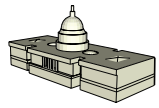
U.S. DEPARTMENT OF ENERGY

SOLAR DECATHLON 2009

THE NATIONAL MALL
WASHINGTON, D.C.
OCT. 9–13 AND
OCT. 15–18, 2009
www.solardecathlon.org

U.S. DEPARTMENT OF ENERGY

SOLAR DECATHLON 2009



U.S. Capitol

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Main Tent

14th Street

Washington Monument

Washington, D.C.

N E S W

- Information
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- First Aid

SOLAR DECATHLON 2009 HOURS

Oct. 9–13 and Oct. 15–18
11 a.m.–3 p.m., Weekdays
10 a.m.–5 p.m., Weekends

Houses are closed Oct. 14 for competition purposes.

Message From the Secretary of Energy

Welcome to the U.S. Department of Energy Solar Decathlon 2009. We are proud to hold this unique competition and to showcase the possibilities of solar power and smart energy use on the National Mall. It is a personal pleasure for me to be a part of the Decathlon because it helps accomplish one of my highest priorities: engaging the next generation of scientists and engineers to help solve the energy problem.

These students are remarkable. For the past two years, they have been designing, engineering, building, and testing solar-powered houses that, ideally, will be self-sufficient. Using off-the-shelf technology, the teams must produce enough electricity and hot water from solar panels to run a modern home with all of the conveniences we've come to expect.

Their work has important real-world applications. Homes and other buildings account for 40% of the energy we use in the United States—more than we use in transportation or industry. There is an incredible opportunity to design and construct living and work spaces that are dramatically more efficient than those we build today. Competitions like this one can lead to new solutions and inspire a new generation of problem solvers.

This competition is also a powerful reminder of the potential of a clean energy economy. President Obama is committed to leading the United States toward a new energy future—to create jobs and ensure our competitiveness, to reduce our dependence on foreign oil, and to reduce our greenhouse gas emissions. The skills these students have learned will be in increasing demand in the years ahead.

The Solar Decathlon shows us what is possible today and points the way to a brighter future. I hope you will take the time to visit the houses, ask tough questions of the competitors, and learn more about the clean energy solutions on display. And, again, welcome.

Steven Chu
Secretary of Energy

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Welcome to Solar Decathlon 2009

Since 2002, the U.S. Department of Energy Solar Decathlon has showcased design excellence in energy-efficient and solar energy-powered home design. The competition challenges 20 college teams from around the world to design, build, and operate the most attractive and efficient solar-powered house. The teams spend nearly two years transforming ideas into reality before transporting their masterpieces to the National Mall in Washington, D.C., for the competition. New this year, all team houses are also connected to the utility grid to take advantage of net metering. The event provides valuable learning experiences for student competitors and market-ready examples of solar and energy-efficient building technologies for the public.

The Solar Village

Take advantage of the opportunity to see the amazing competition houses when their doors **open to visitors Oct. 9–13 and Oct. 15–18**. Please note that the houses are **closed Oct. 14** for competition monitoring purposes. Feel free to ask the students questions, too. They are engaged and passionate about their work.

Walking through the houses, you can see examples of energy-saving techniques and technologies available today. Each house is designed to produce at least as much energy as it consumes, showing the true potential for solar power in everyday living. These zero-energy houses are all connected to the local energy utility, Pepco.

About the Teams

The teams competing this year hail from far and wide, with great representation from the U.S. (including Puerto Rico) as well as Canada, Germany, and Spain. Returning champs from Team Germany will try to extend their reign, while new contenders will raise the bar with innovations. Within each team, the students represent the possibilities that architecture, engineering, and entrepreneurship can bring to a future in which aesthetics and convenience are blended with comfort and efficiency.

We All Win

The winner of Solar Decathlon 2009 will be announced at the **Awards Ceremony on Oct. 16**. This proud team can bask in the glory of knowing that its efforts, and the efforts of its competitors, also contribute to a win for everyone. By moving renewable energy and energy efficiency technologies forward, we all benefit from environmentally sound choices and future economic stability.

How To "Do" the Solar Decathlon

In an Hour

Pick the one or two houses that most interest you. Is your home state or alma mater represented? Pay them a visit! If you're looking for specific designs or technologies, consult pages 10–29 of this program to get a quick preview of what you can expect to see in each house. You might enjoy taking a docent-guided tour of the village or checking out the exhibits, where you can learn about energy efficiency and more.

In Four Hours

Visit two to four houses. Talk with the team members about their strategies and their design inspiration. Check the daily schedule and attend a workshop that interests you. Explore the solar village, including the exhibits.

In a Day

Visit five, 10, or more houses. Take time to learn more about those houses with aesthetics or technologies that appeal most to you. The students are on hand to discuss the process and the inner workings of every component of the houses. Go to a couple of workshops. Stroll through the exhibits in the center of the solar village.

Attend the Ceremonies

Join in the excitement and cheer for your favorite team! The Solar Decathlon Opening Ceremony is at 1 p.m. on Thursday, Oct. 8. The Awards Ceremony is tentatively scheduled for 8 a.m. on Friday, Oct. 16. This is when the overall winner of Solar Decathlon 2009 is announced. (Dates and times may be subject to change. See the Solar Decathlon Web site at www.solardecathlon.org for current information.)

Visit the Houses

Oct. 9–13 and Oct. 15–18
11 a.m.–3 p.m., Weekdays
10 a.m.–5 p.m., Weekends

The Solar Decathlon teams are here to compete. They're also here to share with you what they have learned. The houses are demonstrations of the latest in energy efficiency and renewable energy designs and products and the best in home design.

On Oct. 14, all houses are closed for competition purposes. In addition, during some public exhibit hours, some of the team houses may be temporarily closed for competition purposes. During these periods, the teams perform rigorous performance tests on their houses.

Exhibits and Events

Educational Exhibit Hours

The public is welcome to visit the exhibits every day Oct. 9–18 during daylight hours.

Anatomy of a House

Located near the Metro Welcome Tent, this exhibit provides tips on saving energy for homeowners and includes fun, interactive features. The exhibit includes demonstrations of several building technologies used in the competition houses as well as a representation of a grid-connected photovoltaic (PV) system that shows how a PV system is set up for a typical home. This is similar to how the Solar Decathlon 2009 competition houses are connected to the utility grid.

Get Smart: Take Charge of Your Energy!

Complementing Anatomy of a House, this exhibit demonstrates how smart choices can deliver us into a smart energy future.

Workshops

Free workshops are offered most days on the east end of the solar village. Workshop titles and presenters are listed in this schedule.*

Friday, Oct. 9

10 a.m.	*How Can We Make the Most of Our Energy?*, Schneider Electric
11:30 a.m.	*Solar for the Homeowner*, U.S. Department of Energy
1 p.m.	*Green Jobs*, American Institute of Architects (AIA)
2:30 p.m.	*Energy Efficiency for the Homeowner*, U.S. Department of Energy

Saturday, Oct. 10

10 a.m.	*When the Stars Align*, D&R International
11:30 a.m.	*Solar for the Homeowner*, U.S. Department of Energy
1 p.m.	*How Solar Works for Residential Customers*, BP
2:30 p.m.	*Making Smart Choices To Manage Your Electric Bill*, Pepco
4 p.m.	*Energy-Efficient Lighting Solutions for the Home*, Schneider Electric

Sunday, Oct. 11

10 a.m.	*Energy Efficiency for the Homeowner*, U.S. Department of Energy
11:30 a.m.	*Solar for the Homeowner*, U.S. Department of Energy
1 p.m.	*Solar Panels and the Smart Grid*, Pepco
2:30 p.m.	*Solar Home Basics and Incentive Programs*, BP
4 p.m.	*Energy Efficiency for the Homeowner*, U.S. Department of Energy

Monday, Oct. 12

10 a.m.	*Green Jobs*, U.S. Department of Energy
11:30 a.m.	*Solar for the Homeowner*, U.S. Department of Energy
1 p.m.	*Building for the Future: Sustainable Home Design*, American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
2:30 p.m.	*High-Tech Consumer Products*, Texas Instruments

Tuesday, Oct. 13
No Workshops

Wednesday, Oct. 14
No Workshops

Thursday, Oct. 15
Building Industry Day

9 a.m.	*Top 10 Green Project Awards*, AIA
10 a.m.	*Investing in a Sustainable Future*, ASHRAE
11 a.m.	*Solar Converter Integration Into Microgrid*, Schneider Electric
12 p.m.	*LEED for Homes: Green From the Ground Up*, U.S. Green Building Council (USGBC)
1 p.m.	*Incorporating Solar Into Residential New Construction*, BP
2 p.m.	*Benefits of the Smart Grid*, Pepco
3 p.m.	*Solar at Night – Solar LED Applications,* Meteor Solar LED Lighting
4 p.m.	*Inside the Utility Room: The Biggest Opportunity for Residential Energy Savings*, Honeywell
5 p.m.	*Electronics – The Other Silicon in Solar*, Texas Instruments

Friday, Oct. 16

11:30 a.m.	*Panel: The Leadership of Today*, Popular Mechanics
1 p.m.	*LEED for Homes and ReGreen: Solutions From Remodel to Gut-Rehab*, USGBC
2:30 p.m.	*Panel: Toward a Clean Energy Future – Technology Solutions for Near-Zero Energy Buildings in a Low-Carbon Economy*, ASHRAE/AIA/USGBC
4 p.m.	*Green Jobs*, U.S. Department of Energy

Saturday, Oct. 17

10 a.m.	*Panel: The Architects of Tomorrow*, Popular Mechanics
11:30 a.m.	*Solar for the Homeowner*, U.S. Department of Energy
1 p.m.	*Energy Efficiency for the Homeowner*, U.S. Department of Energy
2:30 p.m.	*Green Building Standards and Guidelines*, National Association of Home Builders (NAHB)
4 p.m.	*Green Jobs*, U.S. Department of Energy

Sunday, Oct. 18

10 a.m.	*Spray Foam – The Answer to the Energy Challenge*, Demilec USA
11:30 a.m.	*Solar for the Homeowner*, U.S. Department of Energy
1 p.m.	*Insulation's Role in a Home's Energy Performance: The Case for High-Performance Insulation*, Honeywell
2:30 p.m.	*Green Building Standards and Guidelines,* NAHB
4 p.m.	*Green Jobs*, U.S. Department of Energy

**Workshop schedule is subject to change.*

Who's Who at Solar Decathlon 2009

The real "who's who" of the Solar Decathlon belongs to the students, whose talent, energy, and commitment are second to none. In the following pages, you will learn more about the students and teams. Here, the Solar Decathlon 2009 jurors and organizers are recognized.

Jurors

The Solar Decathlon values the contribution of its distinguished jurors, who are all leaders in their fields. For biographical and contact information, please refer to the Solar Decathlon Web site at www.solardecathlon.org.

Architecture

Kevin Burke
William McDonough + Partners

Jonathan Knowles
Rhode Island School of Design

Sarah Susanka
Susanka Studios

Engineering

Richard Bourne
Davis Energy Group (retired)

David Click
Florida Solar Energy Center

Ted Prythero
M-E Engineers

Market Viability

James Ketter
Tierra Custom Homes

Joyce Mason
Pardee Homes

Paul Waszink
P.H. Waszink – Construction Consultant

Communications

Maureen McNulty
D&R International Ltd.

Jaime Van Mourik
U.S. Green Building Council

Alan Wickstrom
BuildingOnline Inc.

Lighting Design

Nancy Clanton
Clanton & Associates

Ron Kurtz
Randy Burkett Lighting Design

Naomi Miller
Naomi Miller Lighting Design

Organizers

U.S. Department of Energy

Solar Decathlon Director: Richard J. King

Betsy Black, Kevin Brosnahan, Sheila Dillard, Roselle Drahushak-Crow, John Horst, Christopher Powers, James Rannels, Pete Simon, and Phil West

Akoya, Capitol Exhibits, D&R International, Oak Ridge Institute for Science and Education operated by Oak Ridge Associated Universities, and Strat@comm

National Renewable Energy Laboratory

Carol Anna, John Boysen, John Chase, Mike Coddington, Sue Donaldson, Sara Farrar-Nagy, Shauna Fjeld, Pamela Gray-Hann, Sheila Hayter, David Hicks, Lee Ann Holwager, Alicen Kandt, Ruby Nahan, Michael Oakley, Robi Robichaud, Gary Schmidt, Byron Stafford, Kristin Tromly, Amy Vaughn, Joe Verrengia, Cécile Warner, Chris Wassmer, and Mike Wassmer

Amélie Company, Colorado Code Consulting, Hargrove, Carolynne Harris, John E. Kelly & Sons Electrical Construction, Linder & Associates, Mountain Energy Partnership, New Resources Group, Quatrefoil, Showcall, Sprint, Strat@comm, Takeoffs Construction Estimating, and John Thornton

A Look at the Competition

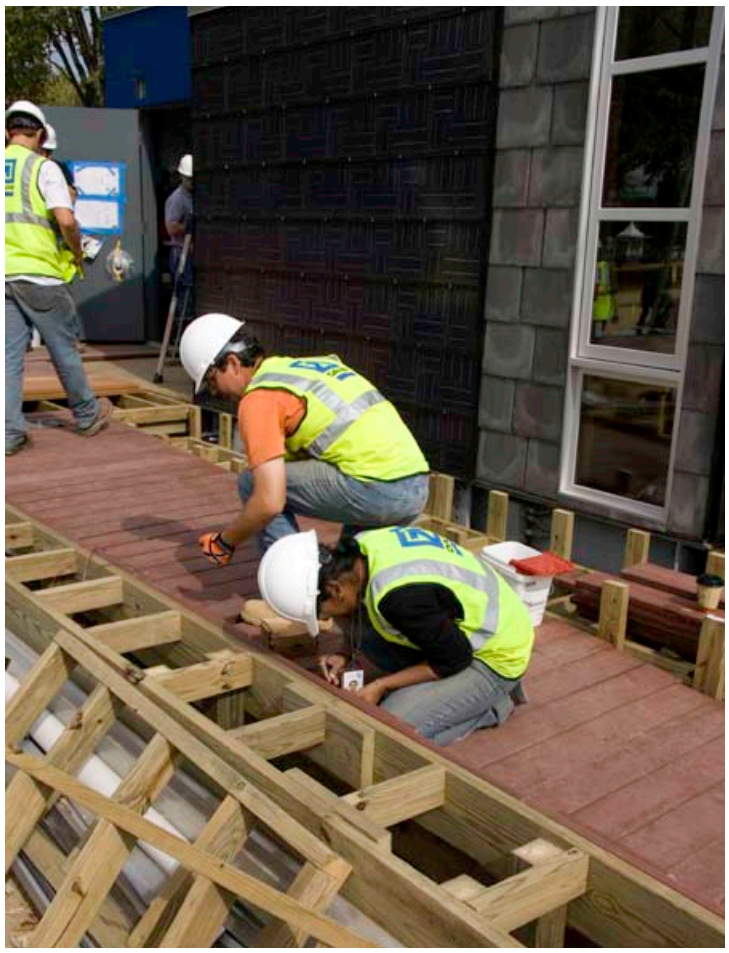
Solar Decathlon 2009 consists of contests that focus on design excellence and the ways we use energy in our daily lives. There are 10 contests, just as in the Olympic Decathlon. In this section, you'll find information about the contests and how they are scored.

