The Solar Decathlon is a biennial program developed by the U.S. Department of Energy (DOE) that challenges collegiate teams from around the world to design, build and operate solar-powered houses that are cost-effective, energy-efficient and attractive. Created to educate students and the public on the benefits of energy-efficient housing, the Decathlon also prepares its student participants to enter our nation’s clean-energy workforce.

Since the inaugural contest in 2002, a total of 92 collegiate teams worldwide from various disciplines have participated in the Decathlon. Over a period of 10 days, the student-built houses are judged in 10 competitions. Contests include juried contests such as the Architecture, Engineering and Design competitions, in which a panel of experts score each home. The Solar Decathlon also includes measured contests such as the Affordability, Comfort Zone and Energy Balance competitions, in which data is collected and recorded to determine the winning scores. The team with the most cumulative points is named the overall winner.

A Two-year Process
Although the Solar Decathlon marked the first time these student-constructed homes were on public display (on the National Mall in Washington, D.C.), it was merely the final step in a long journey to the competition. Typically, teams begin the design development, construction and commissioning phases nearly two years before the Decathlon takes place. To participate in the Solar Decathlon, teams consisting of engineering, architecture and design students, as well as their faculty advisors, submit proposals to the DOE. Of the hundreds of proposals the DOE receives, a panel of professional judges selects approximately 20 teams to compete.

The Solar Decathlon presents a unique challenge to students: They must produce homes that are not only affordable, aesthetically appealing and comfortable, but that also operate at maximum energy-efficiency. The homes must be livable (following the Solar Decathlon, many become homes for families) and meet national building codes, while also incorporating cutting-edge technologies that enable them to function at superior or net-zero energy performance.

The HVAC Solution
The cooling and heating systems in the 2011 Solar Decathlon houses proved to be a critical factor in the competition. Because HVAC systems are typically a huge energy expense, improper sizing or choice

Award-winning 2011 Solar Decathlon Teams Choose Split-ductless for HVAC Solution

2011 Solar Decathlon

| Total Number of Teams | 19 |
| Teams Using Mitsubishi Electric Products | 5 |

The Teams

- University of Maryland
- Appalachian State University
- Parsons New School & Stevens Institute
- SCI-Arc/Caltech
- Tidewater Virginia

Visitors to the 2011 Solar Decathlon saw 19 solar-powered homes built by collegiate teams from around the world.
Performance houses that integrate solar and energy-efficient technologies with an aesthetically appealing design. Because the Mitsubishi Electric split-ductless systems have a small footprint, the indoor and outdoor units can be attractively concealed, helping teams win points in Architecture. Mitsubishi Electric’s residential systems were also ideal for the Comfort Zone contest, which requires houses to keep temperature and humidity levels steady, uniform and comfortable. The split-ductless systems’ ability to make minute temperature adjustments and handle dehumidification gave teams a distinct HVAC advantage in the often-humid Washington, D.C., climate.

In the Energy Balance contest, organizers measure the net energy a house produces or consumes over the course of the competition. A team receives full points for producing at least as much energy as its house needs, achieving a net energy consumption of zero during contest week. Mitsubishi Electric’s split-ductless systems were the ideal HVAC choice for this contest because the INVERTER-driven compressor readily adjusts to changes in the house’s load, so the systems keep the temperature steady, without disrupting the home’s energy balance.

Of the 20 competing teams, five incorporated Mitsubishi Electric systems into their homes because of their ability to provide extremely effective, energy-efficient cooling and heating. Together, the teams using Mitsubishi Electric products took home a total of nine top honors, including Most Affordable, People’s Choice and the top prize as overall competition winner.

