U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

Visitors Guide 2011

National Mall
West Potomac Park
Washington, D.C.
September 23–October 2, 2011

Time to shine

Welcome

to the fifth U.S. Department of Energy Solar Decathlon.

Teams of college students designed and built the solar-powered houses on display here. They represent 13 U.S. states, five countries, and four continents. Now the teams are rising to the challenge by competing in 10 contests over nine days, with the championship trophy on the line. This is their time to shine.

Secretary of Energy Steven Chu (center) stands with Team California at Solar Decathlon 2009.

Use your smartphone to scan quick response, or QR, codes throughout this guide and in the solar village for additional information.

Visitors Guide

The Teams

Here they are: the Solar Decathlon 2011 teams. As you tour their houses, think of the creative spirit, sense of place, and positive energy they embody. Ask questions, search for ideas for your own home, and pick your favorites.

The 2011 teams may share a common goal—to design and build the best energy-efficient house powered by the sun—but their strategies are different. One house is made of precast concrete, while another "dances" in response to its environment. Another house is meant to sit atop a building, proving the sky's the limit for energy innovation. Whatever your idea of sustainable living may be, you are bound to find it at the Solar Decathlon.

New Zealand

VICTORIA UNIVERSITY OF WELLINGTON

New Zealand is the first country to greet the sun at the start of a new day. The First Light house is designed to harvest this sunlight, reflect the relaxed lifestyle associated with the traditional "Kiwi bach" holiday home, and connect residents with the outdoor environment.

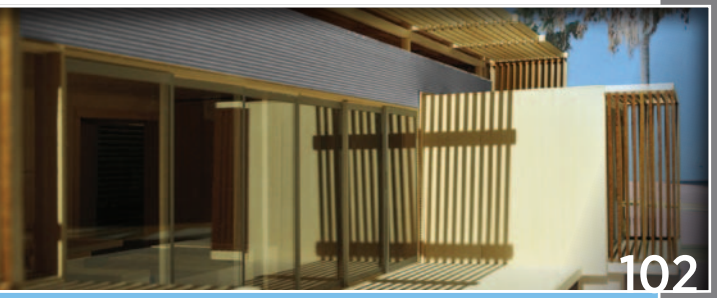
Must See: ***A triple-glazed skylight and large bifold doors illuminate the central section of the house.***

Team Florida

THE UNIVERSITY OF SOUTH FLORIDA, FLORIDA STATE UNIVERSITY, THE UNIVERSITY OF CENTRAL FLORIDA, AND THE UNIVERSITY OF FLORIDA

FleX House blends the wisdom of Florida vernacular design with modern technology. Sliding glass walls open to the outside during mild months and close during the hottest time of year. The corrugated metal siding on the exterior walls was chosen for its reflectivity, durability, and economy.

Cool Solution: ***A shading structure with cypress louvers shields the roof and walls from the hot sun in Florida and Washington, D.C.***

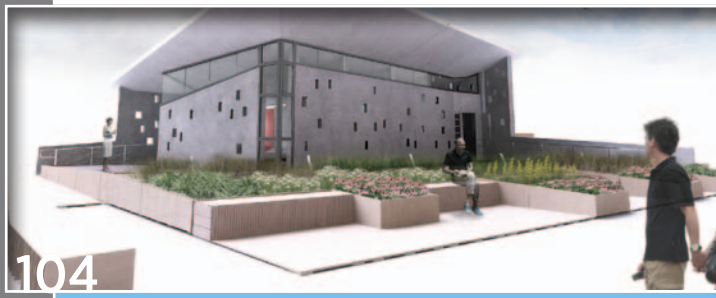


Team New Jersey

RUTGERS – THE STATE UNIVERSITY OF NEW JERSEY AND NEW JERSEY INSTITUTE OF TECHNOLOGY

ENJOY House approaches sustainable design from a different angle. Featuring an inverted-hip roof shape and constructed of precast concrete panels, this house redefines coastal living with an architecture informed by performance criteria.