To compete, the teams must design and build energy-efficient houses that are powered exclusively by the sun. The houses must be attractive and easy to live in. They must maintain comfortable and healthy indoor environmental conditions, feature appealing and adequate lighting, supply energy to household appliances for cooking and cleaning, power home electronics, and provide hot water. These houses must be zero-energy homes, meaning their energy production equals or exceeds their energy consumption over the course of a year. New in 2009, the houses must also be net-metered and connected to the electric utility grid.

The competition is an exciting time for competitors and spectators alike, but it is not without challenges and conflicts. For example, the public wants to visit the houses, but the juries need access to the houses to judge them fairly. This means that some of the houses must be closed to visitors during the public visiting hours when the juries are making their rounds. Rest assured that most other houses will be open at these times, and Solar Decathlon staff and volunteers can direct you to them. **Please note that there are no team house exhibits or workshops on Wednesday, Oct. 14**, when all of the houses must be closed for uninterrupted performance monitoring.

Solar Decathon 2007 Madrid team members show their delight at receiving the third-place award in the Architecture contest. (Credit: Kaye Evans-Lutterodt/Solar Decathlon)

Solar Decathlon 2007 winner Team Germany shows off its first-place trophy. (Credit: Kaye Evans-Lutterodt/Solar Decathlon)



Penn State team members work together to install the deck around their Solar Decathlon 2007 house. (Credit: Jim Tetro Photography/Solar Decathlon)

A Look at the Competition

Scoring

Contests are scored three ways:

- By measured performance (such as meeting indoor temperature and humidity requirements)
- By completion of contest-related tasks (such as washing dishes and doing laundry)
- By the evaluation of juries made up of experts in architecture, engineering, and other appropriate fields.

Some contests are scored subjectively by the juries, some are scored objectively by performance and task completion, and some are scored by a combination of these methods.

The 10 Contests

Architecture (100 points)

Teams are required to design and build attractive, high-performance houses that integrate solar and energy-efficiency technologies seamlessly. A jury of professional architects evaluates team construction documents and the final constructed house. It evaluates three main factors: architectural elements, holistic design, and inspiration.

Market Viability (100 points)

Teams build their houses for a target market of their choosing. They are then asked to demonstrate the potential of their houses to keep costs affordable within that market. A jury of professionals from the homebuilding industry evaluates how well suited the house is for everyday living, determines whether the construction documents would enable a contractor to construct the house as intended, and assesses whether the house offers potential homebuyers within the target market a good value.

Engineering (100 points)

The houses are marvels of modern engineering, and this contest "checks under the hood." A jury of professional engineers evaluates each house for functionality, efficiency, innovation, and reliability.

Lighting Design (75 points)

Teams earn points in this contest by designing functional, energy-efficient, and aesthetically pleasing lighting systems. The jury evaluates the teams' lighting designs, which are required to integrate both electric and natural light, from functional and aesthetic standpoints. Points are also awarded for energy efficiency.

Competition Schedule

Public Exhibit Hours	Closed to Public	11 a.m. to 3 p.m.	10 a.m. to 5 p.m.	10 a.m. to 5 p.m.	11 a.m. to 3 p.m.
Contests	**Thursday, Oct. 8**	**Friday, Oct. 9**	**Saturday, Oct. 10**	**Sunday, Oct. 11**	**Monday, Oct. 12**
Architecture (100 points)		Architecture Jury visits team houses			10 a.m.
Market Viability (100 points)		Market Viability Jury visits team houses			10 a.m.
Engineering (100 points)	Opening Ceremony at 1 p.m.				Engineering Jury
Lighting Design (75 points)					Lighting Design Jur
Communications (75 points)		Communications Jury visits team houses			
Comfort Zone (100 points)		Indoor temperature and humidity measurements			
Hot Water (100 points)		Hot water draws			
Appliances (100 points)		Refrigerator and freezer temperature measurements , dishwashing and clothes washing			
Home Entertainment (100 points)		Cooking, lighting, dining, computer, and home theater tasks			
Net Metering (150 points)		Measurement of electricity produced and consumed			

To accommodate contest activities such as judging and taking measurements, some of the houses will be closed some of the time during public hours.
*Times subject to change.

Communications (75 points)
The Solar Decathlon challenges teams to communicate the technical aspects of their houses, as well as their experiences, to a wide audience through Web sites and the public exhibit of their houses on the National Mall. The Communications contest awards points based on their success in delivering clear and consistent messages and images that represent the vision, process, and results of their project. A jury of Web site development and public relations experts evaluates the team Web sites, communications plans, and National Mall exhibits for effectiveness.

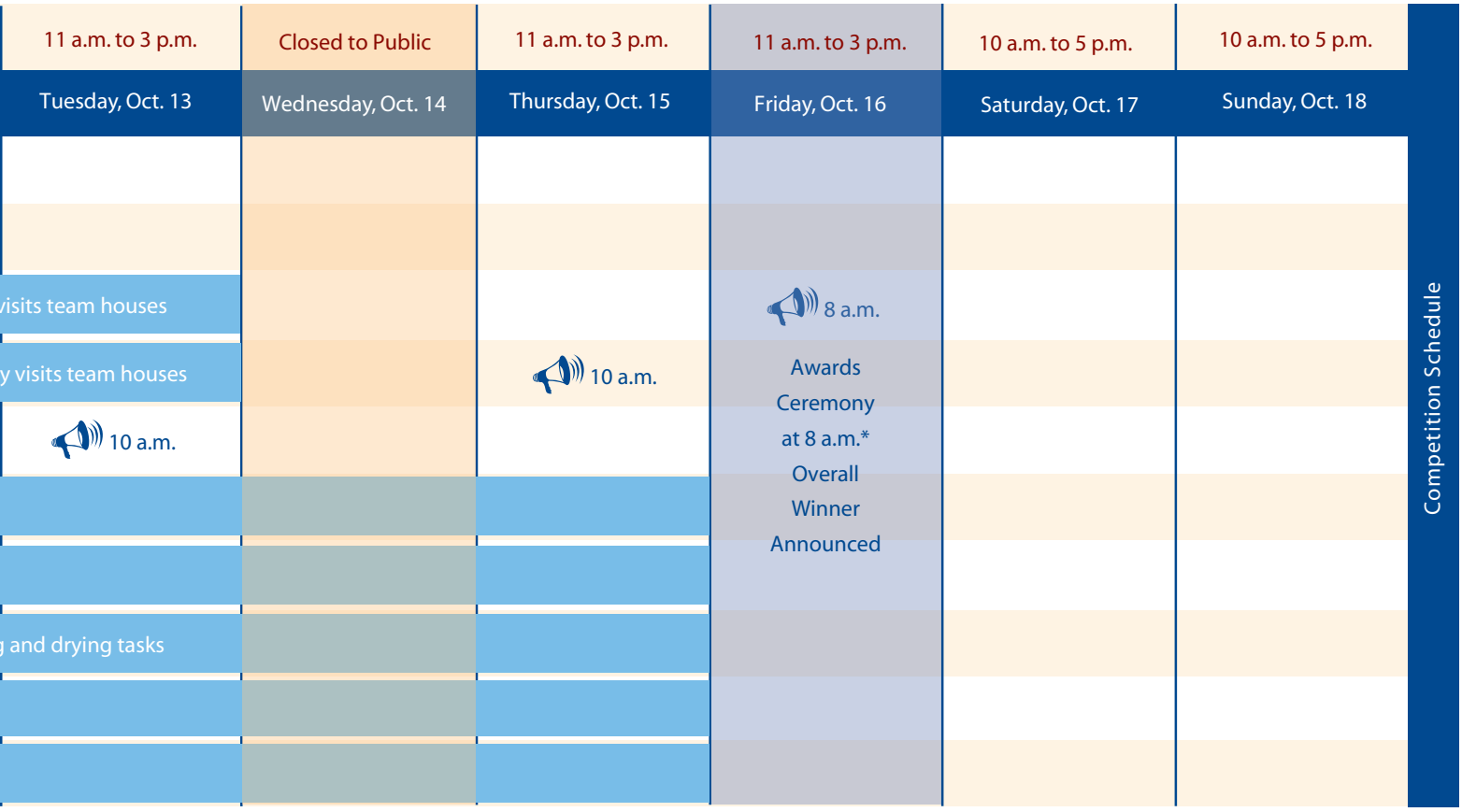
Comfort Zone (100 points)
Teams design their houses to maintain steady, uniform indoor environmental conditions. Full points are awarded for maintaining narrow temperature and relative humidity ranges inside.

Hot Water (100 points)
The Hot Water contest demonstrates that the water heating system can supply all the hot water that households use daily for washing and bathing. Teams score points by successfully completing several daily 15-gallon "hot water draws."

Appliances (100 points)
The Appliances contest is designed to mimic the appliance use in the average U.S. home but using less energy. Points are earned for refrigerating and freezing food, washing and drying laundry, and running the dishwasher.

Home Entertainment (100 points)
The Home Entertainment contest is designed to demonstrate that houses powered solely by the sun can provide a comfortable setting with power for the electronics, appliances, and modern conveniences we love. The Home Entertainment contest gauges whether a house has what it takes to be a home. How well does it accommodate the pleasures of living, such as sharing meals with friends and family, watching movies in a home theater, and surfing the Web? How well does it accommodate a small home office for a telecommuter?

Net Metering (150 points)
Solar Decathlon 2009 features a Net Metering contest. Each house is equipped with a utility meter that enables competition organizers to measure how much net energy the house produces or consumes over the course of the competition. Teams score points for producing as much or more energy than they consume.



About the Technologies

The design strategies and technologies at work in the Solar Decathlon houses are intended to produce zero-energy homes (ZEHs), which produce as much electricity from renewable sources as they consume. The Solar Decathlon competition, and particularly the Net Metering contest, encourages teams to design for net-zero energy consumption and redirect surplus energy into the utility grid. Some common technologies and products employed by the teams are explained here.

Energy-Efficient Lighting – Practical, affordable, and widely available, compact fluorescent lamps (CFLs) are energy-efficient lamps that work in standard incandescent fixtures and provide lighting levels comparable to those of conventional lamps. Light-emitting diode (LED) lighting is a highly efficient strategy for supplementing daylighting. An LED can operate with increased efficiency for more than 50,000 hours—50 times longer than an incandescent bulb. Although relatively expensive, LEDs present many advantages over traditional light sources, including lower energy consumption, longer lifetime, and smaller size.

Energy Recovery Ventilators – Energy recovery ventilators provide fresh outside air while minimizing energy loss and costs. These ventilation systems transfer heat between cooler and warmer air sources to regulate climate control and circulate air. There are two types of energy-recovery systems: heat-recovery ventilators and energy-recovery ventilators. Whereas a heat-recovery ventilator transfers only heat, an energy-recovery ventilator also transfers water vapor, thereby maintaining even humidity within the house throughout the year.

Technology Acronyms & Abbreviations

AC	*alternating current*
DC	*direct current*
CFL	*compact fluorescent lamp*
GSHP	*ground-source heat pump*
HVAC	*heating, ventilation, and air conditioning*
LED	*light-emitting diode*
LEED	*Leadership in Energy and Environmental Design*
PV	*photovoltaic(s)*
SIP	*structural insulated panel*
ZEH	*zero-energy home*

Ground-Source Heat Pumps – A ground-source heat pump (GSHP) is an energy-efficient central heating and cooling system that takes advantage of relatively constant ground temperatures to draw heat to or from the ground, depending on the season. Also known as a geothermal heat pump, a GSHP forces the transfer of heat by passing it through a loop of refrigerant pumped through a vapor-compression refrigeration cycle. Because Solar Decathlon teams are not permitted to break ground on the National Mall to install their own GSHP systems, they are simulating the earth with water bladders.

High-Performance Windows – Windows provide natural light, but they can also negatively affect a home's energy efficiency. Low-emissivity (low-e) coatings for windows are thin, transparent coatings of silver or tin oxide that pass visible light through while reflecting infrared heat radiation into the room, which is particularly beneficial in winter months. Efficiency can also be significantly improved with gas-filled windows. The space between panes is filled with a colorless, odorless gas that transfers less heat than air. Electrochromic technology allows homeowners to electronically adjust the amount of light and heat that pass through windows. A small voltage applied to electrochromic glass causes it to darken; reversing the voltage causes it to lighten. Darkening the windows in summer reduces solar heat gain; in winter, the windows lighten so sunshine brightens and warms the house.

Insulation – The type and placement of insulation are important considerations for energy efficiency because heating and cooling account for nearly half of a home's energy consumption. A home's insulation is rated according to its resistance to heat transfer. R-value rates heat transfer resistance—the higher the value, the better the insulation. U-value, generally used for rating windows, also quantifies heat transfer—the lower values are better. The U.S. Department of Energy recommends ranges of R-values based on local heating and cooling costs and climate conditions. Visit www.eere.energy.gov/consumer/tips/insulation.html and enter your zip code for the recommended insulation levels for your new or existing home.

Passive Solar Design and Daylighting – By properly locating and designing a home, you can naturally capture solar energy and reduce the size of, or completely eliminate, mechanical systems for heating and cooling. Design elements include window overhangs and proper window sizing and placement. South windows, for example, harness heat from the winter sun. Shading elements such as large overhangs and shrubbery minimize heat in the summer. Similarly, daylighting design features such as clerestory windows, glass doors, floor-to-ceiling windows, and skylights provide natural light for home activities and reduce the need for electric lighting.

Phase-Change Materials – Phase-change materials can store energy efficiently within the walls and ceiling of a home and are primarily employed for space heating and cooling. Materials with high melting points store heat (or cold) effectively and release it when the temperature changes by converting a solid to liquid and vice versa. To cool a space, excess hot water or air is run over the phase-change material, which absorbs the extra heat and melts. To heat, the reverse occurs, and the phase-change material solidifies, thereby releasing heat into the space.

Photovoltaics or Solar Electricity – When most people think of solar technologies, they think of solar thermal panels or photovoltaic (PV) panels. PV panels generate electricity by absorbing light energy from the sun, which triggers an electric current. Most commercially available PV panels are made of silicon cells. Many currently available solar cells are configured as bulk materials that are subsequently cut into wafers. Other PV materials are configured as thin films that are deposited on supporting materials. PV systems are often situated on rooftops, but they can be installed on poles or other structures with adequate exposure to the sun. The power they generate is measured in kilowatts (kW). Building-integrated photovoltaics are photovoltaic materials that replace conventional building materials in parts of the building envelope such as the roof, skylights, and facades.

Solar Water Heating – Solar water heaters are generally more cost-effective than PV and generate hot water for domestic use. Solar water heating systems typically include storage tanks and solar collectors, which harness solar energy to heat water or other fluids such as antifreeze. The heated water is stored in a well-insulated storage tank.

Structural Insulated Panels – Made of foam insulation sandwiched between sheets of oriented strand board or other building material, structural insulated panels (SIPs) are prefabricated structural elements for building walls, ceilings, floors, and roofs. They provide superior and uniform insulation compared with more traditional construction methods (e.g., stud or "stick frame") and offer energy savings of 12%–14%. When installed properly, SIPs also provide a more airtight dwelling, which makes a house more comfortable and quieter. SIPs have not only high R-values but also high strength-to-weight ratios.

Harold Remlinger and Brian Eady install solar panels on the roof of the Solar Decathlon 2007 Lawrence Technological University house. (Credit: Kaye Evans-Lutterodt/Solar Decathlon)

Important Terminology

Energy Monitoring Systems – Energy monitoring systems are an efficient and effective way to survey a home's energy use and trends. Greater control over and understanding of energy use means improved energy efficiency and reduced energy costs. By knowing when a household demands the most energy—for example, in the evening hours when multiple appliances run concurrently—homeowners can alter their energy use habits to minimize energy costs and environmental impact.

