
AC 2011-106: PREPARING FOR THE 2011 SOLAR DECATHLON

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Research Areas Building Energy Efficiency Building Retrofit for Energy Use Reduction and Sustainability Alternative Energy Sources for the Built Environment Reuse and Recycling of Building Materials

Brief Resume 30+ years of construction industry experience includes owning and operating a custom homebuilding company in addition to senior management positions with one of the largest homebuilders in the nation as well as a regional commercial/residential development company. Worked as a research engineer for the National Association of Home Builders Research Foundation as a project manager for the EER energy efficiency research and demonstration residence. Currently teaches in and administers the Purdue Department of Building Construction Management's Demolition and Reconstruction concentration, the first college level program in the nation with an emphasis on the management of demolition and reconstruction projects.

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Preparing for the 2011 Solar Decathlon

Abstract

The Solar Decathlon is a high-profile international competition sponsored by the U.S. Department of Energy where university students design, build, and demonstrate solar powered homes that are fully operational and cost effective. It is held every other year and has drawn in excess of 300,000 spectators plus significant national and international media coverage. This project is large and complex, even for a research university where students routinely participate in a variety of national and international competitions. Students have two years to make the home a reality, but the project encompasses far more than design and construction. Tasks like fundraising, public relations, marketing, and logistics are also significant efforts. In fact, the teamwork aspect of the Solar Decathlon might be one of the lasting legacies of the project. Students and faculty from nearly a dozen different departments that wouldn't normally have close collaborations are working together to get this project accomplished. This paper will discuss one team's preparations for the 2011 competition and provide insight about what outcomes other universities can expect by participating in this event.

What is the Solar Decathlon?

The Solar Decathlon is a high-profile international competition sponsored by the U.S. Department of Energy (DOE) where teams of university students design, build, and demonstrate solar powered homes.¹ Although the homes are limited to 1,000 ft²; they are fully operational in every respect. Since its inception in 2002, this event has been held every other year on the National Mall in Washington, DC where it draws in excess of 300,000 spectators plus significant national and international media coverage. Figure 1 is from the most recent 2009 competition. The National Capital is in the background and helps convey the grand scale of the event.



Figure 1. The Solar Decathlon takes place on the National Mall in Washington, D.C.

The Solar Decathlon is part of DOE’s strategy for gradually moving the market for residential buildings closer to net zero energy. In other words, the goal is that homes in the not too distant future will use renewable energy, typically solar and wind, to generate as much on-site energy as they consume on an annual basis. The final year of the Solar Decathlon is planned for 2020; by that time it is hoped that the technologies for net zero energy homes will have become commercially viable and cost effective.

The name “Solar Decathlon” is used because the winning home is the one with the highest cumulative score in ten different events. Table 1 shows that roughly half of the contests are measured and the other half are determined by a jury. All contests have the same point basis. The “home entertainment” contest is a student favorite. It evaluates a dinner party thrown in the solar decathlon house for one of the other teams in the competition.

Table 1. The Solar Decathlon has 10 contests.

Measured Contests	Juried Contests
Comfort Zone	Architecture
Hot Water	Market Appeal
Appliances	Engineering
Energy Balance	Communications
	Affordability
Home Entertainment	

The measured contests listed in Table 1 are mostly self-explanatory. The “comfort zone” contest measures the ability of the home and its HVAC system to maintain specified levels of temperature and humidity. The “energy balance” contest compares the electrical loads for the home to the power generated by the home’s photovoltaic array. The goal is for the home to be net positive in terms of its interaction with the grid. In a change from past Solar Decathlons, the 2011 competition will not award bonus points for power generation past the net zero point.

The juried contests in Table 1 include obvious things like architecture, market appeal, and engineering. The “communications” contest evaluates how well the team conveys information about the home to visitors who tour the home during the competition, either by signs or by tours provided by team members.

The “affordability” contest is particularly compelling for 2011. To emphasize the cost effectiveness of net zero energy construction, the DOE has imposed a cost ceiling of \$250,000 on all homes and has hired an estimating firm to conduct independent appraisals. Homes that are over budget will be penalized. \$250,000 may seem like a lot of money for a 1000 ft² home, but the retail value of the photovoltaic array is at least 25% of the final cost. It will be interesting to see how many teams actually meet the cost cap.

Solar Decathlon Timeline

The scope and timeline for the Solar Decathlon is large and fast-paced, even for a research university where students routinely participate in a variety of national and international competitions. Table 2 illustrates how the event unfolds in terms of academic semesters. Students two years to make their home a reality, but the project encompasses far more than design and construction. Tasks like fundraising, public relations, marketing, and logistics are also significant efforts that take place during the entire project.