User Friendly: ***The team used universal design principles to make this house accessible to people of all generations and levels of mobility.***



Tidewater Virginia

OLD DOMINION UNIVERSITY AND HAMPTON UNIVERSITY

Based on the multifamily buildings commonly found in historic Norfolk, Virginia, Unit 6 Unplugged updates the key features of traditional Arts and Crafts-style homes to suit today's energy- and cost-conscious consumers. Light switches are powered by remote transmitters that can be placed anywhere in the house.

Changing Spaces: ***The open-air porch converts to a passive heating sunspace in colder months via large motorized windows.***

Purdue University

Purdue's INhome, short for Indiana home, offers a realistic and balanced vision for ultra-efficient housing while demonstrating some of the many ways to live sustainably without sacrificing quality or comfort. Although the exterior could blend in well in the typical Midwestern neighborhood, the house includes innovative features that are anything but ordinary.

Wall Flower: ***The biowall of vertically arranged plants is self-watering.***

The University of Tennessee

The Living Light house incorporates the knowledge of Tennesseans past and present. Following in the footsteps of the state's early settlers, the team employs scalable energy strategies to suit the climatic extremes of the Appalachian Mountains.

Don't Miss: ***The ventilated double façade system is composed of alternating translucent and transparent panes and horizontal blinds.***

Parsons The New School for Design and Stevens Institute of Technology

Empowerhouse uses cross-disciplinary, integrative design techniques and a community-based approach to realize a sustainable, comfortable, and affordable house. The shape, building envelope, window placement, and shading were optimized through feedback from energy modeling.

Greater Good: ***Following the Solar Decathlon, the house will be a Habitat for Humanity home in Washington, D.C.***

Middlebury College

This house is named after Emerson's essay "Self-Reliance," which challenges people to think independently and to question the status quo. From recycled insulation to a greenhouse wall, the design reevaluates residential building practices and demonstrates that healthy, sustainable living can be comfortable.

Old Is New: ***A New England farmhouse design combines with energy efficiency features to suit the 21st-century family.***

Appalachian State University

The Solar Homestead reflects the independent spirit of traditional homesteaders. The combination of architecturally integrated technologies and sustainable design creates a distinctive dwelling for the modern homesteader—the person who values independence, the land, and the environment.

Energy Saver: ***A reinvented phase-change Trombe wall passively collects heat throughout the day and radiates it inside at night.***

Florida International University

The ever-changing nature of perFORM[D]ance House is driven by environmental conditions, resulting in an interactive performance that showcases sustainable strategies and technologies. Operable louvers raise and lower as needed for privacy, shading, passive ventilation, and protection from hurricane-force winds.

Balancing Act: ***A counterbalance mechanism allows the perimeter louvers to swing upward, forming a wide canopy.***

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Team Belgium

GHENT UNIVERSITY

E-Cube takes a straightforward approach to solar living. Stripped of nonessential components and finishes, this prototype house is conceived as a do-it-yourself building kit with pre-engineered, factory-built parts that are easily assembled without special skills.

Budget Friendly: ***Team Belgium's primary interest was to create a comfortable, solar-powered house with a lot of space on a small budget.***

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Canada

UNIVERSITY OF CALGARY

Canada's house is designed for the native peoples in Southern Alberta—the First Nations of Treaty 7. TRTL (pronounced "turtle") is a healthy, safe, durable, and affordable house that also has appeal in the broader market of the more than 600 native groups in Canada.

Sun Inspired: ***The rounded, tipi-like form and east-facing entrance acknowledge the sun as a traditional source of energy and life.***

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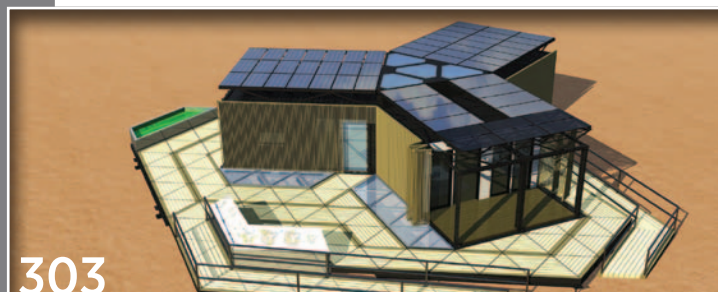
Team China

TONGJI UNIVERSITY

Y Container embodies the belief that one can live anywhere freely. This affordable, transportable, solar-powered house comprises six recycled shipping modules that contain the energy, water, and plants required for an individual to enjoy an independent lifestyle.