Greywater – Greywater is wastewater that originates from domestic processes such as dish washing, laundry, and bathing. Recent concern over water consumption and treatment and efforts at greater water efficiency have led to the recycling of filtered greywater for domestic and agricultural uses, such as for garden irrigation or for flushing toilets.

Net Metering – Net metering is a utility billing policy that encourages people to generate their own electricity. It involves a single meter that spins forward when electricity is drawn from the grid and backward when electricity is fed to the grid. That way, electricity producers are effectively compensated at the retail rate for the electricity they supply to the grid (as long as it is less than the electricity they consume). Without net metering, self-generators are typically compensated at a lower wholesale rate for the electricity they produce.

101 | University of Wisconsin-Milwaukee

Team Web site: www4.uwm.edu/uwm_sd09

Meltwater: A Sand County Solar House

Aldo Leopold, author of the famous *A Sand County Almanac*, which promotes conservation and nature awareness in his home state of Wisconsin, would be proud of the students on the University of Wisconsin-Milwaukee's Solar Decathlon 2009 team. Their house not only is designed to mimic the glacial-carved lines of their rolling landscape but also is built from construction waste materials—including some timber planted by Leopold himself—from the LEED Platinum Aldo Leopold Foundation headquarters near their campus.

Drawing Inspiration From Nature

"The line of our inverted butterfly-shaped roof represents the valleys and hills created by glacial water," says Eric Harmann, architecture project manager and graduate student. "The rain screen is a representation of the rivers." The inverted roof channels water into a reflecting pool, which irrigates plants on the deck. After the competition, a cistern system will harness rain to water marsh and prairie grasses nearby.

Room With a View

The team designed windows and a large glass-door wall to bring in natural light and ventilation. A 12-by-7-ft (3.7-by-2.1-m) glass door opens to the west. This seems counter-intuitive to controlling heat from afternoon sun, but the door allows views of the Washington Monument during the competition and views of the Menomonee Valley in Milwaukee. The door is protected using automated, vertical sunshades, and all of the windows are triple-paned low-e with argon-filled glazing to control heat from the sun.

Eco-Friendly Materials

Materials from the Aldo Leopold Foundation provide the flooring, much of the casework, exterior cladding, and doors—primarily Forest Stewardship Council-certified for sustainability practices. The team believes this will be the first building in the country to use Paperstone—a "wood" product made, in this case, out of recycled paper from the university's schools of architecture and engineering—for the frames and sashes of its windows.

Thermostats Everywhere

As part of the heating and cooling system, multiple sensors take temperature measurements that are averaged for constant monitoring. The house has two heating, ventilation, and air conditioning (HVAC) zones, so adjustments can be made efficiently. "Ideally, this will allow us to reduce the on-and-off cycling of the HVAC system and run it for less time when it is on," says Eric Davis, engineering student and the team's engineering coordinator.

The HVAC system includes an efficient heat pump and heat recovery system, which has a dedicated connection to the PV system, to decrease energy losses that occur when inverting the solar power from direct current (DC) to alternating current (AC).

Solar Technologies

The house uses solar water heating and PV panels to produce hot water and electricity for the house. A grid-connected, 5.6-kW PV system sends excess electricity back to the power grid. The panels are supported on an operable structure that allows them to be adjusted seasonally following the angle of the sun. The solar hot water system includes two flat-plate solar collectors.

> *"This stuff works! It's viable, not ridiculously expensive, and will pay for itself."*
>
> — Eric Davis, University of Wisconsin-Milwaukee student

The team worked with Fat Spaniel Technologies to develop a home energy monitoring system that includes a live Web interface to display energy demand and production. The display, accessible from any Internet connection, becomes a tool for both education and increased energy efficiency.

Working Together Toward Sustainability

The team says that working with different students, government staff, and industry professionals has brought a much better understanding of the "languages" people in different disciplines speak.

Team Web site: www.beausoleilhome.org

Cajun Culture Meets Solar Innovation in BeauSoleil

When the French-speaking Acadians settled in south Louisiana, they brought a vibrant culture and a determination to adapt their way of life to the warm, humid climate. The name "Acadian" evolved to "Cajun" over the years, but the commitment to *joie de vivre* and the unique regional style remains intact to this day.

Those cultural values are the spirit and inspiration behind BeauSoleil, the house designed and built by the University of Louisiana at Lafayette Solar Decathlon 2009 team. The majority of the team is native to the region and considers the project deeply personal—and it shows.

BeauSoleil, meaning "sunshine" in Cajun French, shares its name with one of Louisiana's first Cajun settlers—Joseph Brousard, nicknamed Beausoleil—as well as a Grammy-winning band from south Louisiana. In fact, the BeauSoleil band lent their name to the project, partnered with the team on promotional efforts (including a music CD), and will perform a free concert on BeauSoleil's porch on the National Mall on Friday, Oct. 16 from 5 to 7 p.m.

The Heart of the Matter

BeauSoleil is a hybrid structure in every sense. It combines long-standing passive solar design concepts with the latest innovations in energy efficiency and solar energy.

The house is reminiscent of a traditional south Louisiana home. In the drier seasons, the north-south orientation takes advantage of local breezes, and floor-to-ceiling, French-style windows maximize ventilation. The windows also provide natural daylighting. Exterior cladding is covered with locally harvested cypress.

In line with Cajun custom, the heart of the house is a covered porch for socializing and entertaining, but the technical features of the BeauSoleil porch introduce new flexibility. The 10-by-10-ft (3.1-by-3.1-m) space between the kitchen and living room is lined by a square track. Transparent sliding doors, part of a specially designed NanaWall® system, rotate 360 degrees around the track. The porch can be transformed from an outdoor space into an interior, conditioned room. Atop the porch is a skylight, partially shaded on the south side by a custom solar water heating system that is integrated into the translucent roof.

Technology Behind the Lifestyle

The electricity that powers BeauSoleil comes from a 7.8-kW system of PV panels on the south-facing portion of the roof that is expected to produce a net surplus of electricity for the competition.

> *"I've been able to build a socially responsible house for the university, the culture, and the state that I love."*
>
> — Gretchen Lacombe-Vanicor, University of Louisiana at Lafayette student

BeauSoleil's exterior cladding is a rain-screen system that allows air to circulate between the siding and the wall, minimizing heat from the sun. Walls consist of 6.5-in (16.51-cm) SIPs, which provide double the insulation of common stud walls and reinforce the strength of the building. The house's efficient HVAC system includes three adjustable zones. A dehumidifier controls summer humidity, which is a serious problem in Louisiana.

The team developed many of the technical features of the house, but the real challenge was seeing the project through to completion. "It's totally eye-opening," says Scott Chappuis, an architecture student and a project architect. "We started building in January. Since then, I've learned as much about how buildings go together as I learned the whole time in school."

103 | Team Missouri (Missouri University of Science & Technology, University of Missouri)

Team Web site: www.solarhouse.mst.edu

Show-Me House—Missouri's Fourth Solar Decathlon Entry

Members of the Show-Me House team refer to their project as a "very Missouri" house. From its long, elegant lines and Missouri oak floors to the reclaimed barn wood in both its furniture and exterior siding, the structure recalls the landscape and heritage of the state.

Missouri houses are a fixture at Solar Decathlon. Missouri University of Science and Technology (Missouri S&T) has been a competitor in all four Decathlons. For the 2009 event, the school is partnering with the University of Missouri-Columbia (MU) to broaden the team perspective and make the Show-Me House more representative of the entire state.

Lessons Learned, Lessons Applied

The 2009 Missouri team abandoned the multi-module house concept, as seen in past Solar Decathlons, in favor of a single, easier-to-transport, 15-by-50-ft (4.6-by-15.3-m) module. A hinged roof tops the house. SIPs in both the roof and walls provide an R-40 insulation value.

The roof supports an 8-kW PV system. Also atop the roof is an evacuated-tube solar water heating system for a variety of home uses, including radiant floor heating.

Designers used natural wood and white walls to increase the sense of interior space. "The house itself is very open," explains Andrew Adams, a civil engineering student at Missouri S&T. "From the entrance, you can see the kitchen, dining, and living rooms." At 375 ft^2 (34.84 m^2), the living room and kitchen area is the largest in the house. The bedroom, with 160 ft^2 (14.87 m^2), opens onto the house's expansive outdoor deck.

Nearly Invisible Control System

The most innovative feature of the Show-Me House is the Chameleon Home Automation System, designed by the team. Through a series of environmental sensors, the system activates heating or air conditioning to ensure indoor comfort. Chameleon can also control humidity, automatically run appliances, and turn lights on and off. It can even open and close windows. Residents program the system with an interface that is accessible via touch screens throughout the house.

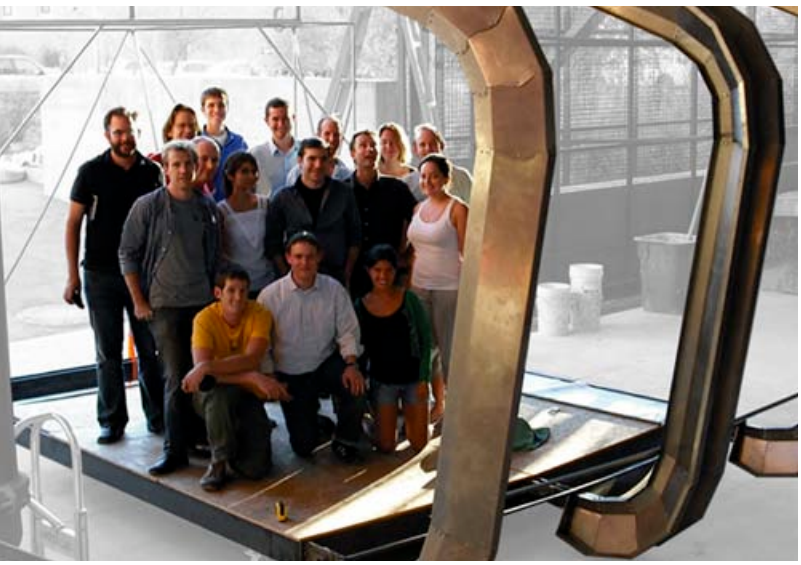
Effective, Electronic Communication

Because the Missouri S&T campus in Rolla is more than 100 mi (160.94 km) from MU in Columbia, inter-campus communication has generally been limited to conference calls, e-mails, and document exchanges, but team members are quick to point out that logistical complications have not diminished the Decathlon experience.

> *"It's really amazing that I can put so much responsibility into my team's hands and things come out so incredibly well. I can't wait to do this in the real world."*
>
> — Cory Brennan, Missouri University of Science & Technology student

"One of the things I've enjoyed most is taking what I've learned in the classroom and applying it in the real world," says Dominic Clucas, an electrical engineering student at Missouri S&T who serves as the team's safety officer. "And some of the friendships we've made. The way we look at each other and laugh. It's a lot of fun."

The house was constructed in Rolla, where the team's previous three Solar Decathlon houses are on display in the campus Solar Village. After the competition in Washington, D.C., the Show-Me House will be transported back to Missouri S&T and added to the village, where it will be used for research projects and student housing.



Team Web site: www.uasolardecathlon.com

Sowing the Seeds of Solar

In nature, seedpods protect and nourish seeds as they grow into plants. The University of Arizona's Solar Decathlon 2009 team is nurturing a vision for an energy-efficient solar house in line with natural principles and available to all. After the competition, the team hopes that the Solar Energy-Efficient Dwelling, or SEED [pod] house, can be easily customized for different tastes and climates and shipped to any location where eco-minded and cost-conscious buyers want to "plant" it. Because the house is modular, customers can size it to fit their needs. The roof angle of the house is adjustable and adapts to a spectrum of solar angles at locations around the world to maximize the efficiency of the solar electric systems.

Matt Gindlesparger, a faculty advisor from the School of Architecture and team project manager, says that the house incorporates both passive (non-mechanical) and active (mechanical) strategies. Building materials come from sustainable sources that are durable, recyclable, and aesthetically appealing.

Blooming Where Planted

To conserve water, a precious resource in Arizona and many other parts of the world, the SEED [pod] features a greywater filter that produces water for its greenhouse. Rainwater is also collected and stored in tanks for use in the greenhouse and for landscaping. Vegetation shades the south wall during the hottest time of the year and can be cut back to take advantage of the sun's heat during winter. The large outdoor deck is made of a permeable material that allows water to run through it to the ground below.

Working With Nature

The team achieved energy efficiency and comfort in the SEED [pod] by looking first to natural daylighting and other passive cooling and heating strategies—such as natural ventilation, strategic insulation placement, and shading of windows and doors—to create a comfortable microclimate inside. Active strategies include efficient heating and cooling systems as well as electronically controlled ventilation shutters.

The south wall of the house has a unique water wall system made of specially designed vacuum-formed clear plastic tanks. The tanks act as "heat sinks," storing heat during the day and deterring it from entering the house and then releasing it slowly after sundown. The team uses the evacuated-tube solar water heating system on the roof to heat water using only the sun to relieve some of the electricity load of the house.

> *"In our design, a greenhouse serves as a biofilter, providing a place for food production, greywater filtration, and air replenishment in the surrounding area."*
>
> — Matt Gindlesparger, University of Arizona project manager

The 8.6-kW PV system incorporates innovative panels, called "bifacial" solar panels, that collect solar energy from both sides of the panels to generate electricity. Used in applications such as carports and shade areas, these panels allow 15% of the daylight to pass through them. A cavity underneath the panels allows for ventilation and up to 30% more efficient panel operation through the collection of ambient light that has passed through the panel or is reflected off surrounding surfaces.

A Smart SEED [pod]

The house features an intelligent building system that monitors energy production and use. Alarms alert occupants when the PV system is not performing properly and can make suggestions when there is surplus electricity available.

Response from the local community is encouraging. "People find the house to be livable and are excited about the technologies," says Adam Strauss, an architecture student.

Team Web site: www.ricesolardecathlon.org

Houston, We Have a House: Rice University's ZEROW HOUSE

From Africa to the Caribbean to the southern United States, "shotgun" houses have been home to low- and middle-income families for centuries. Building on this tradition, the Rice team designed and built the ZEROW HOUSE, a modern interpretation of a shotgun house in a row house community that incorporates affordable, practical, energy-saving solutions.

Instead of building a house just for the competition, the team designed a home they could give back to the community. The team has already negotiated an agreement with Project Row Houses, a neighborhood-based art and cultural organization, to give the ZEROW HOUSE a permanent home in Houston's Third Ward after the competition.

Affordable Energy Efficiency

The team's goal was to build a practical house that demonstrates affordability and energy efficiency using readily available technologies. According to Danny Samuels, Rice team faculty advisor: "We always opted for making it practical. We saw it truly as a market demonstration of what is feasible and possible, to show that an affordable house can be energy-efficient and available to basically everybody."

Architecture student Rebecca Sibley adds that the team chose appliances that minimize electricity use. The house's total lighting fixture energy use is about 250 W—less than three standard, 100-W light bulbs. And at 4.2 kW, the house's PV system is relatively small compared with other Solar Decathlon houses'. According to the team's communications lead, Allison Elliott: "When people come to the National Mall, they can see you don't need a million solar panels. You can do a lot with a smaller array."

