated, yet prior to sheet rock installation. They returned at the end of construction to perform a final inspection, do a blower door test, and evaluate all of the Energy Star appliances. The resultant HERS score became an important number for additional programs. All of the homes in the WWSV had scores between 8 and 18. With most homes in the U.S. scoring between 130 and 150, and a home built to code scoring 100, the significance of the low scores becomes obvious.

The WWSV also participated in a similar program known as the Builder's Challenge launched several years ago by the U.S. DOE, Office of Energy Efficiency and Renewable Energy. This program uses the HERS score to designate an "Energy Smart Home" and provides a colorful sticker to put on the house breaker box—as a mark for future buyers of the home to know how well the home should perform from an energy perspective. Although it is easy to get such information for cars (miles per gallon) and refrigerators (kWh per year), it is not easy to obtain this information for homes. The DOE is trying to change that.

Lastly, the WWSV participated in the U.S. Green Building Council (USGBC) LEED for Homes™ program. The homes were all evaluated by Steven Winter Associates and achieved LEED Platinum status. This program uses the HERS score for the energy efficiency rating, but also evaluates a number of "green" features. Because there is no real definition of the term "green," the USGBC has created categories, in which a builder must earn credits in order to achieve LEED certification. These include

(1) Innovative design process
(2) Location and linkages
(3) Sustainable sites
(4) Water efficiency
(5) Energy and atmosphere (Energy Star)
(6) Materials and resources
(7) Indoor environmental quality
(8) Awareness and education

Some measures are mandatory, others are by choice. The builder chooses which points to earn in each of the categories. In addition to the energy efficiency measures mentioned above, some of the features RDI used to meet the LEED Platinum designation included low-flow plumbing fixtures; dual-flush toilets; natural gas on-demand hot water back up, cook stove, and dryer; no volatile organic compounds (VOC) paints in most applications; locally grown hardwood floors with water-based sealant; linoleum resilient flooring in kitchen and bathrooms; 30% fly ash in the concrete foundations; a cedar playground; and fiber cement siding. In addition, more than 1 acre was left as open space, and all plantings were of native species. The use of an integrated design team also counted toward the LEED designation, as did extensive homeowners' education. Lastly, the location of the WWSV was within walking distance of the town center, the Franklin County Fairgrounds, and a local park with a play structure.

Two important lessons were learned from the construction and technical perspectives.

(1) RDI had built one near-ZNE home in the year prior to the beginning of construction in the WWSV; lessons learned in that home were used in designing the WWSV homes; the radiant floor heat imbedded in a concrete floor was not repeated due to problems with the system and the hardness of the floors.

(2) The solar thermal (hot water) systems that were installed on the roof of every home did not function well without many return visits of the subcontractor, while the PV systems with virtually no moving parts functioned perfectly; in the future, it would be better to install larger PV systems and use on-demand electric hot water heaters than to install solar hot water systems. For a 17-page technical report on the solar thermal systems written by the engineer involved in the WWSV, see: http://www.carb-swa.com/articles/advanced%20systems%20research/RDI_WWSV_solar_thermal.pdf.

Funding

RDI could not have achieved near-ZNE or LEED Platinum without the support of many public and private individuals and organizations. As the project was under development in 2006, ahead of the green building curve, enthusiasm for it gained many supporters. The funding was complex for this $5.8 million project and required many applications. A team of RDI staff members prepared the applications. Initial construction financing came from the Community Economic Development Assistance Corporation in predevelopment funds; the Housing Assistance Council in Self Help Opportunity Program funds and in the Rural Home Loan fund; the Massachusetts Housing Partnership; The Life Insurance Initiative; and the Greenfield Cooperative Bank. These loans were all repaid as homes were sold.

Grants came from the U.S. DOE in an earmark thanks to Congressman John Olver, an early supporter of the project, and were used for the solar thermal systems and local hardwood flooring; Enterprise Green Communities for the integrated design process; TD Bank North Foundation for predevelopment and for a video of the construction; the Western Massachusetts Electric Company for energy upgrades; the

Home Depot Foundation for trees and for payment of the cost of LEED certification; the Massachusetts Technology Collaborative and HAP, Inc. for PV systems; and the Massachusetts Department of Housing and Community Development Community Based Housing program.

A large in-kind donation came from Steven Winter Associates through the DOE Building America program. Substantial mechanical engineering design, support, and monitoring were granted by this source. In addition, the architectural firm of Austin Design, although initially paid, in the end did many hours of in-kind inspections and paperwork. Both organizations believed in the project and went beyond the call of duty to see its success.

In-kind service also came from the buyers themselves who were charged with cleaning up the homes after the subcontractors and with painting the drywall and trim. Each buyer was given a budget to purchase paint and equipment at a specific dealer, where no-VOC paints were purchased. They worked at least 200 hours of "self-help" labor, giving them an emotional investment in their new homes.

Deferred payment loans, which transferred to the low- and moderate-income buyers at closing, came from the Massachusetts Department of Housing and Community Development HOME program, the Massachusetts Affordable Housing Trust, and the Town of Greenfield Community Development Block Grant. These loans vary in the number of years the buyer must live in the home during which the loan must be repaid. At the completion of the terms, the longest being 30 years, the loans are forgiven. These requirements encourage stability as well as assuring tax payers that tax dollars are not supporting real estate market speculation.

