The Northeast Green Building Awards
Entry Form

Project Name: Solar Decathlon, Student Project
Category Entered: Student Projects

Type of Building: Solar Electric, Single Family Residence

Building Location: The building itself was initially designed to meet the conditions in Washington DC, in order to compete in the first US Department of Energy-sponsored 2002 Solar Decathlon held on the National Mall Sept. 26-Oct. 6, 2002. The final location for the house is Newark, DE. The conditions in both locations are similar so no major design modifications were made for the 2 locations.

Building gross square footage: The house is 800 ft^2; it includes living space, mechanical room, and sunshades on the south windows. It does not include the deck on the northeast corner of the house. Note that this size limitation was part of the Solar Decathlon rules and regulations, along with a height limitation of 18ft, which limited the house to one floor.

Project cost (total and cost per square foot): Approximately $200,000 total, which is $250/$ft^2$ for the house. Costs include all building materials, tools and hardware used to assemble the house, "green energy" systems, energy efficient appliances, and furniture. Not included are costs of transporting the house to and from Washington DC, many in-kind donations, and all the hours volunteered by students over 2 years to design, build and participate in the Solar Decathlon.

Sustainable Design Features: All of these design features are commercially available, and most of them can be incorporated into existing structures.

1. *Photovoltaic Electrical System*: The PV power system is based on an AstroPower SunUPS 40 system with expanded batteries. The PV Array consists of 40 Astropower AP 120 panels, wired into 10 strings of four panels, providing approximately 4.8 KW of power, at a system voltage of 48 volts.
2. *Battery Storage System*: An array of 20 Concorde SunXtender PVX 2580 L batteries can provide approximately 3 days of reserve power for the house.
3. *Geothermal Heat Pump*: Florida Heat Pump GT010 with a 1 ton capacity connected to geothermal loop. Used to cool the house in the summer and to provide supplemental heating in the winter.
4. *Solar Hot Water System*: A Thermomax evacuated tube system (40 tubes), is used to generate hot water for DHW, as well as to supply warm water for the radiant floor system.
5. *Hot Water Tank*: 80 gallon double coil heat-exchanger hot water tank from Vaughn Corp., which allows us to have 3 isolated systems: solar thermal collector loop, domestic hot water, and the radiant floor heating loop.
6. *Radiant Floor Heating* (using solar generated hot water): Utilizes Warmboard floor panels, IPEX tubing, and WarmRite manifold to provide winter heating to the house and provide thermal mass.
7. *Highly Insulated Walls and Roof*: Ecothermal walls and roof panels are made of pre-fabricated panels using rigid planks of solid expanded polystyrene (EPS), reinforced with tubular galvanized steel struts and angled steel top and bottom corners. The wall is 7.5 inches thick and roof 11.5 inches thick, with rated R-values of 30 and 50, respectively.

8. *Composite Floor*: The floor is made of an 8" sandwiched composite material by Hardcore Composites. These composite panels are typically used for bridge and marine structural applications and are extremely strong and durable. The strength comes from fiber-reinforced polymer network and can be varied by the density of fiberglass bottles. The network is filled with solid polyurethane foam. The average R-value for the floor is about 17. Although this material is not recommended for typical building applications due to its high cost, the advantage is the compact integration of strength and insulation.
9. *Specialized Windows*: Traco supplied all the windows; they are titanium coated, heat mirror inserted, and krypton filled windows with rated center of glass R-value of 8.3 and a total window R-value of 5.3. This level of insulation is two to three times the average window insulation for a typical home.
10. *Energy Efficient Appliances*: Sun Frost refrigerator, Asko dishwasher, Asko front loading clothing washer, and Spin-X centrifugal dryer; all of these appliances have excellent Energy Star ratings with respect to water and electricity consumption.
11. *Energy Efficient Lighting*: Lighting fixtures designed for compact fluorescent light bulbs from Phillips in order to decrease the house's energy consumption.

Design Goals:

This fully self-sufficient solar house was built to demonstrate new technologies to an energy-conscious nation. Solar power is an essential energy alternative needed to help deal with the shortcomings of fossil fuels. Electricity shortages and rolling blackouts, like the ones experienced in California, have become major national energy concerns. Therefore our primary goal is to showcase how solar energy is a feasible supplement to our nation's already strained energy resources. Equally important, our goal is also to educate the public about the practicality and the benefits of solar power.

The Solar House incorporates many architectural design features in order to make it more energy efficient than typical residences. The primary design feature is its orientation. Delaware's geographical latitude dictates that our photovoltaic panels must be inclined at least 20 degrees to the horizontal to maximize exposure to the sun. The house itself is oriented southward so that the slope of the roof maximizes photovoltaic collection. The semi-circular shape of the house is linked to efficiency as well. It is well known that a circle maximizes the area-to-perimeter ratio for any two dimensional shape. The semi-circular shape enables us to maximize floor area while reducing the wall area, thus reducing heat transfer from the inside to the outside. In addition, the unique shape allows us to fit many photovoltaic panels on the roof.

The house itself was designed and built by undergraduate students for the 2002 Solar Decathlon competition. Experts in the fields of construction and green technology were consulted at every step to optimize the design and the methods of installation. In particular, the house had to incorporate a modular construction to enable quick deconstruction, transport, and reconstruction on the National Mall during the contest. Two major regulations for the Solar Decathlon competition (maximum footprint of 800 ft^2 and maximum height of 18 ft) had to be rigorously followed. The house traveled in modular sections from Newark, DE to Washington, DC for the competition and was reassembled in 5 days on the National Mall. The systems that were successfully incorporated into the house are listed above. All of these systems were broken down into components to allow the house to be relocated. Although the house was designed for a competition it still features the all the amenities of a single-family house.