**University of Maryland – 2011 Solar Decathlon Winner**

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Solar Decathlon</th>
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</thead>
<tbody>
<tr>
<td>Project Location:</td>
<td>Washington, D.C.</td>
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<tr>
<td>Completion Date:</td>
<td>October 2011</td>
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<tr>
<td>Team Name:</td>
<td>University of Maryland, College Park, Md.</td>
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<tr>
<td>House Name:</td>
<td>WaterShed</td>
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</table>

**University of Maryland Team Takes Home First Place**

WaterShed, the Solar Decathlon house built by the team from the University of Maryland, College Park, Md., is a solar-powered home inspired by the local Chesapeake Bay ecosystem. The home features constructed wetlands that filter storm water and gray water for reuse, a green roof, edible landscapes and a durable structural system. With several office elements integrated into the design, the

**Mitsubishi Electric Equipment Installed**

- (2) MSZ-FE09NA Indoor Units
- (1) MXZ-2B02NA Outdoor Unit

**Awards Won**

- 1st Place: Architecture
- 1st Place (tied): Energy Balance
- 1st Place (tied): Hot Water
- 2nd Place: Appliances
- 2nd Place: Market Appeal
- 3rd Place: Comfort Zone
- 3rd Place: Communications
- 3rd Place (tied): Home Entertainment

The University of Maryland’s solar house, WaterShed, took first place in the 2011 Solar Decathlon.
home's two modules) based on the system's independent comfort control, its efficiency and its quietness.

“The zone control that the Mitsubishi Electric system provided was very appealing to us in this competition,” said David Daily, a University of Maryland team member. “Because we have a home that is built in modules, we have one indoor unit in each module that provides independent temperature and humidity control. If the homeowner is only in the north module, only one indoor unit needs to run.”

The team's integrated design garnered impressive results. University of Maryland was the overall 2011 Solar Decathlon winner, with first-place spots in the Architecture and Energy Balance competitions, and top three spots in the Market Appeal, Communication and Comfort Zone categories.

After the contest, Pepco, a power company serving Washington, D.C., and Montgomery and Prince George's counties in Maryland, purchased WaterShed. Pepco placed the home at one of its Montgomery County facilities, where it serves as a living classroom demonstrating clean-energy options.
that is adaptable, self-sufficient, rugged, affordable and attractive.

The design consists of six outbuilding modules built around a generous covered outdoor living space called the Great Porch, which reflects the outdoor-focused lifestyle of early settlers. Inspired by lean-to sheds, the outbuilding modules link to form sheltered outdoor living and work space, and can be adapted to the family’s needs. For example, a Flex Space features a half bath, outdoor shower and outdoor kitchen, and can serve as a home office, guest suite or cabin retreat.

For the HVAC system, the team chose Mitsubishi Electric’s multi-zone split-ductless system, with two ducted indoor units that cool and heat the space.

“We chose the Mitsubishi Electric system because it was efficient and was able to handle the load of the space, and it’s extremely affordable,” said Appalachian State team member David Lee. “The system is able to control the heat and humidity levels without expending too much energy, crucial in both the Energy Balance and Comfort Zone contests. Moreover, the systems were easy to install, and we’ve had no problems with them.”

Appalachian State made some modifications to the mechanical systems in the home to increase efficiency. The team installed a solar-thermal heat dump next to the unit, supplying it with excess heat during sunny winter days and reclaiming the waste heat from the system during the cooling cycle.

To reduce the need for ceiling ducts and maximize the aesthetic appeal of the unit, the team installed ceiling-recess indoor units with an attractive, custom-made plywood casing in the home’s main living area, virtually disguising the look of an air handler. For the outdoor unit, the team designed a mechanical-space alcove clad in perforated metal sheeting that conceals the outdoor unit from

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Appalachian State University

**Project Name:** Solar Decathlon **Team Name:** Appalachian State University, Boone, N.C. **Completion Date:** October 2011 **House Name:** The Solar Homestead

**Appalachian State Honored with People’s Choice Award**

The Solar Homestead, the Solar Decathlon house built by the team from Appalachian State University, Boone, N.C., expresses the concept of “modern homesteading.” The design embodies the pioneer spirit of the Appalachian Mountains’ early settlers, who established a self-sustaining lifestyle on the frontier, and fuses it with today’s technology to create an energy-efficient house targeted for the residents of Asheville, N.C., a town nestled in the Blue Ridge Mountains, part of the Appalachian range. In creating the net-zero energy Solar Homestead, the Appalachian State team applied frontier values by integrating renewable resources and innovative technology into a home.