Almost half of the funding comes from the sales of the homes. Of the 20 homes, 11 were sold to people who had incomes designated by the U.S. Department of Housing and Urban Development to be low income for the region, or 80% of the area median income (AMI). Five were to be sold to people of moderate, or 110% AMI, of which one had sold as of this writing. Two were to be sold on the open market, of which one had also been sold as of this writing. RDI retained ownership of the final two homes, which are accessible under the Massachusetts Community Based Housing program; these homes will be rented to persons with disabilities for at least 30 years. The downturn in the economy caused the moderate homes, with fewer subsidies and a 30-year deferred payment loans, to be more difficult to sell.

The Community

The WWSV was designed to encourage individuals and families to become a community that worked, played, and supported one another. It would have been legally feasible to create a village of 10 condexes, that is, two-family homes each owned by two occupants; however, it seemed likely that the larger number of 20 homes in a condominium would lead to better working relationships. The word "village" was chosen to signify the concept of community rather than naming it a condominium or subdivision, although legally it is both of those entities.

The village is designed to include several different groups of people. There are low, moderate, and any income persons. There are able bodied and people with disabilities. There are single individuals and couples. There are both two- and one-parent families. There are young people with newborn infants and people in their sixties and seventies. And, although Greenfield has a white Caucasian population of over 90%, there is significant racial and ethnic diversity. In addition to the white residents, there are residents from Argentina, Tibet, and Jordan. Lastly, while most homes are owned by the occupants, two of them are rental homes.

RDI made a concerted effort to create community and to educate the purchasers and tenants. Beginning in October of 2006, monthly meetings were held for prospective buyers and tenants, while actual occupancy did not begin to take place until December of 2008. During the early meetings, the civil engineer and landscape architect elicited suggestions for the site layout. Later, the architects brought several house designs to the meetings for comment. As the months went by, presentations were made to the group about condominium structure by an attorney, about PV systems and how they worked by the PV installer, about solar hot water systems by the solar thermal installer, and the mechanical engineer made several presentations about the special workings of the ZNE homes. In all such presentations, the group had the opportunity to ask questions and make suggestions. On occasion, the RDI staff brought in samples of materials for group members to choose from, such as playground materials. One member started bringing in "get acquainted" games for all to play—such as throwing a ball to one another in a circle and having to name a favorite movie. This elicited a lot of laughter and helped integrate new members.

In the early summer of 2009, those members who had moved into the village (or knew they were going to do so) spent a Saturday workday with some RDI staff putting together a cedar play structure they had selected. There was always a lot of excitement when one home was finished and another family moved into the village. Such moves were staggered as homes were completed and sold. Some of the children began a newspaper, the *Solar Village Sun*.

About the time the Village was completed in the summer of 2010, RDI worked with a subcommittee of owners to select a condominium trainer. Although it was anticipated that one person would take on this position, which was expected to extend over a period of 2 years, in fact two individuals were selected with slightly different job descriptions. One was selected to teach the group the legal functions and management of a condominium and the other was to teach mediation and conflict resolution skills. These efforts are currently ongoing. Although there was no conflict that needed to be resolved at the time, it was easy to anticipate that there would be in the future.

Homeowners were given a three-ring binder at the time of sale that included many instructions on how to live in their ZNE home. Very few people in the United States have lived with such unusual systems, and most of the buyers were first-time homeowners. Usually, people who have ZNE homes had been involved in many of the decisions about which systems they preferred. In the WWSV, those decisions had been researched by the integrated design team, which included some of the ultimate buyers, but were new to most of them. So, they needed to learn. Here is an example of one set of instruction given to one buyer who was having some trouble keeping her home at a comfortable temperature

Specific suggestions for "Jane Doe" regarding how to keep the energy bills lowest in her new Solar Way home in Greenfield, Massachusetts.

(1) Keep the temperature on the monitor heater set at one *constant* temperature. We suggest 65°.
(2) Keep the basement door closed. Also, be sure the insulated door to the bulkhead in the basement is always closed.
(3) Turn off the dehumidifier in the basement from September to June. Use it only in the summer when the relative humidity goes above 60.
(4) Always leave the fan switch on in the upper basement hallway. This keeps air flowing from the living room to the upstairs.
(5) Always keep the upstairs bathroom fan running as it is now set. Use the switch to raise the fan speed when anyone is showering.
(6) Always use the range hood fan when cooking.
(7) Call RDI if you see condensation on your windows when it is very cold outside.

Several of the future buyers wrote support letters to be included in funding applications RDI was preparing for the WWSV. One that gets to the heart of the community building that took place as a result of the monthly meetings is quoted here.