Fresh Air: ***A natural ventilation tunnel in the middle of the house regulates air distribution and the fresh air supply without consuming energy.***



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University of Maryland

Inspired by the Chesapeake Bay ecosystem, WaterShed manages storm water, filters pollutants, and neutralizes waste. By managing water and energy consumption, the house demonstrates how the built environment can help preserve watersheds everywhere.

Water Works: ***WaterShed's design features constructed wetlands that capture rainwater runoff and filter greywater.***

Team Massachusetts

MASSACHUSETTS COLLEGE OF ART AND DESIGN AND UNIVERSITY OF MASSACHUSETTS AT LOWELL

The 4D Home demonstrates how dynamic interior spaces can make compact living viable for a small family. Combining adaptability, affordability, and energy efficiency, the house is designed to adjust to a family's evolving needs over time.

Crafty Students: ***Team members designed and fabricated the furniture, decor, and housewares.***

University of Illinois at Urbana-Champaign

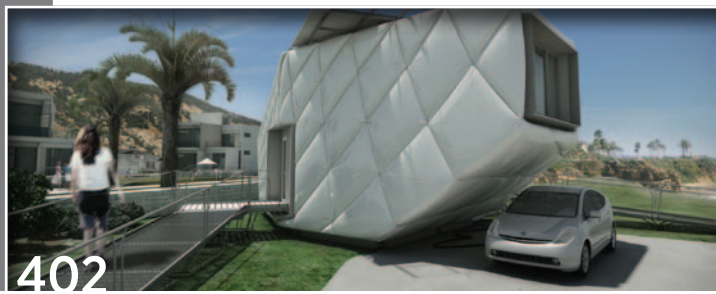
Re_home consists of two modules that can be transported on one trailer for rapid response to disaster situations. By combining good design, smart planning, and low-cost solutions, this house brings environmentally aware living to the forefront of community-led recovery efforts.

Panels With Purpose: ***A building-integrated photovoltaic system provides a source of energy while providing shade to reduce solar heat gain.***

The Southern California Institute of Architecture and California Institute of Technology

CHIP's angular design is motivated by California's soaring land costs and increasing urban sprawl. The north side is lifted to create a car park. The house wears thermal performance on its proverbial sleeve, showcasing a unique exterior envelope made from vinyl-coated fabric mesh.

Wow Factor: ***The team aimed to achieve extraordinary results in affordable, attainable ways.***

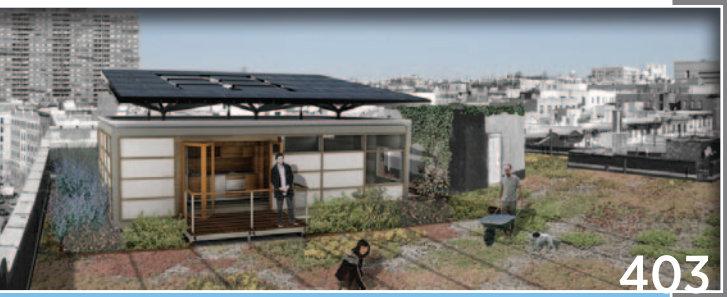


Team New York

THE CITY COLLEGE OF NEW YORK

Team New York's Solar Roofpod responds to the fact that urban rooftops are largely underused. Intended for existing mid-rise buildings, this house enables eco-conscious city dwellers to live lightly by producing solar power, cultivating roof gardens, and retaining storm water.

Market Ready: ***This "penthouse with a purpose" is designed to respond to the market for economical new housing in cities.***



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The Ohio State University

This house, named enCORE, represents The Ohio State University's second Solar Decathlon effort. To address the trend of expanding home square footage despite shrinking family sizes, the 2011 team creates more usable space within a smaller area by concentrating the functional systems in a central core.