For the HVAC system, the team chose Mitsubishi Electric’s multi-zone split-ductless system, with two ducted indoor units that cool and heat the space.

“We chose the Mitsubishi Electric system because it was efficient and was able to handle the load of the space, and it’s extremely affordable,” said Appalachian State team member David Lee. “The system is able to control the heat and humidity levels without expending too much energy, crucial in both the Energy Balance and Comfort Zone contests. Moreover, the systems were easy to install, and we’ve had no problems with them.”

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**Mitsubishi Electric Equipment Installed**

- (2) SEZ-KD09NA Indoor Units
- (1) MXZ-2B02NA Outdoor Unit

**Awards Won**

- 1st Place: People’s Choice
- 1st Place (tied): Hot Water
- 2nd Place: Communications
- 3rd Place: Architecture
- 3rd Place (tied): Home Entertainment
We had to balance out efficiency with cost. It was important to us to make decisions that homeowners must make every day,” continued Lee. “With the Mitsubishi Electric system in this home, we can show the homeowner the most effective and cost-efficient way to cool and heat their homes.”

The Appalachian State team’s homeowner-oriented approach paid off. The team won the Decathlon’s coveted People’s Choice award, given to the home ranked the favorite by visitors.

Following the Decathlon, the Solar Homestead returned to Appalachian State to serve as an educational tool for future Mountaineers.

A perforated metal mechanical-space alcove houses the Mitsubishi Electric M-Series outdoor unit. A discreet door opens for easy serviceability.

**Parsons New School & Stevens Institute of Technology**

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**Team Name:** Parsons New School & Stevens Institute: Parsons New School of Design, New York; Stevens Institute of Technology, Hoboken, N.J.

**House Name:** Empowerhouse

**Mitsubishi Electric Equipment Installed**

- (1) SEZ-KD12NA Indoor Unit
- (1) SUZ-KA12 NA Outdoor Unit

**Awards Won**

- 1st Place (tied): Affordability
- 1st Place (tied): Hot Water

**Parsons-Stevens Team Builds Home for Habitat for Humanity, Scores Most Affordable Prize**

Empowerhouse, built by the Parsons New School for Design, New York, and Stevens Institute of Technology, Hoboken, N.J., is a solar-powered home that competed in the 2011 Solar Decathlon in partnership with Habitat for Humanity of Washington, D.C., and the D.C. Department of Housing and Community Development. Built with the goal of becoming a Habitat for Humanity home, Empowerhouse was designed to maximize energy efficiency by optimizing the building envelope, using a highly efficient micro-mechanical system and incorporating strategic lighting.

Built to Passive House standards, the home will consume up to 90 percent less energy for heating and cooling than a typical home in Washington, D.C., resulting in about $2,300 in annual energy savings, according to the team’s calculations.

The team behind Empowerhouse opted for a synergetic mechanical system, with many systems operating together to help reduce the overall energy load. An Energy Recovery Ventilator (ERV) ensures that fresh, preconditioned air flows directly into the HVAC indoor unit. The water heater recovers waste heat from the HVAC system.
to help heat water. Cool dehumidified air is then exhausted from the water heater, where it is pulled into the return and redistributed, reducing cooling loads.

“Part of the Solar Decathlon is about challenging teams to figure out unique ways to use standard appliances to better their efficiencies,” said Dan Tipaldo, Stevens Institute of Technology. “We integrated several different aspects of our mechanical system so that together they produce more hot water, heating and cooling – using less energy – than they would on their own.”