> A village is not just houses built near each other. A village is people who share a common spirit. . . . We are a diverse group of young families, working families and older people facing retirement from low and moderate incomes . . . . a group of people who have been building relationships as well as homes. Homes which will be sustainable, affordable and environmentally friendly. —Mary

The decision to build all of the homes to be accessible through at least one door was also part of the community building. It was clear that those two tenants with disabilities were only going to be full members of the community if they could visit in others' homes. As one fifth-grade child wrote,

> The project is a small village of about twenty houses with a community center in the middle. All of the houses are Green houses and some of them are built for people with disabilities. This is a way for people to connect and make friends.

Although plans called for a demonstration/community center, that building has not yet been built.

Data Collection

RDI and the Building America program were committed to monitoring and data collection so that the efficacy of the plans and construction could be evaluated. Data were collected for electric use and generation from the Western Massachusetts Electric Company, water use from the Town of Greenfield, and natural gas use from the Berkshire Gas Company.

Several owners were also interviewed to determine their comfort and satisfaction levels. It was discovered that the homeowners are living comfortable lives, and that they are not scrimping on their energy or water use. The homes *themselves* are giving the people the support they need to live lightly on the planet.

Eight families (with 20 individuals) lived in the WWSV between January 1 and June 30, 2010. The public water system supplied during that time averaged a very low 32 gallons a day per person. The national average varies from 59 to 200 gallons. There are several factors in the WWSV homes that have led to such low-water usage. All homes are outfitted with:

(1) Energy Star clothes washers and dishwashers (except one person who washes dishes by hand);

(2) Dual-flush toilets (0.8 gallon per flush for liquids, 1.6 gallon for solids);

(3) Low-flow shower heads (good ones that really work);

(4) Low-flow aerators on the kitchen and bathroom sinks;

(5) Homeowners who choose not to waste resources.

Such low-water usage leads to low-sewer usage and thus saves the municipality money—as well as the homeowners.

The electric data on those same eight families is equally as compelling. From early November through mid-July, the owners combined purchased about 13,000 kilowatts hours (kWh) from the Western Massachusetts Electric Company. At the same time, they were given credit for over 16,000 kWh—for a net savings of 3176 kWh. At $0.17 a kWh, that amounts to $540.00. Each homeowner pays for—or receives credit for—their own electricity, so almost no one in the Solar Village is paying a monthly electric bill. The extra sunlight in the summer helps them earn credit for the winter.

The average annual residential electric use per customer was 7162 kWh or about 600 kWh per month in 2001 in Greenfield. In the WWSV, the average usage was about 426 kWh per month. Thus, the usage itself is considerably less than average, and because the solar electric systems more than cover that usage, the cost to the customer is normally zero.

The third major utility used in the WWSV is natural gas supplied by the Berkshire Gas Company for use in supplemental heat, back-up hot water heating, cooking, and clothes drying. Gas is measured in therms. During the winter months from January to May, the range in use was quite wide—ranging from 17 to 146 therms. The difference depended on lifestyle and family size. The cost ranged from $45 to $377, with the average being $230—for 4 months.

The "average" WWSV household paid a *total* of $363.00 for the first half of 2010 for their water and sewer ($133), electric ($0), and natural gas usage ($230). They report that they were comfortable and enjoyed living in the WWSV. This is indeed affordable housing.

THE NEXT STEP—DEEP ENERGY RETROFITS RDI had the opportunity to crest the wave in the green building of affordable homes, winning the Home Depot Foundation's inaugural *Award of Excellence for Affordable Housing Built Responsibly* in 2004. This award was based on earlier homes built by RDI, and led to the credibility and thus the funding for the WWSV. However, all of the homes built by the RDI Homeownership Program from its inception were newly constructed on previously unused building lots. Those in the green building movement have come to understand that the energy upgrading of existing homes does much more to protect the climate than new construction. Reuse of the land and building materials is clearly more "green." In New England, there are huge numbers of energy *inefficient* buildings—many residential ones—that are prime for what is termed "deep energy retrofits." This term implies adding large amounts of insulation to the attic, walls, and basements; sealing the air leaks as tightly as possible; upgrading windows; and adding appropriate ventilation. Some of the retrofits involve a major rebuilding, leaving only the foundation and structure intact. Others do not touch the interior of the home, so that the occupants can live in it during construction, while adding another wall to the exterior and adding insulation to the attic. While not a simple process, it is this author's belief that the future of energy efficient affordable housing is in deep energy retrofits.

CONCLUSION

Referring again to the IRAS Statement on Energy and Climate Change quoted earlier in this article (Rasmussen et al. 2011), another of the statements is as follows: "Basic energy needs account for a significantly greater percentage of living costs for the poor as compared to the rich." One purpose of building or retrofitting affordable homes to be as energy efficient as possible is to ameliorate this issue. It can be called *foreclosure prevention* for those homeowners who are low income, as a low-energy bill leaves more room in the household budget to pay the mortgage. However, it is also useful to those public and non-profit organizations who manage multifamily rental affordable housing. In this era of strapped budgets for such organizations, low energy bills can assist in keeping them viable.

The WWSV is an example of a green affordable housing project that can be done and done right. It takes commitment to the principle that people of all incomes deserve to live in decent, safe, and affordable housing that minimizes the normal environmental impact of living. The WWSV stands tall as an appropriate ethical response to the coming era in which fossil fuels are becoming scarce.

Note

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