Second Act: ***An adjustable exterior screen provides privacy and protection from the sun.***

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Solar Decathlon 2011

Special Events

The excitement of this international competition is not to be missed! Celebrate these events with the decathletes in the Main Tent at West Potomac Park.

- **Opening Ceremony**
  Thursday, Sept. 22, 10 a.m.
- **Affordability Contest Results**
  Tuesday, Sept. 27, 2:30 p.m.
- **Engineering Contest Results**
  Thursday, Sept. 29, 2:30 p.m.
- **Communications Contest Results**
  Friday, Sept. 30, 2:30 p.m.
- **Final Awards Ceremony**
  Saturday, Oct. 1, 2:30 p.m.

People's Choice Award

The winner of this award gets the bragging rights. Please vote for your favorite house! Fill out a paper ballot in one of the welcome tents, or cast your vote online at **www.solardecathlon.gov**.

The Contests

Teams earn points based on how their houses perform in 10 contests, each worth 100 points.

1. Architecture

Teams are challenged to design and build attractive, high-performance houses that integrate solar and energy efficiency technologies seamlessly into the design. A jury of professional architects evaluates drawings, construction specifications, an audiovisual presentation, and the house itself.

2. Market Appeal

Houses are built for a target client defined by the team. A jury of professionals from the homebuilding industry evaluates how well the design responds to the characteristics and requirements of the target client. Jurors also consider livability, marketability, and buildability.

3. Engineering

A jury of professional engineers assigns a score to each team based on its drawings, construction specifications, energy analysis results and discussion, and audiovisual engineering presentation. Jurors also evaluate the houses on-site.

4. Communications

All communications materials should educate students and the public about the project. A jury of communications professionals assigns a score based on the team's final website, public exhibit materials, public exhibit presentation, and video walkthrough.

5. Affordability *New for 2011*

The challenge is to design and build cost-effective houses that combine energy-efficient construction and appliances with renewable energy systems. A professional estimator determines the estimated construction cost of each house. Full points are awarded for a construction cost of $250,000 or less. A sliding point scale is applied to houses between $250,000 and $600,000. Houses that cost $600,000 or more receive zero points.

6. Comfort Zone

House temperatures and humidity levels should remain steady, uniform, and comfortable. Full points are awarded for staying within target temperature ranges of 71°F (22.2°C) to 76°F (24.4°C) and maintaining relative humidity below 60% during specified time periods.

7. Hot Water

This contest measures the ability of the water-heating system to supply all the hot water needed for daily tasks. Teams must provide at least 15 gallons (56.8 L) of hot water in 10 minutes or less during water draws. Full points are awarded for an average temperature above 110°F (43.3°C). Fewer points are awarded for cooler temperatures, reducing to no points for hot water below 100°F.

8. Appliances

This contest mimics the appliance use of an average U.S. home. Teams earn points for operating the refrigerator, freezer, washer, dryer, and dishwasher within set parameters.