Lots of Light Enlarges the House

The house receives the majority of its natural lighting from the "light core," a glass-encased volume inserted into the house that acts as an exterior extension of the living space. A "light cove" provides a wash of light along one wall achieved with state-of-the-art LED strips attached to the walls and ceilings. David Dewane, the team architecture lead, says that "great integration between architecture and engineering" makes the house feel much larger than its 520 ft^2 (48.31 m^2) of interior space.

The community seems to agree. People who have toured the house say it doesn't feel small and that they'd like to live in it. The team met the Housing and Urban Development guidelines of affordability to those with 80% of the area's median income.

> *"The house we built already has a life beyond the Solar Decathlon, so it's important that we get this right."*
>
> — David Dewane, Rice University student and team architecture lead

An Enthusiastic Community

Team members say they're finding the enthusiastic community involvement particularly inspirational. They've had no trouble recruiting volunteers. Contractors have donated time and materials, and union apprentices pitched in by installing plumbing and electrical systems. Although their fundraising efforts have ranged from "exciting" to "heartbreaking," the team hit a high point when one local structural engineer talked colleagues into grouping small donations into a pool, raising $15,000. According to Dewane, "It helped that the affordability and practicality of our design kept costs low."

The team is excited about the Solar Decathlon 2009 competition, but it's also looking forward to the day when it brings the house back to the mission control center of Houston.

106 | Team Alberta (University of Calgary, SAIT Polytechnic, Alberta College of Art + Design, Mount Royal College)

Team Web site: www.solabode.ca

A Whole Lot of Living

The Team Alberta entry packs a whole lot of living—and working and playing—into its limited space. The house includes an open, vaulted-ceiling living room and kitchen area, a stone-clad core area for the bathroom and mechanical systems, a bedroom and home office space, a rooftop deck, a hallway dividing the bedroom and home office from the more public areas of the house, and even a yoga space.

Nurturing an Idea

Fourth-year University of Calgary business student Mark Blackwell describes the Solar Decathlon experience as having: "been my life. It's like raising a baby as a family." This particular family is highly extended, including students from four schools: SAIT Polytechnic (Southern Alberta Institute of Technology), Mount Royal College, Alberta College of Art + Design, and the University of Calgary.

Team member Mike Gestwick reiterates that students at each of the schools nurtured this "baby." "The project really has been 100% student led," he says. "The faculty has been very hands-off." That is, if you don't count Calgary architecture graduate student David Silburn, who says, "All the work we have been willing to put into the house shows the power of the project." Silburn has already parlayed his Solar Decathlon experience into a position as a sustainable architecture faculty advisor at SAIT Polytechnic.

High Tech—and Northwoods

University of Calgary environmental design graduate student Matt Beck says the Team Alberta house is intended "to show off a different side of Alberta—ingenuity, efficiency, and solar technology." And there is plenty of that in the house, with a programmable logic controller that automatically adjusts blinds, a solar-assisted GSHP, an energy-recovery ventilator, and LED lighting (which the team developed because commercial automated dimmable LEDs were not quite available at the time, although they are now). The house even includes a "call for service" function, if there were a problem. The audio system isolates itself from the house's AC power when it is fully charged and runs on higher-quality, lower-draw DC power. The house is also equipped with a 7.6-kW PV system. The TV, which is integrated into the kitchen island, is LED backlit for low power draw. Controls and instrumentation were an important emphasis of the Team Alberta effort.

> *"I came to this school to learn about energy use in buildings. What better way could there be to learn?"*
>
> — Mike Gestwick, University of Calgary environmental design graduate student

At the same time, the house is very much "Northwoods." "Historic post and beam" or "Western Canadian timber frame" in style, the house showcases local stone and wood and was intended to feature local suppliers. In addition to providing materials, local companies responded generously to general fundraising, which, like the entire project, was totally a student effort that went much better than expected.

Premium Market

The Team Alberta house was designed with young, value-driven residents in mind. The combination of sophisticated utility and entertainment systems, traditional exterior and modern interior styles, and the balance of private spaces such as the home office and yoga room with public spaces such as the living area and rooftop deck should serve that market well. The house features lots of "extra" touches such as attractive stone finishes, special-effect lighting (some of which highlights integrated artwork), Web-enabled control of almost everything, and even cutlery designed to match the décor. In keeping with the house's private and public split, an expandable kitchen counter and other features are designed for entertaining large groups.

107 | Team Ontario/BC (University of Waterloo, Ryerson University, Simon Fraser University)

Team Web site: www.team-north.com

Designing for the North

The objective of Team Ontario/BC was to build a house appropriate for the Canadian climate. Toktam Saeid, a mechanical engineering master's student at Ryerson University in Toronto, describes the challenge: "Because we are a Canadian team, we wanted to design for the north and show how to make things work in the north. We therefore have to deal with extremely cold winters and hot and humid summers."

Designing for northern latitudes also meant a different approach to passive solar heating and solar electricity. The team could not count on much power from rooftop panels in the winter but could make good use of low-angle sunlight for much of the year. Thus the south, east, and west sides of North House have floor-to-ceiling windows framed by vertical solar panels to help with winter heating. How will this northern design work in Washington, D.C.? "No problem. October in D.C. fits what we are designing for in summer months," says Saeid.

Looking to the Future

Maun Demchenko, a University of Waterloo graduate architecture student, joined the team in January but has been working on it full time—and then some—ever since. "The interdisciplinary work has been great. We're getting an amazing view to what the future will be like for all of us," Demchenko says.

Teammate Johnny Rodgers, a Master of Interactive Arts and Technology student from Simon Fraser University in Vancouver, British Columbia, says: "The energy and environment are very important to me. We are all very excited to go to Washington. It will be really neat to see what other teams come up with." Rodgers' specialty for the project is developing a computer "living interface system" for North House. Whereas the building mechanical systems will be able to operate automatically, the living interface is designed to give the residents as much feedback as possible.

Compact and Mobile

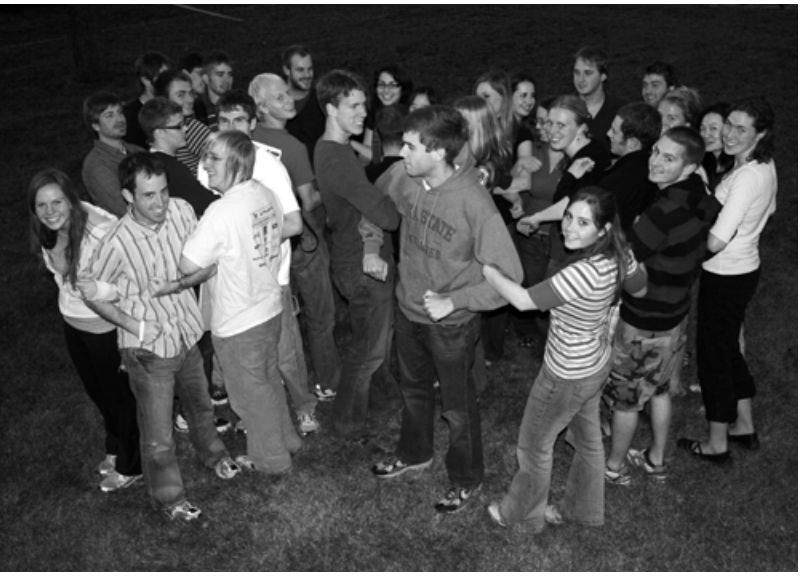
In addition to design that capitalizes on low-angle sunlight and visualizes energy use, the house employs functional furniture that stores away when not needed. The bed retracts to the ceiling, the home entertainment system occupies minimum space, and the entire work space becomes mobile to suit user needs and maximize comfort. In addition, the north side of the house, which houses all the mechanical systems, is clad with a "Swiss Army wall" that is packed with hooks, storage nooks, and as many functions as possible.

Connecting With the Outdoors

Whereas the team describes the house as "minimal contemporary" and "performance-driven in style," it was also designed to be open, light, and airy. Its floor-to-ceiling windows on three sides not only let in warming winter sunlight but also build a strong connection to the outdoors. Dynamic shading on the exterior of those windows can keep out solar heat in the summer or retain heat at night and in the winter.

> *"We tried to maximize available space. We didn't want this to be just a small house but rather a celebration of the small home."*
>
> — Lauren Barhydt, University of Waterloo graduate architecture student

Other incorporated technologies are an 11.9-kW PV system that produces electricity to power the house; salt-hydrate, a phase-change material, in the floor; and cascading storage tanks integrated with evacuated-tube solar collectors. The house also incorporates a heat pump that increases the tank temperatures to provide hot water for heating and household needs and a second heat pump, used for cooling, that is tied to a heat-sink "pond" under the deck.



Team Web site: www.solard.iastate.edu

Solar and Sustainability for Seniors

Interlock House offers seniors a new option for living independently: in a sustainable house as a contributing part of a community. It will become increasingly important to consider the needs of seniors who want to "age in place" because seniors will account for about 20% of the population in 20 years.

Interlock House meets all regulations for accessibility under the 1990 Americans With Disabilities Act. The house is also designed to increase the density of existing communities by incorporating seniors into them instead of taking over undeveloped land. Peter Mauro, the team's architecture project manager, says, "Interlock House is designed to help retirees move onto existing lots, perhaps with their families, interlocking with existing sewer and water systems and social networks." The house's ability to give electricity back to the grid is an added benefit.

Form and Function

The "heart" of the house is an enclosed sun porch on the south, where occupants can relax during all seasons. The sun porch is surrounded by a specially designed, ENERGY STAR®-rated, easy-to-move, glass NanaWall that slides open in good weather to increase ventilation and extend the living space into the outdoors.

Louvers covered with PV materials passively follow the sun. This system maximizes efficiency on a much smaller PV installation without electric motors. The tracking louvers also act as shades for the sunspace, allowing only diffuse light in.

The house is insulated with spray polyurethane foam manufactured from soybean oil (instead of petroleum) that expands and hardens to seal the building, preventing air drafts and moisture infiltration.

Hot Water From the Sun

An evacuated-tube solar water heating system heats the house, supplies domestic hot water, and recharges an innovative desiccant dehumidification system in the summer. Desiccant systems remove humidity from the air. Because it is easier to cool dry air than humid air, the air conditioner operates more efficiently.

Generating Electricity

Two kinds of PV panels make up the 8.9-kW system. The main system consists of typical crystalline silicon as well as an integrated thin-film layer that is estimated to produce electricity more efficiently than similar systems. A smaller array is made of custom thin-film modules integrated into the southern and eastern window louvers as well as into a tracking louver array on the roof.

> *"Interlock House will allow older adults who want to live independently, sustainably, and as part of a neighborhood to age 'in place.' There isn't anything else out there like it."*
>
> — Eric Berkson, Iowa State University architecture student and IT coordinator

Making the House a Home

The team collaborated with students in three College of Design classes—a furniture studio, an advanced ceramic studio, and a file-to-fabrication class—to deck out the house with unique touches. The resulting one-of-a-kind collection includes chairs that can be side tables, bird feeders made of metal and bio-based plastic, and ceramic tiles.

Berkson sums up the learning experience: "This project has served to prepare me for how important sustainability will be in the future. We really can't go forward without using some of these techniques in building design."

Team Web site: www.naturalfusion.org

Fusing Form and Function Through Teamwork

Natural Fusion is the holistic integration of elements. That's the theme for the Penn State Solar Decathlon 2009 house. As the team members began working together, they found that reaching their goal required another principle: interdependence. To reach true integration, it was vital that the students exchange knowledge among their multiple disciplines.

Alyce DiLauro, Penn State's events coordinator, says: "I always wanted to make a difference through volunteering. I used to do everything myself just to make sure things got done. But, in the Solar Decathlon, you have to work as a team."

Penn State's student team leader, Kyle Macht, concurs. A veteran of Solar Decathlon 2007, he found himself in a new role during the 2009 event. "In the 2007 competition, I was the jack-of-all-trades," he says. "Now, I'm leading the team. It's all about collaboration so we can integrate our vision and ideals."

All that collaboration has paid off. The Penn State team has managed to meld nature-inspired aesthetics with functionality.

Using the Power of the Sun

Penn State is employing a new technology called Green Roof Integrated Photovoltaics. This approach combines a solar electric system with plants that help remove heat from the roof. The team is also using a new type of cylindrical, thin-film PV system designed to maximize sunlight collection throughout the day. The 5.1-kW system generates electricity to power the house.

The team put a lot of effort into passive solar and daylighting design. Clerestory windows, tri-fold doors, and solar water heating panels that function without pumps

are all found on the southern façade. The windows and doors provide ample daylight throughout the year. When the doors are open to the deck, the living space expands to the outdoors. The vertical position of the solar panels mimics the design of the tri-fold doors.

A southern overhang blocks the sun's heat in the summer and allows it in during winter. An awning has tracking fins coated in PV material that align themselves for maximum exposure to the sun, thus generating more power.

Buffering Temperature Changes

Natural Fusion uses the concept of thermal mass to regulate indoor temperatures and reduce the house's energy requirements. A water bladder system embedded in the floor and phase-change material in the walls and ceiling store heat during the day and emit heat at night. The phase-change material converts from solid to liquid when the temperature rises and from liquid to solid as the temperature decreases. The water bladder system can be emptied to reduce the house's weight for transport, which, in turn, requires less fuel.

Making It Feel Like Home

Like the exterior, the kitchen features a wall composed of wood slats that can be used like a pegboard to hang shelves, pots, pans, spices, planters, or a combination of these. The Penn State team populated this wall with lush herbs that provide fresh seasoning for cooking and a pleasing, natural visual element for residents.

> *"The Solar Decathlon is helping me grow. I really want to be at the forefront of this green movement."*
>
> — Dan Sutton, Penn State co-architecture project manager

Natural and recycled materials are used throughout the house, including sustainably harvested lumber, reclaimed chalkboards and hardwood flooring, bio-based foams, and paint containing no volatile organic chemicals.

The team has created an impressive house, but the experience each team member has gained may be its biggest legacy.

110 | Team Spain (Universidad Politécnica de Madrid)

Team Web site: www.solardecathlon.upm.es

Siga el Sol—Follow the Sun

Make a squat pyramid of glass—invert it base up, and install both solar electric panels and solar heating water collectors in the upward-facing base. Next, set the tip of the pyramid on a ball-and-socket mechanism pivoted by a solar tracking system like a very slowly spinning or tilting toy top. Put this on top of a house, and you have the essence of the unique Team Spain Solar Decathlon 2009 entry.

Great Art Studio Light

Architecture student and lighting specialist for the project Victor Garcia explains that because the sides of the pyramid are reflective, the house is filled with northern light passing through skylights in the actual roof, plus light passing down through the open tip of the pyramid. Louvers on the sides of the house are also automated to let in natural light without glare or unwanted solar heat—except for a glass conservatory on the southwest corner that helps heat the house when needed. Daylighting is supplemented by highly efficient LED lights, many placed in the skylights. Garcia says, "Energy is what I'm here for," and because of his Solar Decathlon experience, he has chosen lighting design for a master's program.

Black and White House

Just as the pyramid rooftop and louvers automatically follow the sun, the house will follow the sun by crossing the Atlantic Ocean from Spain to the United States. Graduating architecture student Irene Garrido says that the team refers to the house as the "black and white house—but with an orange touch of color," because it meets the yin and yang of high efficiency and comfortable living.

