Martin Residence

Whole Building Design

The Martin residence features a large solar roof, oriented due south with unobstructed solar access and sloped to optimize annual solar harvest. The 10 kWp PV system is utility-interactive and includes a battery bank, which is capable of providing up to two days of managed loads during a power outage with no solar production. Solar thermal absorbers cover the top 600 square feet of the southern roof, providing space heating and domestic hot water, which is stored in a 1000-gallon storage tank located in the basement.

Demand

Electrical load minimization is at the core of the home's energy balance. The majority of most houses' energy usage is associated with heating, ventilation, and cooling (HVAC). In order to make this area more efficient, the home incorporates passive solar concepts-south-facing windows, high insulation, and thermal mass. During the winter, when the sun remains low in the sky, large, south-facing windows allow sunlight to penetrate deeply into the living space. During the summer, when the sun is higher, the overhang over the southern porch shades the windows and keeps unwanted solar gain out of the house. Windows on the western and eastern facades feature heat-rejection coatings and provide a thermal resistance of R-8. Lightweight concrete slabs in the floors add thermal mass, which absorbs passive solar gain and helps keep the house warm when the sun is down.

High efficiency appliances-all Energy Star-rated and commercially available-as well as compact fluorescent lights (CFLs) further reduce the electrical load. Recessed CFL downlights use a remote ballast system to improve efficiency and increase the lifespan of both the lamp and ballast.

Thermal Integrity

The walls are framed with 2 by 6's at 24 inches on center using a "light" framing method, in which all nonessential wood is eliminated to improve the wall's thermal properties. Five inches of sprayed-in urethane foam insulation provides excellent protection against air infiltration, and when combined with two inches of expanded polystyrene insulation outside the building sheathing, the wall insulation value reaches an "honest" value of R-38. The insulation value of the ceiling is R-50, and all ceiling penetrations are completely encapsulated with an air-sealing barrier.

Dual high-efficiency, air-to-air heat exchangers provide controlled ventilation for the tight building envelope, while a high-efficiency, 5-ton water-to-water geothermal heat

pump provides cooling and supplemental heating for the 4500 square feet of conditioned space. The HVAC system is divided into five cooling zones and twelve heating zones, which can be switched off so that only occupied zones are heated or cooled.

The long-lasting, standing-seam metal roof decouples unwanted solar gain from the attic space via an innovative dual-venting strategy, where the metal roof is held 2 inches above a radiant barrier and passively vented separately from the attic space. Large-aperture eave vents, gable vents, and a continuous-vent louver across the north side of the ridge all help to keep both the attic and integral large-area PV modules cool during summer months, while allowing passive heating in the winter when the sun is lower in the sky.

Solar Electricity
The solar electric array consists of 32 large-area 300W modules (1 spare is also installed on the roof). These modules are directly integrated into the roof to form the roof structure and finished weathering skin. The array is installed above the roof framing to create an air plenum, allowing convection air flow to cool the modules. The direct current (DC) electricity produced by the PV array is converted to utility-quality alternating current (AC) through two utility-interactive 5500W DC-to-AC inverters.

Net Metering
The solar electric system is utility-interactive with the ability to export its surplus to the utility grid via a net metering arrangement with the local power company. Net metering allows the solar system owner to effectively "store" their surplus solar-generated electricity in the utility grid by essentially running their meter backwards. They can then draw upon their surplus at night and during periods of cloudy weather. Although the home also has a bank of batteries to draw upon for power when the utility fails, the net metering relationship with the local utility company is considered a fundamental prerequisite to meeting the home's power needs with solar generation. Net metering provides 100% efficient electric "storage", eliminating the costs and losses of on-site storage. Both the homeowner and the utility benefit.

Solar Thermal
The solar thermal collector array is also constructed as a roof-integrated assembly using the same glass size and glazing details as the solar electric array. The array is composed of 22 4'x6' collectors and provides both space heating and domestic hot water. The collector array is configured as a drain-back loop with a siphon return to minimize pumping energy. When collection is complete, circulation stops and the water drains back from the collectors into the storage tank to avoid freezing. During the winter, the storage tank temperature rarely falls below 100 degrees, which means that the energy-intensive heat pump is rarely needed. Water is used as the circulating fluid instead of the antifreeze solution typically used, as water carries more thermal energy, suffers no degradation under stagnation conditions, and is free.

Solar Design Associates completed work on the residence in early 2003, and the owners are quite pleased with the home. If they could do it all over again, they "would build a smaller house, but aside from that, it's what we wanted and is performing flawlessly."