9. Home Entertainment

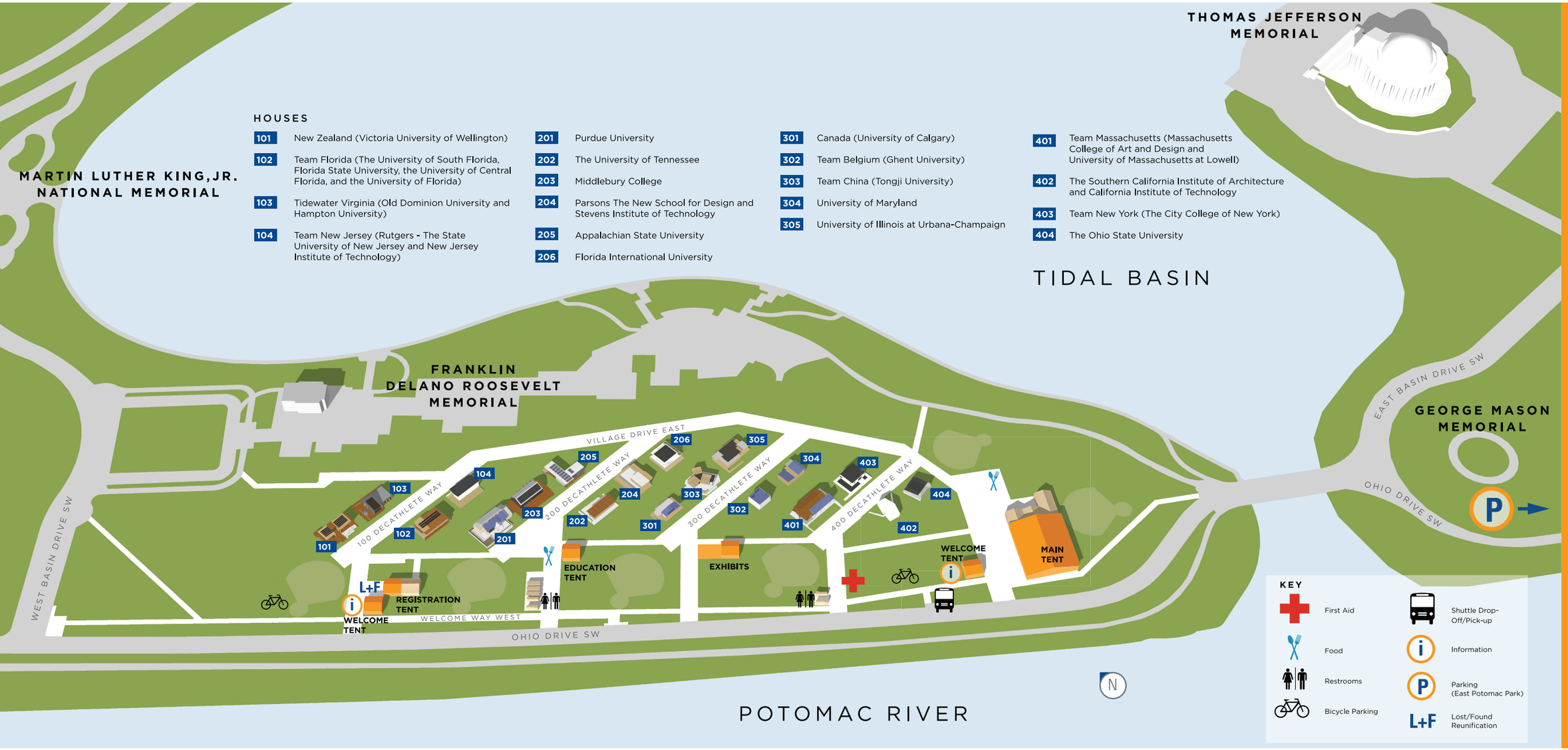
To demonstrate that houses powered by the sun can provide a comfortable setting with modern conveniences, teams host two dinner parties and one movie night. They also complete operational tasks with their lights, televisions, and computers.

10. Energy Balance

A bidirectional utility meter measures the net energy each house produces or consumes over the course of the competition. Full points are awarded for producing at least as much energy as the house needs during the competition. Fewer points are awarded for a net electrical energy balance between 0 and –50 kilowatt-hours (kWh), meaning the house consumed more energy than it produced. No points are awarded for balances less than –50 kWh.

U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

2011



HOUSES

- **101** New Zealand (Victoria University of Wellington)
- **102** Team Florida (The University of South Florida, Florida State University, the University of Central Florida, and the University of Florida)
- **103** Tidewater Virginia (Old Dominion University and Hampton University)
- **104** Team New Jersey (Rutgers - The State University of New Jersey and New Jersey Institute of Technology)
- **201** Purdue University
- **202** The University of Tennessee
- **203** Middlebury College
- **204** Parsons The New School for Design and Stevens Institute of Technology
- **205** Appalachian State University
- **206** Florida International University
- **301** Canada (University of Calgary)
- **302** Team Belgium (Ghent University)
- **303** Team China (Tongji University)
- **304** University of Maryland
- **305** University of Illinois at Urbana-Champaign
- **401** Team Massachusetts (Massachusetts College of Art and Design and University of Massachusetts at Lowell)
- **402** The Southern California Institute of Architecture and California Institute of Technology
- **403** Team New York (The City College of New York)
- **404** The Ohio State University

Food Available

Free Wi-Fi

House Tours and Exhibits

Friday, Sept. 23–Sunday, Oct. 2
Weekdays:
10 a.m.–2 p.m.
Weekends:
10 a.m.–5:30 p.m.