The Black and White House features a 14.9-kW PV system to power the house and a solar water heating system for radiant floor heating and domestic hot water. An electric GSHP, powered by the PV system, provides supplemental heat. When the house is installed permanently, the heat pump will save energy by tapping the thermal mass of moderate-temperature, ground-source water pipes. On the National Mall, a bladder with 8 m^3 of water will provide this thermal mass. Overall, the need for supplemental heating is reduced by passive solar heating from the conservatory and phase-change material in the ceiling and interior walls.

First of Its Kind

Licensed architect team member Jaime Promewongse says the house's solar-tracking top roof may be the first of its kind. The university has filed for a patent on the ball-and-socket, central-pivot system that makes it possible. The rooftop's PV panels, solar thermal collectors, and glass walls provide the house's solar energy.

David Sigüenza says that making the house highly modular was also a primary objective. In addition to making it easy to ship to the Solar Decathlon, this makes the house more marketable, allowing easy addition of extra rooms, addition of the rooftop to existing homes, and sale of the house as a "portable house" under Spanish law.

> *"I was really motivated to help. All of us want to continue working on this. We gained a lot of valuable experience."*
>
> — David Sigüenza, Universidad Politécnica de Madrid economics student

The portability might also come in handy for future use of the house, one option for which is a 2010 sustainable architecture exposition in Shanghai, China.

111 | University of Kentucky

Team Web site: www.uky.edu/solarhouse

Something Old, Something New, Something Blue

Fans of the University of Kentucky men's basketball team often call the team "Big Blue." s•ky blue merges the Big Blue nation with the innovative solar research taking place in Kentucky. And now, the team can add platinum to its color palette. The s•ky blue house exceeds the USGBC LEED for Homes Platinum standards.

Constructed with active energy-efficient systems and technologies, the house is eclectic, historic, and modern at the same time, with both human-made and natural energy sources, each individually and collectively controlled.

The s•ky blue house embodies Kentucky's historic and indigenous breezeway house design—a rectangular building with a central open space that naturally ventilates the house on sultry summer days. The house also captures the beauty and spirit of Kentucky through the photographic images of landscapes integrated into screens on its exterior walls, the sky-viewing ribbon of continuous clerestory windows around the top of each wall, and a deck that blurs indoor and outdoor spaces alongside a selection of native plants.

A Unique Relationship With Light and Space

The team's mantra, "live.light," calls first on passive strategies to lower electrical load and then uses simple, smart, and active solutions to minimize the house's carbon footprint. Integrated lighting strategies balance natural and artificial light sources through an adaptive and controllable system to not only harness the sun's energy via PV cells and solar thermal collectors but also channel light to illuminate an articulated core that anchors the house.

HVAC System

The heating and ventilation system uses a high-efficiency, reverse-cycle chiller coupled with a small thermal storage tank to provide hot water for floor heating and cold water for air conditioning and dehumidification. The house is separated into three radiant heating zones and two cooling zones based on occupancy and use. The house's east-and-

west orientation allows for natural ventilation, and operable windows cross-ventilate the interior and minimize the need for air conditioning.

Optimization

The house features a unique computer monitoring and optimization system so occupants can view and change their energy consumption to meet changing conditions. Based on a weather-monitoring system developed at the university, the system receives zip code-specific, short-term (24- to 72-hour) weather forecasts at three-hour intervals. There's always enough energy, and the system provides occupants with the best scenarios for using it.

Living Under the Sun

The house's 9.9-kW PV system—a single-axis tracking roof array and a fixed array on the south façade—generates electricity. An evacuated-tube solar water heating system and a high-efficiency heat pump provide hot water for domestic use and space heating through a radiant floor heating system. The reverse-cycle heat pump also furnishes cold water for air conditioning and dehumidification.

> *"The s•ky blue house is designed by Kentucky ... for the world. Taking its cues from its surrounding natural context, our s•ky blue house is intended as a catalyst for bringing solar and sustainability to Kentucky and beyond."*
>
> — Gregory Luhan, University of Kentucky architectural team leader

Learning and Teaching

Communications student Renee Human says she's enjoyed learning how the systems work and how to "translate" that information for the public. "A lot of times in communications things are so conceptual," she adds. "To see this living, breathing thing come to life has been exciting. There's always something changing, something new."

Faculty adviser Don Colliver adds, "I'm starting my 30th year with the university, and there have been more teachable moments in working on this project over the past year than in the previous 29 years combined."

Team Web site: www.solardecathlon.osu.edu

"You Win With People"

There's a famous Ohio State University quote by legendary and long-time football coach Woody Hayes: "You win with people." The students on the Ohio State Solar Decathlon team have taken his words to heart, applying hard work and dedication to create a team, a house, and a message that honor the land and people of Ohio.

"That mantra is exactly what this team and project are all about," says environmental policy student and Media Relations Manager Rob Hedge. "The university, alumni, and community have responded to our mission with tremendous 'Buckeye Nation' support. They are proud that we're taking ownership to help solve one of the biggest issues our world is facing."

Architecture student and Co-Lead Designer Deanna Hinkle explains that the team's house is "Ohio-centric," using local materials when possible, Whirlpool® (an Ohio manufacturer) appliances, and reclaimed barn wood on the façade to honor the agricultural heritage of the state.

Design + People = Flexibility

The unusual design invites, and even requires, people living in the house to be aware of environmental conditions outside and participate in the operation and function of their house. The layout features an open interior space, a "blank canvas" that transforms from kitchen to dining room to entertainment room to bedroom as needed. An operable rain screen, part of the outside façade, and louver window shades on the southern façade allow occupants to admit sun and heat into the house in the winter or shade the interior space in the summer.

Solar panels are mounted on adjustable racks to make the most of solar resources. The 5.1-kW PV system will produce enough electricity to power the house. "This adjustable design is ideal because we can optimize the location and angle of the panels for any location—be it Columbus, Ohio, or Washington, D.C., and for any season," says engineering student and Engineering Project Manager Kara Shell.

Efficient Heating and Cooling

For heating and cooling, the design relies primarily on passive design, including an orientation that makes the most of natural ventilation and daylighting strategies, triple-paned windows, and a "second skin" made of reclaimed wood, which both insulates and shades the house. When additional heating or cooling is needed, three split-system heat pumps, using preheated or cooled air from a heat recovery system, are available. In spring and fall, when less cooling is needed, only one system needs to operate. During summer, all systems can be used to maintain comfort.

> *"We want people to be aware of the energy they use and ways they can conserve. This is an opportunity for a bunch of students to make a difference."*
>
> — Kara Shell, Ohio State University engineering student

A Winning Team

The team itself is a dedicated and enthusiastic group of 60 undergraduate and graduate students from 19 majors. Faculty Co-Advisor Mark Walter is proud of the team's student focus and points out that every aspect of the project, including the construction, has been done by students.

Students learned how to work as a team, communicate across age and disciplinary boundaries, and negotiate to find the middle ground where everyone contributes to the best design possible. They are confident that their hard work and team effort will help them score well at the Solar Decathlon. Perhaps even more importantly, they hope to win the hearts and minds of their community by educating it about the importance of using these kinds of design ideas to save energy in their own homes.

113 | Team Boston (Boston Architectural College, Tufts University)

Team Web site: www.livecurio.us

Empowering Homeowners To Live Sustainably

Curio.House was designed by Team Boston to trigger curiosity about how well-designed homes can help save energy and money and improve the health of the planet. The team, a collaboration between Boston Architectural College and Tufts University, has satisfied that curiosity by incorporating an energy-monitoring system into its house. This system provides real-time feedback so homeowners can know exactly how much energy they are using, when they are using it, and how to adjust their habits to reduce their energy bills and environmental impact. The system employs a Web-based display that can be accessed from a home computer, Internet connection, or iPhone. In this house, designed to perform during the frigid Boston winters, energy will come mostly from the sun and be conserved a variety of ways.

Solar Electric Panels and Micro-Inverters

The house employs a 6.4-kW PV system to generate electricity. These panels connect to inverters that convert the DC to AC so energy can be used in the house and fed into the electricity grid. Instead of a centralized inverter configuration, with many panels feeding into a single large inverter, Team Boston is using micro-inverters that attach to each PV panel. This method gives the homeowner flexibility, allowing for easy repair, replacement, modification, and expansion of the system.

Solar Water Heating System

The house uses a flat-plate system to provide most of its hot water. Tubes within the collectors are filled with liquid that absorbs heat from the sun. To avoid freezing in the sub-zero temperatures of Boston winters, the liquid contains an organic-based glycol. The heated liquid is then transported to a heat exchanger that transfers the heat to the household water.

Daylighting and Solar Heat Retention

Daylight streams through the expansive windows on the north and south sides and reduces the need to use the energy-efficient fixtures, fitted with LEDs and CFLs. In the summer, exterior roller shades and an overhang on the south roof block the sun and help keep the house cool. In the winter, the southern "heat glass" windows capture the heat to provide warmth throughout the night. Polycarbonate panels on the north window frames decrease heat loss and help block winter winds.

Appealing to a Wide Market

Curio.House aims to attract homebuyers with varying degrees of technical expertise. As Boston Architectural College student and Project Manager Colin Booth says, "My grandma might not want to see all the data available in the monitoring system, but it could still allow her to set her own targets for consumption, rather than being told how to live."

> *"Research shows that when you present people with identical products, except one of them is sustainable, people choose the sustainable product."*
>
> — Ben Steinberg, Tufts University project director

Others, however, may dig deeper into the monitoring data so they can make more refined adjustments, such as expanding a solar array or using the exterior window shading at different times of day.

"It's about information, not about being controlled, and becoming comfortable interacting with the technology," Booth says. "We believe that this is a crucial part of sustainable living—getting average people to be curious and engaged."

114 | Team Germany (Technische Universität Darmstadt)

Team Web site: www.solardecathlon2009.de

Sustainably Encased

Team Germany started with a "focus on the façade," creating a house that is essentially a two-story cube. The surface is covered with solar cells: an 11.1-kW PV system made of 40 single-crystal silicon solar panels on the roof and about 250 thin-film copper indium gallium diselenide solar panels on the sides that is expected to produce an incredible 200% of the energy needed by the house. The side panels are slightly less efficient than the silicon panels but will perform better in cloudy weather. The façade is made of highly insulating, custom vacuum insulation panels plus phase-change material in the drywall to maintain comfortable temperatures and automated louver-covered windows to control passive solar gain.

Standing on the Shoulders of Giants

The 2009 German team is relatively small with only 24 students, mostly architects. But Sardika Meyer relates how many others took part. "Even my boyfriend, all the families and friends got involved," she says. "We had so much support. It was really incredible." And although the team members are all new, several people from the 2007 first-place team are still around. "They are like big brothers, looking over our shoulders, teasing us," says Franziska Hartmann. The team is also grateful for help from the university and many equipment manufacturers.

Evolution of an Idea

"In the beginning, there were 16 individuals with 16 ideas of the 2009 house," explains Annike Gaigl. "We had an internal competition and now are building only this one house. It is absolutely amazing having the chance to realize our own vision, from planning up to the last screw." Patrick Tauchert says that that evolution was a big part of the learning experience for him. "We started with a vision but had to consider both German and American building codes as well as Decathlon rules as plans became more definite," he says. "We also had to make cost and material availability compromises, such as giving up on prototype flexible thin-film photovoltaic cells that we really wanted."

Living in Maximum Solar Architecture

The Team Germany house epitomizes the architectural single-room concept. Other than the bathroom and a small, open, second-level gallery above it, the house is a single, multifunctional room. Every window affects the lighting for the whole house, and nonreflective materials and controllable LED lighting provide a warm atmosphere. Custom equipment and furniture maximize the utility of the living space, and all of the furniture, including the bed and entire kitchen, can be stored or serves multiple functions.

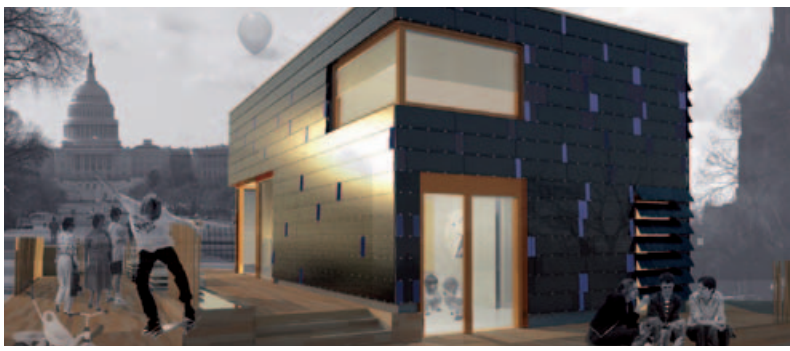
With its multiple-use possibilities, but limited private space, this "aesthetic solar architecture" is intended for open-minded young couples, singles working from home, and people who travel a lot.

> *"We are now part of the solar market; we're kind of experts. For the first time in our lives, we're taken seriously; somebody listens to us. It has become really special."*
>
> — Franziska Hartmann, Technische Universität Darmstadt fourth-year architecture student

Technologies and Features

The Team Germany house features an electric air-source heat pump system that provides all of the house's heating and ventilation needs, most of its cooling needs, and domestic hot water. This system can be upgraded to a ground-source system with permanent installation. The house also features phase-change material in the walls and ceiling that reduces heating and cooling needs and an automated operation system that controls the heat pump, window louvers, lighting, multimedia entertainment system, and appliances.

Team Germany aims to demonstrate innovative sustainable design and make it an object of discussion. Its architectural vision offers an alternate lifestyle that introduces the concepts of energy efficiency and sustainability as substantial elements of everyday life.



Team Web site: www.solar.arch.vt.edu

Lumenhaus—Bright Ideas With an International Focus

Virginia Tech is the only U.S. team participating in both Solar Decathlon 2009 and Solar Decathlon Europe 2010. The team members are excited to compete in both competitions, though they feel some added pressure going up against 40 student teams from around the world. They are confident that the Lumenhaus will score both during and after the competition—bringing new ways of living, designing, and working to team members and communities near and far.

Lumenhaus Delivers a Brighter Day

The central theme of Lumenhaus is light. A pavilion design features sliding north and south walls made of glass. The glass walls can be completely opened to allow air as well as light into the house and also can expand the footprint of the house onto the decking and outdoor space. Skylights in the bathroom bring natural light into the farthest interior spaces and allow for a translucent membrane ceiling. The lighting system features dimmable fluorescent fixtures with daylight sensoring that allows diffuse light to filter throughout the house to maintain consistent light levels when the house is occupied.

Responsive Architecture

"We're really focusing on bringing the outside in and vice versa and on responsive architecture," architecture student Kristin Washco says. Two sets of movable wall systems are automatically controlled by the house computer based on weather conditions, or they can be operated using an iPhone. Responsive architecture features include the ability to operate the heating, cooling, lighting, and sun shading with a computer, which receives environmental condition data from sensors inside the house and a weather station outside the house.

Borrowing Power From the Earth

A concrete floor—rare in Solar Decathlon houses—is part of a strategy to provide passive, radiant heating. The floor functions as thermal mass that is heated by the sun and a radiant hot water system of piping underneath the slab. Keeping sun off the floor in summer is also a cooling strategy.

Water is heated using a geothermal loop coupled with efficient water-to-water and water-to-air heat pumps. The geothermal system consists of a series of pipes in the earth that keep water at a fairly consistent temperature throughout the year—efficiently delivering heated water in the winter and cooled water in the summer. Because it is not possible to drill a 500-ft (152.4-m) well on the National Mall, a simulated geothermal loop system has been constructed that consists of a 1,000-gallon (3,785.4-liter) water tank coupled with a waterfall and evaporator system.