The team needed an HVAC system that allowed for easy installation as well as efficient use of the allotted housing space. To enhance the aesthetics, the team wanted to use ducted mini-split indoor units in which the air handler could be concealed within the ceiling. The team knew that, as with all ducted systems, there is a potential for duct loss, which gives these systems a lower Seasonal Energy Efficiency Ratio (SEER) and Heating Seasonal Performance Factor (HSPF) efficiency rating than ductless systems. It was critical for the team to choose a ducted mini-split that had the highest efficiency in the market. After testing three brands, the team chose the Mitsubishi Electric system. Team members found that it had the highest efficiency and would satisfy the house’s cooling and heating capacity without oversizing it.

According to Tipaldo, the team tried to select systems that are easy for homeowners to operate and use little electricity. “The Mitsubishi Electric system satisfied both of these requirements. It is easy to control and install while also being extremely efficient.”

Empowerhouse tied for first place in the Hot Water category and won the Affordability contest, with the home’s final cost estimated at $229,890.26.

Following the Solar Decathlon, Empowerhouse became a home for a family in the Greater Deanwood neighborhood, east of the Anacostia River in Washington, D.C. The Empowerhouse team participated in the selection of the family.

Built to Passive House standards, Empowerhouse consumes 90 percent less energy for cooling and heating than other homes. Mitsubishi Electric’s M-Series was chosen because of its ability to handle the home’s cooling and heating load efficiently, and its small footprint allowed for maximum use of the allotted housing space.
“CHIP” House Uses Common Technologies in Unconventional Ways

The Southern California Institute of Architecture (SCI-Arc), Los Angeles, and California Institute of Technology (Caltech), Pasadena, Calif., team designed its home, CHIP (Compact Hyper-Insulated Prototype), to challenge every architectural and engineering preconception. CHIP’s futuristic look derives from its geometric shape and its unique “outsulation,” an exterior insulation and finishing system that gives the polygonal home the appearance of a large quilted sculpture.

With California’s soaring land costs and urban sprawl in mind, the team designed CHIP to be an affordable dwelling with a small footprint that fits onto lots in accordance with Los Angeles’ Small Lot Ordinance. However, the home is flexible enough for a larger lot; it can expand by opening the large southern aperture, extending the living area to the exterior.

With CHIP, the SCI-Arc/Caltech team aimed to achieve extraordinary results by using common technology and products in unconventional ways and combinations, to create an affordable home perfectly suited for the Southern California lifestyle. The spaceship-like “outsulation” that provides the home with a thick layer of insulation is composed of billboard material fastened with zip ties, dowel rods and lag screws. The “outsulation” white covering is made of vinyl, so the building didn’t have to be waterproofed.

The CHIP team took a holistic approach when designing the energy-efficient mechanical core, with the HVAC system, the domestic hot water system, an Energy Recovery Ventilator (ERV) and a whole-house fan working together. The team chose a Mitsubishi Electric two-zoned split-ductless system for its HVAC system and developed custom control software that automatically adjusts the set points (based on weather conditions and predicted demand) to maximize both energy savings and comfort. The home uses the waste heat from the air conditioning to heat hot water for significant energy savings. The heat from the split-ductless system is stored in a thermal storage tank until it is needed to heat the water, and a secondary heat pump ensures that the domestic hot water maintains a

CHIP’s futuristic-looking “outsulation” is actually made of everyday products and helps keep the home’s temperature stable. A tight envelope and an integrated mechanical system, including the Mitsubishi Electric M-Series system, earned CHIP a tie for first place in the Energy Balance contest of the competition.

Mitsubishi Electric Equipment Installed

(2) MSZ-FE09NA Indoor Units
(1) MXZ-2B20NA Outdoor Unit

Awards Won

1st Place (tied): Hot Water
1st Place (tied): Energy Balance
2nd Place: Engineering
2nd Place: Home Entertainment
3rd Place: Affordability
constant temperature, even when the air conditioning is not in use.