Scan QR code for more info

U.S. DEPARTMENT OF ENERGY
DOW CORNING
LOWE'S Let's Build Something Together
M.C. DEAN BUILDING INTELLIGENCE
NREL NATIONAL RENEWABLE ENERGY LABORATORY
pepco Your life. Plugged in.
Schneider Electric
Time to shine

The Workshops

Find out how to apply solar technologies and efficiency strategies in your own home by attending a workshop. Various topics are offered throughout the day; they include creating an energy-efficient home, selecting and operating a solar-electric system, and building a more sustainable future. Sept. 23 is Building Industry Day, with all workshops tailored to builders, architects, engineers, and green building professionals. No workshops will be held on Sept. 26 and 27, which are Solar Education Days for local students.

Visit the Main Tent for a list of the day's topics. These free educational sessions are held in the Main Tent at the times listed below.

September

Friday 23	Saturday 24	Sunday 25
10:00 a.m.	10:00 a.m.	10:00 a.m.
11:00 a.m.	11:00 a.m.	11:00 a.m.
12:00 p.m.	12:00 p.m.	12:00 p.m.
1:00 p.m.	1:00 p.m.	1:00 p.m.
2:00 p.m.	2:00 p.m.	2:00 p.m.
3:00 p.m.	3:00 p.m.	3:00 p.m.
	4:00 p.m.	4:00 p.m.

Wednesday 28	Thursday 29	Friday 30
10:00 a.m.	10:00 a.m.	10:00 a.m.
11:00 a.m.	11:00 a.m.	11:00 a.m.
12:00 p.m.	12:00 p.m.	12:00 p.m.
1:00 p.m.	1:00 p.m.	1:00 p.m.

October

Saturday 1	Sunday 2
10:00 a.m.	10:00 a.m.
11:00 a.m.	11:00 a.m.
	12:00 p.m.
	1:00 p.m.
	2:00 p.m.
	3:00 p.m.
	4:00 p.m.

U.S. DEPARTMENT OF
ENERGY

U.S. Department of Energy and Office of Energy Efficiency and Renewable Energy

The Office of Energy Efficiency and Renewable Energy invests in clean energy technologies that strengthen the economy, protect the environment, and reduce dependence on foreign oil.

To help make better buildings and homes in the United States and with global partners, we work closely with industry and manufacturers to research and develop technical solutions and practices for energy-efficient living and work spaces.

We founded the U.S. Department of Energy Solar Decathlon in 2002 to help encourage widespread adoption and use of energy-saving technologies and renewable energy sources and to train the future innovators in sustainable building.

Once again, it's time for energy-smart and attractive, solar-powered houses—along with a remarkable corps of students—to find their place in the sun. The experience will serve them, and all of us, well in the future. As the next generation of architects, engineers, and builders, the decathletes are positioned to apply hands-on experience to the future clean-energy economy jobs. So far, about 15,000 students have taken advantage of the unique training opportunity that is the Solar Decathlon.

Secretary of Energy Steven Chu cuts the ribbon to open Solar Decathlon 2009.

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

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

National Renewable Energy Laboratory

Solar Decathlon 2011 Organizer

Solar decathletes are the innovators, architects, and green builders of the future, and the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) is pleased to support the kickoff to their careers—Solar Decathlon 2011.

Wrapping buildings in smart, clean, and efficient technology, capturing photons from dawn to dusk, and drawing inspiration from nature, the solar decathletes share a common passion with NREL staff—a commitment to building a cleaner, sustainable world.

Since the competition began in 2002, NREL has worked side by side with the U.S. Department of Energy to ensure a fair, safe, and educational event for decathletes and visitors.