Table 2. Work on the Solar Decathlon spans 2 academic years.

Topic	2009	2010			2011			2012
	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring
Proposal								
Conceptual Design								
Recruit Project Team								
Detailed Design								
Construction								
Commissioning								
Competition								
Monitoring								
Event Planning								
Fundraising, PR, etc.								

A proposal for participation in the 2011 Solar Decathlon was submitted to the National Renewable Energy Laboratory in Fall of 2009. The proposal did not have much technical detail; it focused on the overall design philosophy, the structure of the team, and the resources available for completing the project. Based on that document, our team was also invited to submit a conceptual design, which included a 1/48 scale model and a poster board describing the home. The judges liked what they saw because our team was one of 20 invited to join the competition.

The summer of 2010 was needed to recruit a team for completing the project. Up until this point the group had consisted of about 5 to 10 dedicated students from Mechanical Engineering Technology, Building Construction Management, and Interior Design, but a much larger group was required to tackle the design, construction, fundraising, event planning, and public relations work. A high profile competition to create a new generation of sustainable housing proved to be a compelling topic because recruiting new talent was surprisingly easy. The team grew to nearly a dozen faculty and 150 students by fall of 2010.

The design work for the Solar Decathlon house started in earnest during the fall of 2010. A detailed design was submitted to DOE by mid-November. Figure 2 shows the preliminary home design that was delivered in a Building Information Model (BIM), along with a project manual and a health/safety plan. The DOE provided feedback to students at a design review meeting held in conjunction with the 2011 International Builders Show in Orlando, FL.



Figure 2. The design phase produced a BIM model of the home.

A public awareness campaign is a significant effort conducted in parallel with the technical design. Students from the Visual Design Department created a website to convey information about the project to homeowners, building contractors, and the general public. Another class of students in Computer Graphics Technology completed an animated 3-dimensional walk-through of the home to convey some of the design philosophies in a user-friendly format.

By spring of 2011, the technical work had shifted to construction. A student team from Building Construction Management completed the pre-construction planning and assisted with the construction process. A variety of industry collaborators assisted the team with ideas for fabricating and shipping the home. Although students were heavily involved in all phases of the project, some aspects of construction were completed with the assistance of outside contractors.

In parallel with construction efforts, a student team from Hospitality and Tourism Management began event planning. The logistics of transporting, lodging, and feeding a small army of university students in our nation's capital for one month requires a significant amount of advance coordination. Our team is planning to send groups of roughly 20 students for ten day shifts. Three shifts of students, 60 students in all, will be needed to cover the entire event.

The goal is to have the home finished by mid-June of 2011, about the time of the ASEE Annual Conference in Vancouver, BC. That allows about two months for commissioning to make sure all aspects of the home and the photovoltaic array are fully operational. Then the home will be dismantled into modules and shipped to the competition site.

Project Execution

The DOE does a good job of managing the 20 university teams on this project. They established contract deliverables and posted them to a web-based discussion group. The DOE also held monthly teleconferences with all 20 student teams to make announcements about explain expectations for upcoming contract deliverables. Most deadlines were aligned with a typical academic calendar so it was relatively easy to tackle the entire project as a series of semester-long classes. For example, students submitted an 80% complete design to DOE in November of 2010 and they received detailed comments back from DOE in January of 2011.

The Solar Decathlon project has attracted a talented team of students and faculty from at least 6 different colleges (Technology, Liberal Arts, Engineering, Consumer & Family Sciences, Agriculture, and Management) at our university. Most of the students have received university credit for their participation through one or more multidisciplinary courses. Table 3 shows how departmental leadership has shifted as work has progressed. To get the project started, a faculty member in Mechanical Engineering Technology led a course in the fall of 2009 that submitted the initial proposal to DOE's National Renewable Energy Laboratory. A faculty member in Interior Design, who is also a registered architect, guided a team of students through the conceptual design in the spring of 2010. It seems obvious that Building Construction Management should take the lead during construction of the house in spring of 2011.

Table 3. The Solar Decathlon is a team effort.

Semester	Course Topic	Lead Department
Fall 2009	Proposal Development	Mechanical Engineering Technology
Spring 2010	Conceptual Design	Interior Design
Fall 2010	Detailed Design	Computer Graphics Technology
Spring 2011	Construction	Building Construction Management

Even though the Solar Decathlon emphasizes work by students, resources from an entire university are needed to be most successful. Figure 3 highlights some of the key contributors to our team. The Facilities Department provided technical advice to students and oversight for construction. The Development Office assisted with fundraising efforts. Government Relations helped with the event logistics in Washington D.C. Marketing & Communications worked with students on outreach to media. The university's Research Foundation provided the land and infrastructure that allowed the house to be built.