Making Energy From the Sun

The Lumenhaus 9-kW PV system is also unique. Monocrystalline silicon wafers are mounted between transparent glass plates, so some sunlight passes through the PV panel, reflects off the roof, and bounces back up to the back side of the wafer, generating additional electricity. The team estimates that these panels will produce twice the energy needed to power their energy-efficient house so they can score high in the Net Metering contest.

From Campus to Real World

Like many teams, Virginia Tech is discovering that the biggest learning experiences during the project are developing the skills to work with team members from different disciplines and seeing how a project goes from a design on paper to a real-world working prototype.

> *"Every day there's something new, another surprise, something I've never seen before. It's a great experience."*
>
> — Corey McCalla, Virginia Tech architecture student

Team Web site: www.cusd.cornell.edu

Architecture and Engineering—Collaborating for Change

For Cornell's third consecutive Solar Decathlon competition, the 2009 team wanted to do something bold. They decided to make their house and their project unique at every step, starting with a juried competition to select the design.

"Our initial goal was to move away from the 'conventional' houses that are common in the Solar Decathlon," says Irina Chernyakova, an architecture student and one of 11 team leaders. With 15 design submissions to choose from, the team opted for an approach that provides the eye-catching look they wanted and incorporates the high-tech, energy-efficient features that make a 21st-century house a home.

Interdisciplinary collaboration, especially between architecture and engineering, characterizes virtually all the team's choices. "It's a team philosophy," says Chris Werner, an architecture student and team leader. "The challenges to engineering are unique," adds Myra Wong, a mechanical engineering student and team leader. "We really try to look at the big picture."

Looking Back to the Future

The collaborative result is the Silo House, which consists of three separate "plug and play" cylindrical modules that interconnect to form a single structure. All the modules open onto a common courtyard. Reflecting the shape of the grain silos that dot the rolling hills of upstate New York, the house and its landscape of carefully selected grasses present what the team calls a "post-agrarian look," a reminder of vanishing farmland.

Each silo is 16 ft (4.9 m) in diameter, with about 130 ft^2 (12.1 m^2) of floor space. The three modules—kitchen, living room, and bedroom—are joined on the south side, leaving the north side open. The exterior is covered with COR-TEN®, a corrugated steel cladding that acts as a weather barrier. As the outer layer oxidizes, it gradually loses its original sheen and takes on a rusty, ruddy look.

To ensure that the building envelope is tightly sealed, the team used soy-based, closed-cell spray foam insulation in the wall assembly to give the wall an R-30 rating—better than the R-19 rating of conventional Ithaca, New York, homes. SIPs were installed in both the roof and the flooring. The module walls facing the courtyard are a transparent NanaWall system that provides insulation while opening the rooms to the outdoors, increases natural light, and helps protect the interior from overheating.

> *"I never thought that in college I'd build a house with solar power and be responsible for more than 150 people."*
>
> — Bobby Harvey,
> Cornell University student

More and Less, Under One Roof

The house is designed and equipped to maximize space and minimize energy use without sacrificing comfort. The kitchen, which can accommodate up to eight people, features an island with a countertop that slides back to reveal ENERGY STAR appliances. A student-designed bed is supported by a counterweight system. When not in use, the bed can be raised to the ceiling, where it stays subtly out of sight to increase the available floor space. In the living room, a television and speakers are connected to a custom-made computer, which is the home's entertainment center. Some of the chairs, on loan from a Brooklyn, New York, company, are made from recycled bourbon barrels.

Electricity for Silo House comes from an 8-kW PV system. A building-integrated solar water heating system sits beneath the exterior cladding and preheats water for the main evacuated-tube solar water heating system, which is mounted on the south side of the kitchen and living room modules. Working together, these systems provide space and water heating.

117 | Universidad de Puerto Rico

Team Web site: www.casasolar.uprrp.edu

A Model for the Caribbean

The objective of the 2009 University of Puerto Rico team was to build a house that could serve as a model energy-efficient home for the Caribbean. The Universidad de Puerto Rico is one of only two schools to enter all four Solar Decathlons, but a key inheritance from that history was a negative comment. In 2007, a non-Decathlon student observed: "That doesn't look like the Caribbean. It looks to the inside, not the outside."

Billed as CASH—Caribbean Affordable Solar House—the L-shaped house clearly looks to the outside and responds to the opportunities and challenges of the Caribbean climate. The two legs of the L are connected by an outdoor patio. One is enclosed with special screens to allow occupants to look out and cooling breezes to pass through but block nearly 90% of the sun's rays. The other mechanically conditioned leg uses the same screens but has sliding glass doors that can be closed off when conditions warrant.

Building on the Past …

Team member Zoé Galán Comas, a recent graduate of the university's Master of Architecture program, points out that with all its high-tech mechanical systems and passive solar design, the 2009 house design builds on the distant as well as recent past. "The basic approach is Caribbean Vernacular, a floating style that originated with early Puerto Rican buildings whose raised floors keep out pests, alleviate high humidity levels, and encourage natural ventilation," says Comas.

… For Homes of Tomorrow

Teammate David Ramírez, another recent graduate from the master's program, underscores the importance that an energy-efficient home model could have in Puerto Rico. "Most people I know have absolutely no idea how the design of a house can save energy," he says. Faculty Advisor Sonia

Miranda Palacios adds that Puerto Rico is currently working on adopting a more stringent energy code, and the team's house "could be a showcase project for this effort."

Assisting Nature

Technological highlights of CASH include a 10.4-kW crystalline silicon PV system that generates electricity, an evacuated-tube solar water heating system that provides domestic hot water, and a radiant ceiling system of piped water that provides cooling and heating. An extra dehumidifier addresses humidity—the biggest cooling challenge in the Caribbean. A small conventional air conditioner, with sensors that turn it off when doors are open, provides mechanical cooling. The house also features supplemental LED lighting.

Looking to the Outside

Natural lighting and cross-breeze ventilation through the screens are central to the house's passive energy features, but it also has tight-sealing, locally made, radiant film-glazed windows and closed-cell, foam-insulated walls of wood.

> *"This work has opened my eyes to the complexities of a real architecture project. It takes a lot more than just planning or 'getting it done.' I now know I also want to study structural engineering."*
>
> — Shellar Garcia, Universidad de Puerto Rico architecture student

Generous use of wood—particularly reclaimed—contributes to the Caribbean feel of the house. The exterior uses redwood recovered from a reconstruction project at the university; the interior uses teak recovered from replaced park benches.

Recent graduate Glory Moyet explains that the team designed systems for both rainwater and greywater to water planters on the patio.

Paying for Itself

With its Caribbean ambiance and sustainable lifestyle, CASH should make an ideal retirement home—on the beach or in the mountains.

Team Web site: www.solardecathlon.umn.edu

A New Icon for Solar Homes

The University of Minnesota's Solar Decathlon 2009 team has created a solar house with an iconic new look designed to meet the challenges of heat loss in an extremely cold climate.

The gabled roofline, resembling a "real" house, is one of the features designed to appeal to a large group of eco-conscious consumers who might not want to live in a "futuristic" house. By shifting the roofline slightly, the team has taken traditional design and modified it to create easy access for solar energy collection.

The Heat Loss Challenge

The team set out to design a house that uses as much "free" heating from passive solar sources as possible and also creates a tight envelope that keeps heat from escaping.

Large areas of insulated glass on the south side of the house bring the sun's heat into the space. The offset gable of the roofline and the south wall are used as solar collectors, generating hot water and electricity. Windows have special insulating shades and are triple-paned, low-e, and filled with gas. The wall and roof insulation have values of R-50 and R-70, respectively. Windows on the east and west walls are made of electrochromic glass, which has adjustable tint to keep out much of the sun's heat in the summer.

Cold Weather, Hot Solar

When passive solar heating isn't enough, the house features a system that circulates hot water under the floor to produce radiant heat. Flat-plate solar collectors on the roof heat water for the kitchen and bath in addition to heating the house. In the summer, the solar hot water system recharges an innovative desiccant, or drying, system that efficiently maintains humidity and comfort levels.

The 8.2-kW PV system consists of conventional roof-mounted PV panels that produce most of the electricity and a translucent bi-facial PV product—some light passes through and is reflected back to the underside to also generate electricity. Designed to maximize production, these systems feature different inverters (to change DC to AC) for the different types of PV and different orientations.

Sunshine on a Tight Lighting Budget

Using a design that maximizes the use of natural light and reduces the energy spent on electric lighting, the team calculated that it could stick to a lighting budget of 500 W of electric light for the entire house. Electric lights create different effects in various spaces, with the most dynamic lighting in the kitchen at the east end of the house and the most static lighting in the living room at the west end, where occupants may need to control light carefully.

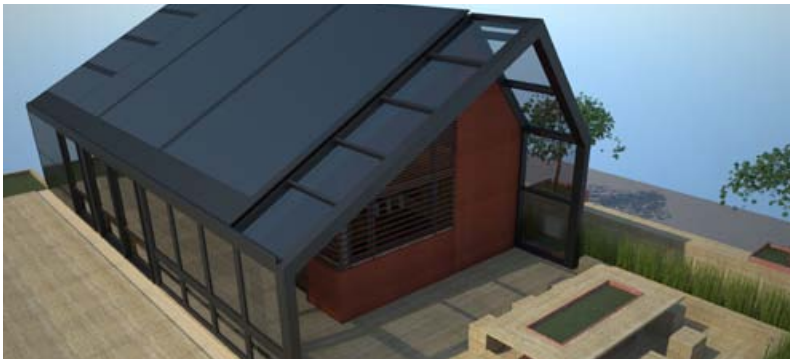
> *"The public can look at our house and identify with it. It's a house that anyone could live in with things that go in a normal home, not the EPCOT Center."*
>
> — Josh Quinnell, University of Minnesota student

"We're using new light-emitting diode fixtures from local lighting designers, with warm color light that contributes to the familiar feel of home," says Joe Messier, a master's student in the College of Design and the commissioning team leader.

Not Your Average Competition House

Quinnell says that the team has never forgotten that they're really designing this house for consumers, who might be willing to make lifestyle changes or buy different products if they think it's easy and comfortable.

"Looking at previous years' houses, they were 'competition houses,'" Quinnell says. "Ours is meant to be one that consumers and D.C. visitors will be able to identify with, one that encourages market transformation."



119 | Team California (Santa Clara University, California College of the Arts)

Team Web site: www.refracthouse.com

California Living

Sunny, quick-paced, outdoor. These aspects of the California lifestyle guided the design and construction of Team California's Refract House. "It really is an outdoor-indoor house, and every room has very large windows," says Santa Clara University Engineering Team Leader Timothy Sennott. "We have worked really hard to engineer something that is luxurious and functional."

Refract House takes full advantage of the sunny California climate. The passive solar design virtually eliminates the need for heating. Cooling and heating are both handled by a highly efficient, reversible air-to-water heat pump. Radiant heating and cooling are also employed, as is smart ventilation and heat recovery. Intelligent control of windows and external blinds maximizes passive heating and cooling. An unbroken plane of PV panels on the roof provides electricity for the systems, including a solar water heating system. The PV system is 8.1 kW.

Designed with busy occupants in mind, Refract House features built-in furniture and a low-maintenance interior. State-of-the art appliances conserve energy while providing a well-appointed environment. Outside, a seasonal pond stores rainwater as well as greywater from the house that has passed through a multi-stage biofilter. Fluctuating with the seasons, the pond will help keep the landscape green.

Design Process

After reviewing comments from the 2007 design competition, Santa Clara University decided to partner with the California College of the Arts to integrate design and technology into a beautiful, functional house. A California College of the Arts Solar Decathlon Design Studio generated 16 house designs. The chosen design went through many changes as the architecture and engineering students made compromises to reach their goals. "A huge part of the design

process was trying to connect the indoors with the outdoors both visually through the windows and functionally with the house layout," says Sennott.

In another design choice, the roof is cut at a different angle from the house to hide the technologies. "The big thing we were trying to do with the house is to hide the energy system," says Sennott. "We want to make the energy systems transparent to the homeowner."

Managing Energy Consumption

The 2000–2001 California energy crisis impressed the team with the need to manage the daily timing of energy consumption. A programmable controller turns appliances on and off throughout the day. "The idea is to empower the homeowner to control what is being used and when by making them aware and giving them direct control over things like lighting and entertainment circuits," says Sennott. The sophisticated controls and monitoring system will display the house's performance in real-time. A special iPhone application allows homeowners to control systems even when they are not home.

> *"The Refract House is a long, bent rectangle. A bent tube meant to capture and refract light is a metaphor for taking something and making it into many things, like using solar energy to make appliances run."*
>
> — Allison Kopf, Santa Clara University project manager

Information for Visitors

The team wants visitors to learn about things they can apply in their own homes. The team will use interactive technology to stir interest and educate visitors while they're waiting to enter Refract House. Information panels pose questions about the technologies of the house. Guests can text a code or scan a barcode with their phones. The answers as well as more information are sent directly to their devices. These visitors will leave having gained valuable and applicable renewable energy knowledge.

Team Web site: www.solardecathlon.uiuc.edu

Old Is New Again

What has 100-year-old wood on the outside, the newest structural bamboo on the inside, and can be heated with a single hair dryer? If you guessed the University of Illinois Gable Home, you chose a house that melds a traditional look with state-of-the art energy performance.

Using passive solar design, the team optimized windows, insulation, and roofing material for energy efficiency and solar gain on sunny winter days while keeping the sun's heat out during the summer. The Passive House Institute U.S. in Urbana, Illinois, will certify Gable Home as using 90% less energy than typical construction.

Gable Home also produces the energy it needs within its traditional design. Rather than having a single flat roof facing south for maximum installation of solar panels, the gable design presents only half the roof to the south. This area accommodates the 9-kW PV system. "We hope this proves that solar panels are efficient enough to generate necessary electricity and, when combined with different disciplines, will maximize energy efficiency," says student Joe Simon.

Technology Details

One of the newest technologies in the Gable Home is bamboo laminate board that substitutes for wooden studs in the walls. Developed by a company working with the University of Illinois, this product is appealing because bamboo grows much faster than trees, has stronger material properties, and is resistant to thermal expansion. "Before we could use the Lamboo, though, we had to understand its material properties," says architecture student Camden Greenlee. "So the company conducted structural tests to prove that the material could meet our needs."

Because the Gable Home is so well insulated and resistant to temperature swings, it requires only a small system to control heating, cooling, ventilation, and dehumidification. The team's mechanical engineers built a custom HVAC system with a unique heat pump that helps condition the interior. The warm or cool air is blown very gently through the house using very little energy.

Sustainable Materials

"The siding was pulled from my grandparents' barn in northern Illinois," says Greenlee. "They sold the farm for development, and we harvested the barn wood, which was well over 100 years old." Summer shade panels slide like barn doors in tracks along the south side of the house, and the decking material was salvaged from deconstruction of an old grain elevator.

> *"We set out to prove that there is no schism between new technologies and traditional ways of building houses. Our whole process has been a back and forth to find relationships between vernacular or traditional styles of housing and new technologies."*
>
> — Camden Greenlee, University of Illinois at Urbana-Champaign architecture student

Making a Difference

To reach consumers, the team is working with a builder of modular homes to make this more than a one-of-a-kind project. "A modular home builder can move about one modular house off the assembly line every day," says student Ryan Abendroth. "This kind of production of net-zero homes is important when you talk about really pushing the green idea. One house doesn't matter so much, but multiple houses start to add up."