This system helped the CHIP house tie for first place, with a perfect score, in the Hot Water contest. CHIP’s integrated approach also helped the team achieve a perfect score and a tie for first place (along with the University of Maryland) in the Energy Balance competition.

“We did a lot of testing for the HVAC system. We found the comfort control is extremely precise with the Mitsubishi Electric system, which is why we chose it for this competition,” said SCI-Arc/Caltech team member Sarah Ahmed. “We have to stay in a certain temperature and humidity zone throughout the contest, and our calculations indicated that Mitsubishi Electric was the best choice.”

Following the competition, CHIP has been part of various museum and public exhibits throughout California (including the California Science Center in Los Angeles) to educate visitors on sustainable home building. Plans are in the works for the house to serve as an educational facility for Caltech students.

**Mitsubishi Electric**

**Cooling & Heating**

**Live Better**

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**Tidewater Virginia**

Project Name: Solar Decathlon
Project Location: Washington, D.C.
Completion Date: October 2011

Team Name: Tidewater Virginia: Old Dominion University, Norfolk, Va; Hampton University, Hampton, Va.

House Name: Unit 6 Unplugged

**Mitsubishi Electric Equipment Installed**

(1) SEZ-KD12NA Indoor Unit
(1) SEZ-KD09NA Indoor Unit
(1) MXZ-2B20NA Outdoor Unit
(2) PAR-21MAA Remote Controllers

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**Tidewater Virginia Team Uses Futuristic Technology in Traditional Home**

In creating Unit 6 Unplugged, the Tidewater Virginia team (students from Old Dominion University, Norfolk, Va., and Hampton University, Hampton, Va.) drew its inspiration from the Arts and Crafts style homes found throughout the center-city neighborhoods of Norfolk, Va. The house is conceived as part of a larger six-unit multifamily building that will save money by sharing infrastructure costs among the units.

Unit 6 Unplugged is targeted to Norfolk’s population of young professionals, many of whom are recent college graduates and military personnel. The home is meant to be located in a pedestrian-friendly, historic neighborhood, encouraging walking and a reduced carbon footprint.

The home’s design is focused on value engineering, using technologies that achieve high performance at a relatively low cost. The team installed highly efficient photovoltaic modules that convert more than 18 percent of sunlight into electrical energy and a rainwater collection cistern that irrigates the landscape, reducing the load on the municipal water system. Unit 6 Unplugged also features a porch with motorized windows that allow it to open to the outside or serve as an enclosed sunspace.

For the home’s HVAC system, the Tidewater Virginia team chose a Mitsubishi Electric multi-zone outdoor unit and two ducted indoor units.

“We chose the Mitsubishi Electric system because the units are super-efficient and use very little energy. They get the job done heating and cooling the house,” said Jordan Smith, an architecture student from Hampton University. “The recessed indoor units allowed us to conceal them in a closet and a ceiling in the back hall. Plus, their small size meant we could integrate the mechanical system into the home’s architectural design.”
To increase the efficiency of the home, the team installed window and door sensors that prevented the HVAC system from operating when either is open. Additionally, to minimize losses, a solar hot water system was installed using an inline heater instead of the storage tank’s auxiliary heating coil.

For the Tidewater Virginia team, the ability to integrate energy-efficient elements while preserving the desired look was critical. Besides its energy efficiency, the small footprint and inconspicuous indoor and outdoor units served as another reason to choose the system, according to Smith. “With the Mitsubishi Electric system, we could keep HVAC behind the scenes so a house still feels like a home. We didn’t want our house to wear its technology on its sleeve.”

After the competition, Unit 6 returned to Norfolk where it serves as a design studio shared by architecture and engineering students from both schools, continuing the collaboration among disciplines fostered by Solar Decathlon 2011.