Figure 3. Much of the university is involved in the Solar Decathlon effort.

Fundraising Efforts

The Solar Decathlon is an expensive competition. Our Solar Decathlon team expects to spend on the order of \$650,000 by the time the home is designed, built, transported and displayed in the competition. As shown in Figure 4, construction is the single biggest expense, nearly 1/2 of the total cost. The construction cost includes more funding for site preparation, safety materials, and tools than at a typical residential jobsite; mainly because the house is being built by students and it needs to be fully tested before being moved. Other significant expenses include transportation (physically moving the house to and from Washington, D.C.), lodging for students at the Solar Decathlon competition, and promotional materials that explain solar-powered housing to college students and the general public.

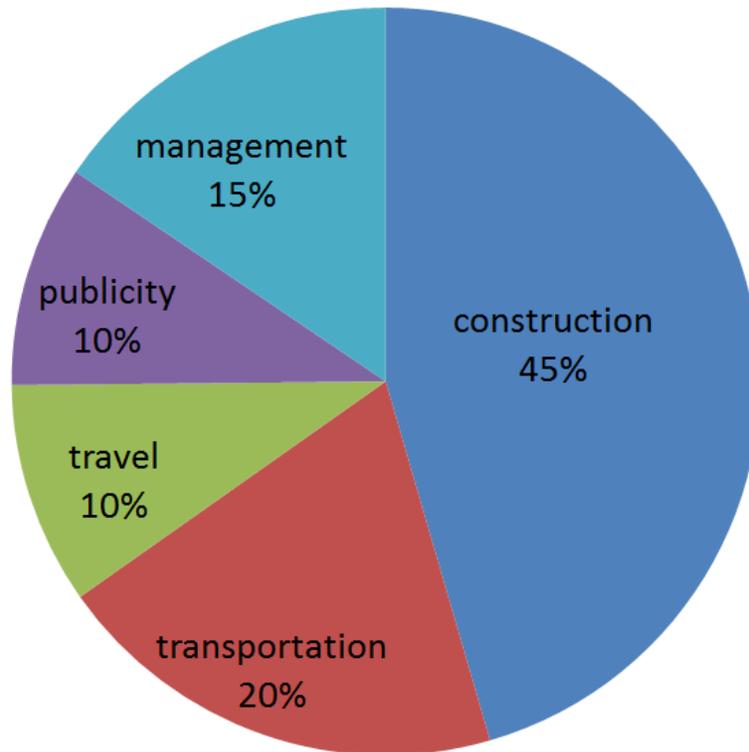


Figure 4. Construction is less than half of the overall solar decathlon cost.

Establishing a budget for a solar decathlon house is one thing, but actually raising the funding is another issue. \$650,000 is a lot of money, particularly in a difficult economy. Our team benefited from a close working relationship with the university's Development Office, who put us in contact with generous corporate sponsors. Figure 5 summarizes our team's funding model. We expect that most of the funding, roughly 60%, will come from cash donations and gifts in kind from corporate sponsors.

Many of these organizations participate because they are good friends of higher education, but they also recognize and value the public relations exposure associated with a high-profile event like the Solar Decathlon. The remaining funds came from a variety of government sources. The U.S. Department of Energy provides \$100,000 for all participating teams. Our State and University could provide up to 25% of the funding to complete the fundraising.