"In this project, we see how our design choices in the beginning affect the building's actual outcome," says Abendroth. "Then, because we will be monitoring this building and using it in the competition, we will see how that outcome works over time. Often, architects don't get the feedback to see how their choices actually influenced the building. That is one of the most important experiences we get out of the Solar Decathlon."

U.S. Department of Energy

Office of Energy Efficiency and Renewable Energy

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Laying the Foundation for a Net-Zero Energy Future

Today, the U.S. building sector accounts for approximately 40% of our country's primary energy consumption and 38% of carbon dioxide emissions. With advanced technologies and practices, this picture can be very different. In partnership with industry and universities, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) is conducting research to enable a net-zero energy future—a future in which net-zero energy buildings produce as much energy as they consume over time by combining high levels of efficiency with renewable energy technologies such as solar power.

Solar Decathlon 2009 is part of EERE's Building Technologies Program, which aims to develop technologies and strategies that lead to marketable net-zero energy homes by 2020 and net-zero energy commercial buildings by 2025. These net-zero energy buildings will be a cornerstone of a clean energy future and will strengthen the economic vitality, energy security, and environmental quality of our nation.

EERE Programs

EERE's energy-efficiency programs focus on technologies that make buildings, transportation, and appliances more energy-efficient. Many such technologies, strategies, and design approaches—for example, geothermal heat pumps, daylighting, and low-emissivity windows—are on display throughout the solar village. Used together, today's residential technologies, strategies, and design approaches can reduce the energy consumption of new buildings by 30%–40%.

Innovation on Display

The Solar Decathlon 2009 houses showcase a powerful combination of energy efficiency and renewable energy—specifically, solar energy. Solar technologies use the sun to provide heat, light, hot water, electricity, and even cooling for homes, businesses, and industry. A growing solar industry also stimulates the U.S. economy by creating jobs in solar manufacturing and installation. The U.S. Department of Energy is investing in solar technology research and development in order to make electricity from solar technologies cost-competitive with conventional forms of electricity by 2015.

Assistant Secretary for Energy Efficiency and Renewable Energy Catherine Zoi is responsible for leading the programs, staff, and policies of EERE.

In addition to advancing these technologies, EERE is devoted to improving building codes and appliance and equipment standards and guidelines and educating homeowners, builders, and developers about energy-efficient technologies and practices to accelerate market adoption of new technologies.

The "New Era" Begins

In February, President Obama signed into law the American Recovery and Reinvestment Act of 2009 and began what Secretary of Energy Steven Chu called a "new era" at the U.S. Department of Energy. The act focuses heavily on reducing our nation's dependence on foreign oil and provides new resources for EERE's mission to get more clean energy from wind, solar, and other sources while reducing our energy needs through smart building technologies and practices. The funds allocated will speed the U.S. Department of Energy's research and development efforts, support energy-efficiency projects throughout the country, and create new industries based on the vision of a net-zero energy future for our nation.

www.energy.gov
www.eere.energy.gov

Solar Decathlon 2009 Organizer

National Renewable Energy Laboratory

National Renewable Energy Laboratory
Innovation for Our Energy Future

The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) welcomes students from around the United States and the world who have come to compete in Solar Decathlon 2009. NREL's role as America's primary laboratory for renewable energy and energy efficiency research and development is a natural fit for this unique and important event.

At NREL's facilities in Golden, Colorado, researchers work to nurture a wide range of technologies that benefit America's economy, national security, and environment. Its research portfolio extends into solar energy, building design, wind power, biomass power, biofuels, geothermal energy, hydrogen, fuel cells, distributed power, advanced vehicle design, and basic energy science.

NREL believes in "walking the talk" and is building a state-of-the-art "Laboratory of the Future" with environmentally friendly research buildings to facilitate innovation. Two projects currently taking shape are the Research Support Facilities and the Integrated Biorefinery Research Facility. The 218,000-ft^2 Research Support Facilities is designed to be a model for sustainable, high-performance building designs and is expected to achieve a LEED Platinum designation. The Integrated Biorefinery Research Facility will expand NREL's capabilities to develop new cellulosic ethanol technologies and allow the laboratory to work simultaneously on multiple research projects with multiple research partners.

After publicly committing to reducing its greenhouse emissions by 75% from 2005 to 2009, NREL achieved "carbon neutrality" in all operations for the second consecutive year in 2009.

By combining energy efficiency with renewable energy technologies, NREL is working with the nation's homebuilders to advance the concept of net-zero energy buildings—structures that produce as much energy as they use on an annual basis.

Solar Decathletes will likewise help the nation shape its energy and architectural future. NREL joins with fellow Solar Decathlon 2009 sponsors in wishing the student teams continued success throughout the competition and in meeting the challenges that await them.

NREL is operated for the U.S. Department of Energy by the Alliance for Sustainable Energy, LLC.

www.nrel.gov

NREL's Research Support Facilities, scheduled for completion in the summer of 2010, will house 740 NREL and U.S. Department of Energy staff members. (NREL PIX 16250, RNL Design)

Researchers developed the inverted metamorphic multi-junction solar cell at NREL's National Center for Photovoltaics. (NREL PIX 15936, Pat Corkery)

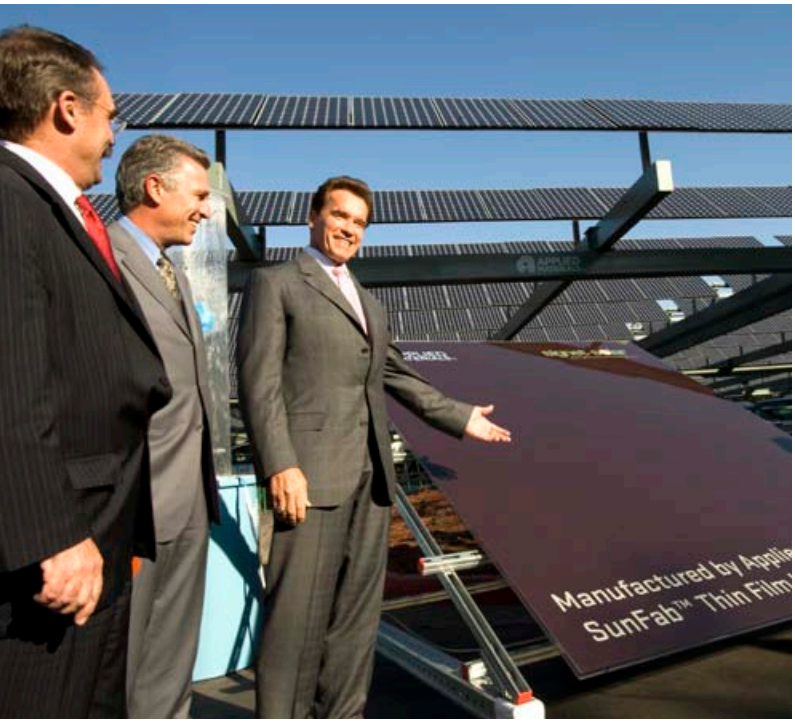
Solar Decathlon 2009 Sponsors

Applied Materials

Applied Materials is proud to sponsor Solar Decathlon 2009 and help showcase some of the world's smartest "green" technologies in our nation's capital. Applied Materials is sponsoring a media package that will provide daily updates on ABC's Washington, D.C., affiliate station.

At this critical time, with global action required to combat climate change, the students and universities competing in Solar Decathlon 2009 are demonstrating the innovations and applications that will shape our future. The students and universities prove that solutions are ready and available today and that implementing clean technology doesn't mean sacrificing livability, aesthetics, or economics. Together, we can show how clean, free power from the sun is being harnessed to power our world and how solar energy and renewable energy can be powerful engines of growth to drive the next wave of economic prosperity.

Applied Materials is the world leader in nanomanufacturing technology™ solutions—engineering the microscopic "thin films" that make electronic innovations such as smart phones, powerful computers, and consumer electronics possible and affordable. For more than 40 years, Applied Materials has fueled virtuous cycles of growth that have made these innovations ubiquitous around the world. Now, the company has focused this capability on changing the economics of solar power.



California Governor Arnold Schwarzenegger viewed Applied Materials' solar installation and its large SunFab panels, which are well suited for utility-scale solar installations.

Every day, the sun beams 45,151,524 trillion Btu of energy to the earth. Solar PV panels can convert this energy to electricity when the world needs it most: during the warmest times of the day and year. Applied Materials is the leading solar equipment supplier and is bringing technology and scale to solar, speeding the point at which the cost of solar falls below the cost of traditional forms of energy generation. Applied Materials is also driving down the cost of manufacturing crystalline silicon solar panels. These panels serve residential, commercial rooftop, and utility-scale solar farm markets.

www.appliedmaterials.com

Applied Materials changed its parking lot to a power plant with what was, at the time, the largest corporate solar installation (2 MW) in Sunnyvale, California.

The parking lot solar plant provides shade for employee vehicles while generating substantial power.

BP

A BP Solar energy system of about 3.5 kW helps power this home in California.

BP is pleased to continue its support of the U.S. Department of Energy Solar Decathlon as a 2009 sponsor. A consistent sponsor since the program began in 2002, BP is investing in the Solar Decathlon to support some of the world's finest academic teams as they learn about and advance solar technology and energy-efficient applications. BP Solar is again offering discounted solar materials and technology support to university teams. Through its Solar Decathlon participation, BP is also helping provide energy education opportunities for consumers, policy makers, teachers, and students of all ages.

As one of the world's largest energy companies, BP provides people with fuel for transportation, energy for heat and light, and various products and services they want and need. As an energy company that is committed to building a sustainable future, BP is making diverse investments to enhance energy supply and security while reducing the impact of energy use on the environment. The largest producer of oil and gas in the United States, BP has invested billions of dollars over the past decade to develop solar and other alternative energy resources.

BP Alternative Energy, launched in November 2005, combines BP's interests in low- and zero-carbon energy, including solar electricity, wind power, hydrogen power with carbon capture and storage, and biofuels. BP Solar, part of BP Alternative Energy, is a global company that designs, manufactures, and markets products that use the sun's energy to generate electricity for a wide range of applications, including existing and new homes, small and large businesses, and various industry, public, and government facilities.

With more than 35 years of experience and installations in most countries, BP Solar is one of the world's leading solar energy companies. The company plans to grow its U.S. and global business by offering clean energy solutions that are competitive with other energy resources available to the electric power grid. BP Solar provides peace of mind by delivering the most reliable solar power offers at a lower cost per kilowatt-hour over the life of the system.

BP Solar Home Solutions® are available through its distributor and dealer network. For more information, visit www.bpsolar.com or call 1-866-BPSOLAR.

www.bp.com

Energy Tile™, BP Solar's building-integrated product, is featured in homes by PinnBrothers in the Orchard Heights Community of San Jose, California. (Photo courtesy of PetersenDean)

Pepco

Pepco, a regulated electric utility that serves 767,000 customers in the District of Columbia and most of Montgomery and Prince George counties in Maryland, is delighted to be a part of the U.S. Department of Energy Solar Decathlon 2009. The company provides critical event support in the form of electricity meters, electric utility interconnection, outreach, and volunteers.

The world has changed since Pepco first began providing service more than 100 years ago. Today, our nation is facing critical energy challenges that include the high cost of energy and the impact of energy use on the environment. Energy conservation, the smart grid, and renewable energy sources such as solar power offer solutions to some of these challenges. In 2007, Pepco installed PV panels at two locations in the District of Columbia as part of the company's plan to meet future energy needs and demonstrate the technology to others. The company's service center on Benning Road and a substation located in northeast D.C. each feature a 10-kW solar array that supplements the power needs of the facility. An increasing number of customers also is seeking to install renewable energy systems. Pepco's Green Power Connection™ net metering service ensures those systems are safely connected with Pepco's electrical system and allows customers to sell unused power back to the power grid.

Pepco's headquarters building in the District of Columbia earned LEED Gold certification in 2009 under the Existing Buildings, Operations & Maintenance program.

pepco

Your life. Plugged in.™

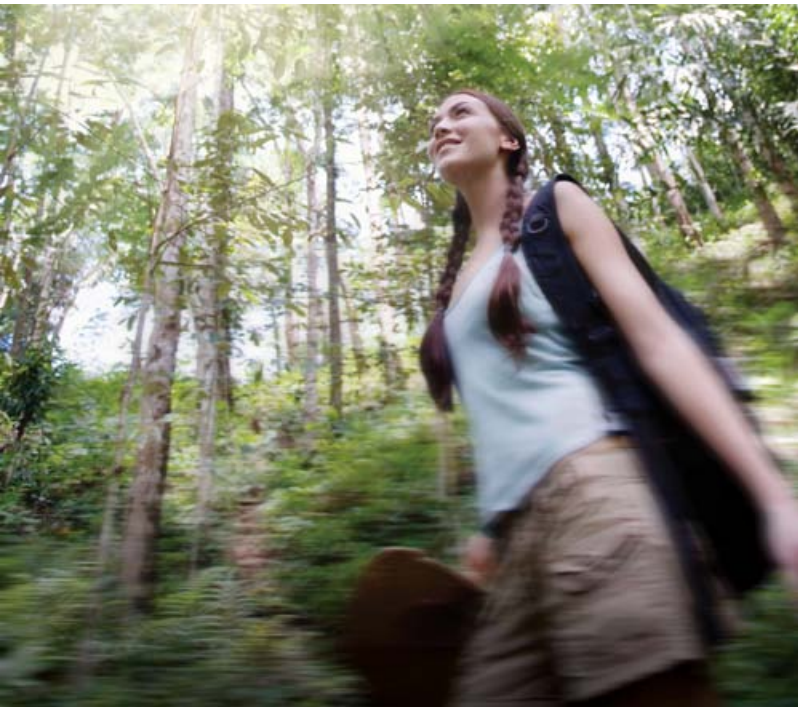
The PV system on this Pepco substation reduces the conventional power needed to provide service to run the facility. The solar panel array supports Pepco's commitment to reduce the company's carbon footprint and is a model for future substation construction.

Pepco is moving forward with plans to install a smart grid, which will help the power delivery system operate more efficiently and enable consumers to better manage their energy use and save money. The smart grid will provide technologies to help consumers make full use of solar and other renewable energy options.

Pepco's plans include a balanced blend of technology and energy-efficiency solutions. Advanced electronic meters with two-way communication will provide data that allow customers to accurately monitor household energy use, including when they use it, how much they use, and how much it costs. Information will be communicated via a smart thermostat, or an in-home display device, on www.pepco.com or by contacting Pepco. This will allow consumers to be better informed and help them make adjustments that can reduce electricity use and lower their bills.

www.pepco.com

Schneider Electric



As a global specialist in energy management with operations in more than 100 countries, Schneider Electric offers integrated solutions across multiple market segments, including energy and infrastructure, industrial processes, building automation, and data centers and networks as well as a broad presence in residential applications. Focused on making energy safe, reliable, efficient, productive, and green, the company's 114,000 employees achieved sales of more than $23 billion in 2008 through an active commitment to help individuals and organizations "Make the most of their energy[SM]."

In addition to proudly contributing to Solar Decathlon 2009 as a sponsor, Schneider Electric features products in many of the Solar Decathlon houses—made available through donations from the Square D Foundation. Energy management solutions incorporated into the houses include Xantrex solar inverters, TAC building automation and control, PELCO security, Juno lighting, Power Logic metering and software solutions, Square D electrical distribution equipment, programmable logic controllers, and lighting controls.