NREL's main campus in Golden, Colorado, includes one of the most energy-efficient buildings in the world, the Research Support Facility. With photovoltaic panels on the roof, smart windows, daylighting, native landscaping, and a concrete labyrinth to store thermal energy, the Research Support Facility serves as a living model for smart energy use, as will the student-designed masterpieces in the solar village.

For 34 years, NREL's research and partnerships have given the United States and the world clean, sustainable energy choices. In that spirit, NREL applauds the brainpower, altruism, and competitiveness gathered at Solar Decathlon 2011.

The Research Support Facility at NREL is a living model for smart energy use.

www.nrel.gov

The Sponsors

They are leaders in their fields, generous with their time and support, and committed to the ideals of the Solar Decathlon. They have stepped up to share their expertise and resources with the decathletes and the public. They are making a difference now and for the future of our planet. Some have been sponsors since the first Solar Decathlon in 2002, and others signed on for the first time this year. Everyone involved with the Solar Decathlon expresses a heartfelt thank you to each of them.

DOW CORNING

Dow Corning

As part of its commitment to drive innovation in the solar industry, Dow Corning's sponsorship of the Solar Decathlon includes overseeing creation of an educational curriculum and on-site learning center to help strengthen students' understanding of solar energy and sustainability.

A global leader in silicones, silicon-based technology, and innovation, Dow Corning and its joint venture, the Hemlock Semiconductor Group, have announced investments of more than $5 billion over the past six years to research, develop, and expand production of materials critical to the solar industry.

Through the Solar Decathlon and beyond, Dow Corning will continue to be an active collaborator with students, researchers, manufacturers, and governments to advance science, technology, engineering, and math (STEM) education.

Lowe's

Lowe's is committed to providing the education, tools, services, and products needed for consumers to make their homes more efficient so they can save both energy and money. The Solar Decathlon is a prime example of how whole-home energy efficiency can be achieved aesthetically and affordably.

Lowe's is contributing volunteers from its stores and nonprofit partnerships, hosting the consumer workshop series, and supporting local and national media outreach efforts. In addition, the company is actively supporting the decathletes during the assembly period with resources, including Kobalt construction tools, supplies, and staff expertise.

Pepco

As one of the largest electric utility companies in the mid-Atlantic region, Pepco has provided service to customers in the Washington, D.C., metropolitan area for 115 years. Pepco is proud to again serve as a sustaining sponsor of the Solar Decathlon, which it views as an important showcase of the potential of solar power.

In 2011 as in 2009, Pepco is supporting the Solar Decathlon by providing an expert team of Pepco engineers and project managers to arrange for electrical power and net-metering services for the student-built houses. The company is also providing volunteers to serve as greeters, speakers, and docents.

M.C. Dean

M.C. Dean Inc. is proud to be a first-time sponsor of the Solar Decathlon. For more than 60 years, M.C. Dean has provided engineering and technology services and systems for mission-critical systems and facilities in the D.C. area—and throughout the world.

For its event sponsorship, M.C. Dean is providing the Solar Decathlon with grid-connected solar power system design, installation, operation, and monitoring to deliver reliable service to the teams, sponsors, attendees, U.S. Department of Energy, and everyone involved in the competition. M.C. Dean salutes the solar decathletes for their designs, engineering, determination, passion, and drive for a more energy-efficient world.

Schneider Electric

Schneider Electric, a global specialist in energy management, is committed to producing innovative and effective solutions that make energy safe, reliable, efficient, productive, and green. Fulfilling its mission to help people make the most of their energy, it has been involved in the Solar Decathlon as a sustaining sponsor since 2009.

Schneider Electric is the supplier of the microgrid solution enabling a safe and reliable electrical connection between the solar village and the utility service for the duration of the event. The company has also provided energy management products in more than half of the houses through direct donations to the competing universities as well as consulting services from its energy experts.

Alliance for Sustainable Energy

The Alliance for Sustainable Energy manages and operates NREL for the U.S Department of Energy. The Alliance is pleased to be a sponsor of Solar Decathlon 2011 by providing organizer uniforms.

