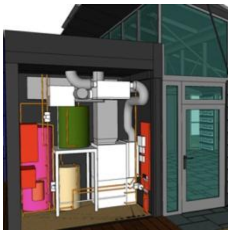
Overview

The Penn State Solar Decathlon Team pursued advanced, high-performance engineering systems for the 2007 competition. The approach was to reduce loads via conservation and efficiency, effectively capture and use solar energy, and reclaim waste energy. Through the integration of cutting-edge mechanical, electrical, and photovoltaic systems into a quality-controlled prefabricated "Technical Core," a reliable, long-term, and cost effective operation was pursued. Occupant feedback systems including the Energy Dashboard help actively educate and involve occupants in everyday decisions such as the timing of laundry and dishwashing, and the choice of lighting schemes.

Goals:

- **Innovate:** Implement solar collection, conversion, and storage systems that are state-of-the-art, energy efficient, flexible, and responsive to the load profile of the Solar Decathlon.
- **Educate:** Demonstrate how renewable energy, energy efficiency , and energy conservation can be integrated into residential construction in an economically feasible and attractive way.
- **Translate:** Simplify and filter the engineering design for the affordable marketable prototype home constructed in Montana on the Northern Cheyenne Reservation.



Mechanical Room

Simulation

Modeling tools were used extensively to inform the MorningStar design process. Software programs used include:

- **3D Design:** *(REVIT and SketchUp)* - To visualize design and construction sequence.
- **Structural Analysis:** *(STAAD Pro 2006)* - To calculate loads and size framing elements.
- **Computational Fluid Dynamics:** *(Phoenics)* - To assess natural ventilation paths.
- **Energy Modeling:** *(Energy 10/Solar Design PRO)* - To inform and assess systems design.
- **Mechanical Design:** *(Advanced Design Suite)* - To calculate the heating load; *(Trane TRACE)* - To calculate the cooling loads.
- **Lighting Simulation:** *(AGI32)* - To assess daylighting and lighting performance.
- **Economic Analysis and Cost Analysis:** *(Excel)* - To evaluate energy efficiency measures with custom spreadsheets.
- **Flow Simulation:** *(Arena)* - To optimize throughput and overall flow of the tour path.

Structure & Envelope

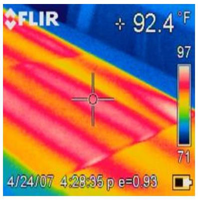
The structure of the MorningStar is built primarily of polyurethane Structural Insulated Panels (SIPs) manufactured in Pennsylvania, and structural steel fabricated locally. **Structural Insulated Panels** are engineered for maximum use of spanning and insulating properties. **Steel Framing** is engineered to support a high-mass home and to be expressive of the architectural concept.

“Breezeway” Steel

Mechanical System

The main components of the mechanical system for the MorningStar Pennsylvania include:

- **Radiant Floor Heating System**: ‘Transportable’ Bluestone floor system constructed of plywood, tubing and aluminum heat transfer panels.
- **Evacuated Tube Solar Collectors**: Preheats domestic hot water.
- **Direct Digital Control (DDC) System:** Controls the systems remotely.
- **Ground Source Heat Pump:** Provides heating and cooling.



Radiant Floor Test

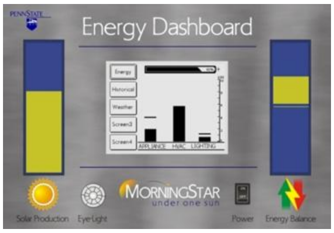
MEP Controls & Monitoring

The **Direct Digital Control** (DDC) system installed within the home provides:

- Control of energy consumption of the mechanical and domestic water equipment.
- Opportunities for innovation through sequencing that respond to changes in the home.
- Opportunities for research into the detailed performance of the mechanical systems.

Energy Dashboard

A unique feature of the MorningStar is the **Energy Dashboard**. This simple monitor provides and records real-time data to teach the occupants about their energy production, facilitate informed decisions and potential behavioral changes, and to further reduce energy consumption.



Energy Dashboard Interface Schematic

Energy Collection, Conversion, & Storage

The MorningStar home has two strategies for energy collection, conversion and storage.

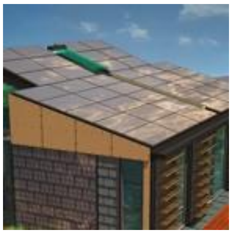
Primary AC system:

- Dual Solar Arrays: A 5.7kW fixed array and a 2.3kW adjustable array.
- Conversion and Storage: Efficiency is gained by providing AC power from the inverter directly to the AC loads, and only storing excess.

Secondary DC System:

- East and west façade arrays of solar slates experiment with building integrated PV applications.
- DC power generated by the secondary system is utilized for LED lighting devices, eliminating the need for an inverter.

Solar Panels



Solar Slates

Lighting & Daylighting

The **MorningStar Lighting Design** was approached as a significant opportunity to experiment and make bold statements in design. The main investigation is how light fixtures, control systems, and daylighting applications can contribute to the overall success of solar design.

The lighting system design was completed using simulation software to effectively distribute the required illumination. Lighting is controlled through a wireless system that permits dimming scene selections. LED lights are powered through a **dedicated DC power system**, and controlled digitally through computer software and weather data.

Future

In 2011, the MorningStar was placed on a permanent foundation at the Center for Sustainability. At this location, the MorningStar is used as a teaching, outreach and research facility.

Research projects planned for the MorningStar systems include:

- Participating in NREL's Solar Building Benchmarking (SBB) project.
- Developing weather responsive control strategies for building control systems.
- Advancing energy storage, such as Lithium Ion batteries.
- Comparing the power consumption of AC powered appliances to DC powered appliances.
- Investigating other sustainable technologies such as wind turbines and ground source heat pumps.
- Advancing partnerships to promote interaction between academia and industry.