Energy and environmental responsibility lie at the core of the Schneider Electric culture and strategy. Sustainable development is a real and essential opportunity for mobilization, growth, and differentiation, and Schneider Electric is committed to producing innovative and effective solutions to curb energy waste, promote production, and influence consumption habits that respect the environment. By sponsoring Solar Decathlon 2009, Schneider Electric shares broad-based knowledge and resources as well as passion with a new generation of energy enthusiasts.

As a sponsor of Solar Decathlon 2009, Schneider Electric has supplied the solar village microgrid with design, site, and engineering services as well as the electrical distribution equipment required to safely and reliably connect the solar village to Pepco, the utility service on the National Mall, for the duration of the event. The Net Metering contest showcases these capabilities and illustrates how residential solar electric systems operate when connected with the power grid.

Schneider Electric wishes all competitors and visitors great success at Solar Decathlon 2009!

For more information, please visit www.sereply.com and enter keycode: k525w.

www.schneider-electric.com

Focused on making energy safe, reliable, efficient, productive, and green, Schneider Electric is committed to producing innovative and effective solutions that demonstrate environmental responsibility. As sponsor of the Solar Decathlon 2009 microgrid, Schneider Electric has made it possible for the team houses to connect safely and reliably to the utility service on the National Mall.

Alliance for Sustainable Energy

The Alliance for Sustainable Energy, LLC (Alliance)—co-governed by Battelle Memorial Institute and Midwest Research Institute—manages and operates NREL for the U.S. Department of Energy. Alliance is pleased to be a sponsor of Solar Decathlon 2009 by providing uniform clothing needs and branded gift T-shirts for participants.

Under the guidance of Alliance, NREL is leading the way in the delivery of market-relevant sustainable energy innovation, integrating renewables in efficient systems at all scales, leading strategic energy analysis and deployment, and creating a laboratory of the future that is a model for sustainable development—all to support the profound transformation required to achieve a new energy future for the nation and the world.

www.allianceforsustainableenergy.org

American Institute of Architects
American Institute of Architecture Students

The AIA and the American Institute of Architecture Students (AIAS) are long-time sponsors of the U.S. Department of Energy Solar Decathlon. For the 2009 competition, AIA and AIAS are providing meals, gifts, a reception, and water for the student Decathletes. In addition, AIA and AIAS are offering architecture tours of the solar village and hosting a dinner for jurors.

Based in Washington, D.C., the AIA has been the leading professional membership association for licensed architects, emerging professionals, and allied partners since 1857. Since 1956, the AIAS has been helping build interest and enrich the educational experience of students (of all ages) and others in architecture and design.

www.aia.org
www.aias.org

American Society of Heating, Refrigerating, and Air-Conditioning Engineers

ASHRAE is proud to once again be a sponsor of the Solar Decathlon. In 2009, ASHRAE's participation includes recruiting a team of "official observers"; co-sponsoring the student reception; providing water bottles, books, and services to the university teams; and promoting Solar Decathlon 2009 to ASHRAE members.

ASHRAE's involvement in Solar Decathlon 2009 is a natural progression from the society's long-standing role in energy guidance. ASHRAE is at the forefront of improving the technologies that make energy-efficient, healthy, and comfortable buildings possible. ASHRAE established the principles and guidance for proper indoor air quality, energy efficiency, and comfort that the Solar Decathlon 2009 participants integrate into their design efforts.

ASHRAE's 50,000 members worldwide are committed to economic energy-efficiency standards and advanced energy-efficiency guidance. ASHRAE is the foundation of energy conservation in buildings.

www.ashrae.org

Dell

Dell is proud to be part of the U.S. Department of Energy Solar Decathlon 2009. As the sponsor of the text-message voting system for this year's People's Choice Award, Dell encourages you to vote for your favorite Solar Decathlon 2009 house.

Technology Business Research recently called Dell "the most environmentally progressive IT vendor in the world." Dell is incredibly proud of that, but the company knows it has more work to do. Dell is committed to becoming the "greenest" technology company on the planet. For more than a decade, Dell has built environmental considerations into every aspect of its business. Dell aspires to a zero-waste goal in its facilities and sources more than 25% of its global electricity needs from renewable sources such as wind and hydroelectric power. Dell also offers free and convenient computer recycling programs, even for non-Dell-branded systems.

www.dell.com/earth

Dow Corning

As a supporter of Solar Decathlon 2009, Dow Corning is pleased to sponsor the electronic scoreboards that provide daily information to visitors on the National Mall.

One of the world's largest researchers, developers, and manufacturers of silicon-based materials, Dow Corning works with customers to develop, evaluate, and pilot materials solutions used to manufacture solar panels. The company delivers products that focus on improved cost efficiency, durability, and performance to the solar industry. Dow Corning's long-term commitment to sustainability and solar energy solutions is demonstrated by investments of more than $5 billion to expand polycrystalline silicon capacity by 90% within the next four years and the construction of the company's first facility to produce high-purity monosilanes—the key raw material used in the production of thin-film solar cells and liquid crystal displays.

www.dowcorning.com

Meteor Solar LED Lighting

Meteor Solar LED Lighting is supporting the U.S. Department of Energy Solar Decathlon 2009 by providing solar-powered LED walkway lights for use in the solar village.

California-based Meteor Solar LED Lighting is one of the world's foremost green lighting companies. The company provides landscape architects, lighting designers, and engineers with a high-quality, energy-efficient lighting solution for outdoor projects.

The specialty of Meteor Solar LED Lighting is integrating both solar and LED technology in the most efficient and effective way, using the best-quality materials and components.

www.meteor-lighting.com

National Education Association

The National Education Association (NEA) is organizing Solar Education Day for Solar Decathlon 2009. By providing support to develop and broadcast educational programming to schools nationwide while the solar village is open to the public, NEA will help spread knowledge of the goals and objectives of Solar Decathlon 2009 among NEA's members and their students.

The nation's largest professional organization, NEA represents 3.2 million elementary and secondary teachers, higher education faculty, education support professionals, school administrators, retired educators, and students preparing to become teachers. With an ongoing interest in sustainability of the planet, NEA is working in partnership with a growing number of organizations and businesses to expand the reach of green initiatives in communities across the country.

www.nea.org

OxBlue Inc.

A proud sponsor of the U.S. Department of Energy Solar Decathlon 2009, OxBlue is providing three time-lapse video cameras that are placed around the solar village. Images transmitted from these cameras appear on the Solar Decathlon 2009 Web site at www.solardecathlon.org.

OxBlue's rugged solar-powered cameras have been used around the world to reduce costs and save time on construction projects of all sizes. During the Solar Decathlon, the cameras will transmit live, high-definition images from the National Mall in Washington, D.C., for the entire world to view.

These dramatic images, and the time-lapse videos created from them, serve as testaments to the progress made in both construction camera and solar power technology.

www.oxblue.com

Perkins+Will

Perkins+Will is sponsoring the All-Team Meeting for student participants of the U.S. Department of Energy Solar Decathlon 2009. In addition, the company is providing students with a meal on the National Mall and branded gifts.

Among the world's foremost architecture and design firms, Perkins+Will holds a commitment to sustainable design and is constantly creating solutions that contribute to the human and environmental health of our global ecosystem. Perkins+Will has the most USGBC LEED Accredited Professionals in North America. Nearly half of the firm's professionals are LEED-accredited.

www.perkinswill.com

Popular Mechanics

Popular Mechanics magazine and PopularMechanics.com (PM) together represent a proud first-time sponsor of the Solar Decathlon. The October 2009 issue of *Popular Mechanics* is devoted to the theme of sustainability and includes a story on the U.S. Department of Energy Solar Decathlon 2009.

In addition to celebrating the event in print and online, PM provided the U.S. Department of Energy with a free full-page ad to promote Solar Decathlon 2009 to the magazine's 9 million readers. Editors will be on site to cover the competition and lead public workshops on the future of solar energy, and PM volunteers will help with the event.

PM provides readers with solutions—from how to fix a leaking faucet to how to slow global warming. Its three-part "Know Your Footprint" series, which taught readers how to measure and reduce their energy, water, and waste footprints, won a National Magazine Award in 2008.

www.popularmechanics.com

U.S. Green Building Council

The USGBC is proud to serve as a sponsor for Solar Decathlon 2009 by further advancing green building education to a new generation of building professionals.

USGBC is providing branded gifts to participants, co-sponsoring a student reception, and hosting a dinner for jury members. In addition, USGBC will be rewarding members of the winning student team with an all-expenses-paid trip to its annual conference, the Greenbuild International Conference and Expo, this November.

USGBC, a nonprofit organization composed of leaders from across all building-related industries, is committed to expanding the green home market. LEED for Homes is the premier green homebuilding rating system, which has certified more than 2,500 homes. LEED for Homes promotes the design and construction of high-performance homes that use less energy, water, and natural resources; create less waste; and are more healthy and comfortable for occupants.

www.usgbc.org

Thanks to So Many

The U.S. Department of Energy Solar Decathlon 2009 would not be possible without the generous support of so many people and is grateful to the sponsors listed on the preceding pages—and to those listed below. The event organizers also acknowledge the volunteers, technical experts, and in-kind contributors whose support is vital to making Solar Decathlon 2009 an enriching experience for teams and spectators alike.

ARCHITECTURAL DIGEST

Architectural Digest
www.architecturaldigest.com

Architectural Digest is providing a one-third-page announcement in its October "date book" section.

Construction Specifications Institute
www.csinet.org

The Construction Specifications Institute donated 20 copies of the National CAD Standard, Master Format Standard, and the Project Resource Manual for use by Solar Decathlon 2009 teams in the development of their construction documents.

Demilec (USA) LLC®
www.demilecusa.com

Demilec (USA) is providing a branded gift to Solar Decathlon 2009 students.

Duke Energy
www.duke-energy.com

Duke Energy is helping fund Solar Education Day on Tuesday, Oct. 13.

ENERGY STAR
www.energystar.gov

ENERGY STAR, a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy, is organizing Solar Education Day and providing a snack to visiting schoolchildren.

Honeywell
www.honeywell.com

Honeywell is providing shirts for the volunteers who help make the Solar Decathlon a success.

International Code Council
www.iccsafe.org

The International Code Council donated 22 copies of the 2006 International Codes Complete Collection for use by Solar Decathlon 2009 teams and organizers in the development and review of house designs. It also donated a copy of the I-Quest Complete Collection for use by organizers in the review of designs and the on-site inspections of houses.

JetBlue
www.jetblue.com

New York-based JetBlue Airways is offering 10 round-trip airfare tickets.

National Association of Home Builders
www.nahb.org

The NAHB's support includes sponsorship of the People's Choice Award printed ballot and NAHB membership to student Decathletes.

National Fire Protection Agency
www.nfpa.org

The National Fire Protection Agency donated 22 copies of the 2007 National Electric Code Handbook for use by Solar Decathlon 2009 teams and organizers in the development and review of the electrical designs.

Nationwide Marketing Group
www.nationwidemarketinggroup.org

Nationwide Marketing Group is donating ENERGY STAR appliances for Solar Education Day.

Oak Ridge Associated Universities
www.orau.org

Oak Ridge Associated Universities is donating pre-paid Metrorail fare cards for participating students.

Solar Energy Industries Association
www.seia.org

The Solar Energy Industries Association is co-sponsoring a congressional staff reception and conducting personal outreach to Congressional Hill staffers.

Spray Polyurethane Foam Alliance
www.sprayfoam.org

The Spray Polyurethane Foam Alliance is contributing event volunteers and a promotional gift for student team members.

Texas Instruments
www.ti.com

Texas Instruments is providing speakers for workshops, volunteers, social media resources, water bottles for university teams, and two breakfasts for students on the National Mall.

The 2007 Maryland team hangs out on the deck of their house. (Credit: Kaye Evans-Lutterodt/Solar Decathlon)

A Special Thank You

On behalf of the U.S. Department of Energy, the Solar Decathlon 2009 organizers would like to thank the following nonprofit organizations and associations for their generous support. The ongoing assistance of these influential groups—whose missions so closely align with the Solar Decathlon's—has helped make Solar Decathlon 2009 successful:

- *American Institute of Architects*
- *American Institute of Architecture Students*
- *American Society of Heating, Refrigerating, and Air-Conditioning Engineers*
- *Construction Specifications Institute*
- *International Code Council*
- *National Association of Home Builders*
- *National Education Association*
- *National Fire Protection Agency*
- *Oak Ridge Associated Universities*
- *Solar Energy Industries Association*
- *Spray Polyurethane Foam Alliance*
- *U.S. Green Building Council.*

Sincerely,
Richard J. King, Director
U.S. Department of Energy Solar Decathlon

Vote for Your Favorite Solar Decathlon House!

The Solar Decathlon 2009 People's Choice Award gives you the opportunity to vote for the U.S. Department of Energy Solar Decathlon 2009 team house you like best. The winning team will receive an award at the Victory Reception on Oct. 17.

You can vote by paper ballot or phone. You'll find People's Choice Award ballots in each of the three Solar Decathlon information tents on the National Mall. To vote by phone, text the code of your favorite team house to 99503. (One vote per cell phone allowed.) The codes are:

Cornell	HOUSE10	Ohio State	HOUSE39
Iowa State	HOUSE12	Arizona	HOUSE42
Penn State	HOUSE13	Puerto Rico	HOUSE47
Rice	HOUSE14	Team Spain	HOUSE51
Team Alberta	HOUSE15	Illinois	HOUSE55
Team Boston	HOUSE25	Kentucky	HOUSE71
Team California	HOUSE31	Univ. of Louisiana	HOUSE76
Team Missouri	HOUSE32	Minnesota	HOUSE83
Team Ontario/BC	HOUSE33	WI-Milwaukee	HOUSE86
Team Germany	HOUSE38	Virginia Tech	HOUSE88

For More Information

For Solar Decathlon 2009 daily updates and photos, feature stories, general information, and competition results, visit the Solar Decathlon Web site at www.solardecathlon.org.

U.S. Department of Energy Office of Energy Efficiency and Renewable Energy (EERE)
Provides information about renewable and energy-efficiency technologies
www.eere.energy.gov

EERE Information Center
Answers questions about EERE's products, services, and technology programs
www.eere.energy.gov/informationcenter

U.S. Department of Energy Building Technologies Program
Covers high-performance buildings and other solar building technologies
www.eere.energy.gov/buildings

U.S. Department of Energy Solar Energy Technologies Program
Covers photovoltaics, solar heating and lighting, and concentrating solar power
www.eere.energy.gov/solar

Energy Savers
Provides options for saving energy and using renewable energy at home, at work, in the community, and while driving
www.energysavers.gov

ENERGY STAR
Contains home-improvement tips and a locator map for purchasing ENERGY STAR-labeled products
www.energystar.gov

Find Solar
Has loads of information about solar topics, including how to find a solar energy professional
www.findsolar.com

Photovoltaics
Includes an introduction to photovoltaics, also called PV or solar electricity
www.eere.energy.gov/solar/photovoltaics.html

Database of State Incentives for Renewable Energy
Includes a guide to state, local, utility, and selected federal incentives that promote renewable energy
www.dsireusa.org

Efficient Windows
Offers a primer on windows and a guide to selecting energy-efficient windows for specific regions
www.efficientwindows.org

Produced for the U.S. Department of Energy by the National Renewable Energy Laboratory (NREL), a DOE national laboratory.

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