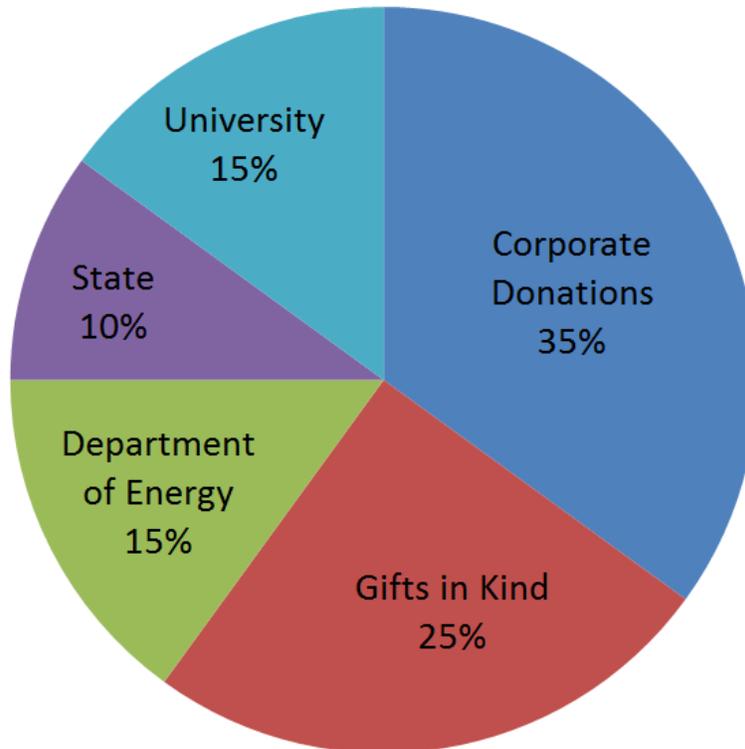


Figure 5. Corporate partners provided 60% of the funding with cash donations and gifts.

Outcomes of Solar Decathlon

Many different universities have participated in the Solar Decathlon since it started in 2002. Although each team has a unique approach to the competition and understanding of its value to their home institution, several common outcomes appear in literature:

Cross Campus Collaboration

Florida International University competed in the 2005 Solar Decathlon. A series of multidisciplinary courses were used to execute the project. The opportunity for Engineering and Architecture students to work together on a real-world project was one of the main benefits to their institution.² This concept is also essential to our participation in 2011. Students from the Colleges of Technology, Engineering, Liberal Arts, Consumer & Family Sciences, Business, and Agriculture are all making significant contributions. One participating faculty member noted that “converging diversity of expertise is a great catalyst for creative thought. I wouldn't be surprised to see several new collaborations spawning from this experience.”

Broader Societal Impacts

Tuskegee University competed in the first Solar Decathlon held in 2002. At that time, their team noted that the Solar Decathlon was intended to illustrate the practicality of emerging sustainable energy technologies and the importance of working with nature in developing national priorities.³ That spirit is alive and well in the 2011 Solar Decathlon, even though the venue may change from its original location on the National Mall. This location has long been a rallying point for change in the United States and is a primary reason that participating universities are attempting to get that venue reinstated for the 2011 competition.

Meet Educational Outcomes

The University of Virginia noted how the inaugural competition in 2002 helped them meet accreditation requirements.⁴ The Accreditation Board for Engineering & Technology (ABET) requires that both Technology and Engineering programs incorporate standards and other realistic constraints into their educational program. The design process for Solar Decathlon homes includes not only standards, but also brings economic, environmental, manufacturing, ethics, safety, health, social, and marketing issues along with it. It is hard to imagine a better way to expose students to the broad range of issues they'll face during their careers.

Design Innovations

The Pennsylvania State University's entry into the 2009 Solar Decathlon provided an opportunity to evaluate a novel photovoltaic awning that was built into their home.⁵ The device shaded the southern walls and also provided optimal electric power by tracking the sun. These types of design innovations have become a hallmark of the event. Our own entry into the 2011 competition will feature several innovations that could ultimately lead to commercial products.

Industry Collaboration and Research

The 2011 Solar Decathlon is also becoming a launching point for a number of industry collaborations. As one example, Trane Corporation is supplying our home with HVAC equipment featuring their newest "smart" controller that monitors energy use in real time. Unfortunately, that controller is not compatible with energy management tools for the photovoltaic array or appliances, meaning that a homeowner cannot get a full picture of home energy use from one device. We hope that our Solar Decathlon home will become a platform for integrating these systems and potentially lead to further applied research.

Community Outreach

Plans are already underway for ongoing community education and research after the Solar Decathlon competition. There is a good chance that our home will be permanently located as part of a community redevelopment effort where it will become a showcase for commercially viable low energy residential construction. Although a family will be living in the home, it will be fully instrumented so that its energy performance can be monitored over time.

Conclusions

The Solar Decathlon is a great opportunity for universities to showcase the talent of their students in a high-profile event that draws large crowds and international media attention. It is also an opportunity to help address the environmental and energy security issues facing our country by raising student and public awareness of the potential for commercially viable low energy residential construction. The event is a lot of fun for students and faculty who participate.

Faculty and universities who want to compete in future Solar Decathlons need to understand the high level of commitment required for successful participation. Significant funding and university support are needed. Our team is working with corporate sponsors and government agencies to raise at least \$650,000 in just one year. Additional support from many academic departments and many administrative units at the university are also needed. In fact, the teamwork aspect of the Solar Decathlon might be one of the lasting legacies of the entire project for our institution.

Acknowledgment

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