BP Solar

BP Solar—a leading designer, manufacturer, and marketer of solar energy products and services—continues the legacy of BP by once again sponsoring the Solar Decathlon. BP Solar is providing advertisements in *The Washington Post* and is co-sponsoring a congressional reception.

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

ASHRAE has sponsored the Solar Decathlon since 2005. As the world's leading HVAC&R technical organization, ASHRAE provides essential resources for sustainable building design and operation.

DC-Net – District of Columbia Office of the Chief Technology Officer

DC-Net provides telecommunications services for government and public safety purposes throughout Washington, D.C. The service provider is supplying Internet, LAN, and Wi-Fi connections for the event.

Applied Materials

Applied Materials, a leader in scaling green manufacturing, returns to support the Solar Decathlon and engage the innovators of tomorrow. Applied Materials helps recognize decathlete achievements, is co-sponsoring a congressional reception, and is providing outreach via *The Washington Post*.

Dow Solar

Dow Solar, developer of DOW POWERHOUSE Solar Shingles, is pleased to support Solar Decathlon 2011 by providing food for the Victory Reception and co-sponsoring a congressional reception.

Bosch Group

Bosch is proud to support the commitment to innovation for a sustainable future. This global supplier of technology and services is contributing to the Solar Decathlon Opening Reception and volunteer uniforms.

Meteor Solar LED

Meteor Lighting is proud to be a part of the Solar Decathlon again. As the sponsor of the event's architectural exterior pathway lighting, Meteor's involvement reflects the company's commitment to sustainable lighting solutions.

My Green Neighborhood

My Green Neighborhood works to supply price-friendly renewable energy solutions to urban households. It is providing full-service meals for all team members at the event.

Perkins+Will

Perkins+Will, one of the world's foremost architecture and design firms, is sponsoring the bike partnership and bike valet program. The firm is committed to sustainable design and creating solutions that contribute to human and environmental health.

National Association of Home Builders

NAHB supports the growth of energy-efficient, solar-powered houses. Decathletes displayed models of their houses at NAHB's International Builders' Show—the world's largest residential construction expo.

Popular Mechanics

Popular Mechanics, a second-time Solar Decathlon sponsor, helps readers demystify complex science and technology, leaving them feeling competent in their personal lives and informed about the issues that shape their future.

National Education Association

The NEA, a second-time Solar Decathlon sponsor, is organizing Solar Education Days for local K–12 schools again. By providing support to develop and broadcast educational programming, NEA helps spread knowledge about the Solar Decathlon to school kids and teachers.

Wells Fargo

Wells Fargo supports the Solar Decathlon as part of its dedication to effecting positive environmental change. In addition to its sustainable business practices, Wells Fargo makes significant lending and investment commitments to the clean tech industry.

American Institute of Architects

Lighting Science Group

Aquilent

Nationwide Marketing Group

Audubon

REC Group

Autodesk

RS Means

Duke Energy

Solar Energy Industries Association

Electrolux

Washington Gas

First Solar

U.S. Green Building Council

Lafarge North America

Prepared by the National Renewable Energy Laboratory (NREL), a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy; NREL is operated by the Alliance for Sustainable Energy, LLC.

Experience

Solar Decathlon 2011!

Tour the houses. Enjoy the exhibits. Be enlightened.

Friday, Sept. 23, through Sunday, Oct. 2, 2011

Weekdays: 10 a.m.–2 p.m.

Weekends: 10 a.m.–5:30 p.m.

House Tours

The solar village is open for visitors to explore the houses, meet the decathletes who designed and built them, and learn more about clean energy technologies.

Public Exhibits

- **Anatomy of a House**—Take advantage of energy-saving tips. Learn about the building technologies used in the competition houses.
- **Electric Vehicle Charging Station**—Check out a plug-in hybrid electric vehicle and see how it is charged.
- **Education Tent**—Have fun with interactive exhibits related to various renewable energy technologies.
- **Energy & Your Home**—Visit this tent showcasing an array of energy efficiency and renewable energy technologies. Learn how you can save energy and money.

Visit www.solardecathlon.gov

Please recycle this Visitors Guide in one of our welcome tents unless you would like it as a souvenir.

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

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