SOLAR DECATHLON: AN OVERVIEW AND CONSTRUCTIVE CRITIQUE

Sumit Brahmbhatt
Douglas Noble, FAIA, Ph.D.
University of Southern California
School of Architecture, Watt Hall 204
University Park, Los Angeles CA 90089-0291
e-mail: sbrahmbh@usc.edu and dnoble@usc.edu

ABSTRACT

The Solar Decathlon competition sponsored by the US Department of Energy is well designed to give participants an invaluable real-world learning experience advancing the state of the art in energy efficient architecture. It provides an avenue to help educate consumers, and to showcase new materials, methods and technologies developed in the field of solar energy and sustainable building design.

The first Solar Decathlon was held in 2002 with 14 universities completing a final competition entry. The finalists included teams from Auburn, Carnegie Mellon, Crowder College, Texas A&M, Colorado at Boulder, Delaware, Maryland, Missouri, North Carolina, Puerto Rico, Texas at Austin, Virginia, and VPI.

The competition generates interest and awareness in solar energy and sustainable design. The public display of the analysis and evaluation of the completed projects draws significant participation. The "contest" based substructure allows each team to excel and be recognized in their own area of expertise. The transparent monitoring and evaluation process expresses the importance of verified results and the analysis uses the types of instruments, measurements and methods that are easily adoptable. The competition structure recognizes the value of multidisciplinary teams and rewards teamwork. The popularity of the competition is demonstrated in the 30% increase in participation for the second competition. Teams websites help downplay the competitive aspects in favor of an open participatory model.

Although the competition is highly successful, there are opportunities for improvements. For example, in the first two competitions, the display location at the Mall in Washington DC is good for publicity and the potential for influencing government and policy, but it misses opportunities to reach out to different audiences and favors eastern competitors. The Mall in Washington also presents construction and design limitations (such as height) that have become significant determinates of the final projects. The new competition brief is substantially the same as the one for the first competition, giving experienced competitors an additional advantage. These issues and the others presented in this paper are relatively minor criticisms of a powerful competition that has a demonstrated record of success.

1.0 INTRODUCTION

The Solar Decathlon encourages different universities to design a small, highly energy efficient live/work house. The focus of the

Solar Decathlon is demonstrations of active and passive solar technologies. The competition generates enthusiasm for the next generation of architects and engineers to explore energy efficient building concepts.

Fig. 1: Solar Decathlon 2002, teams and organizers in front of the solar village on the National Mall in Washington DC

1.1 Why have a Solar Decathlon?

While most people have some knowledge about conventional energy sources and alternatives, as the resources are depleted we must explore alternative technologies and applications. The Solar Decathlon is effective at spreading awareness among the public and among students of architecture and engineering because it is a highly visible and it generates a friendly but serious competitive spirit among the participants.

1.2 What are the tangible results?

After the competition in September 2002, visitors and participants got chance to see 14 advanced, solar energy operated, off the grid, efficient, and beautiful small houses. The competition was also covered by many media networks which were later widely broadcast. More than 100,000 people visited the houses of Solar Decathlon in September and October of 2002.

2.0 THE COMPETITION

A group of experts in building energy use and solar energy technologies at National Renewable Energy Laboratory (NREL) were the official organizers. They were the developers of the rules, regulations, and the constitution of the ten "contests" for the competition.

Fig. 2: Visitors to the 2002 Solar Village learned about energy efficiency and renewable energy technologies from the student teams.

2.1 The design brief

The Solar Decathlon design brief asks participants to design, build, and operate an attractive, effective, and energy-efficient solar-powered house responding to the rules and regulations set by the organizers. The Solar house should meet the needs of a single-family residence. Within a total building footprint of 800 square feet, the program calls for a living area, bedroom, kitchen, small office space and utilities.

2.2 Some rules and regulations

The complete rules and regulations are detailed in "Solar Decathlon 2002: The Event in Review."[1] A few of the most important rules are:

-Each team had to construct its house on a predetermined "lot" of approximately 5500 square feet (511 sq. mt.), the location of which was assigned in advance.

-The homes' photovoltaic and solar hot water systems, as well as any other feature of the house (e.g., shading) that worked with solar energy were restricted in size by a "solar array" regulation that limited such features to within the 800 square feet (74.3 sq. mt.) footprint.

-To comply with the Americans with

Fig. 3: An official for the checks the Auburn University team's house for compliance with rules and regulations.

Disabilities Act (ADA), teams were required to provide an accessible route through their home for public tours (The entire house did not have to be ADA compliant).

2.3 The Sponsors

The Solar Decathlon is sponsored by the United States Department of Energy's office of Energy Efficiency and Renewable Energy in partnership with its National Renewable Energy Laboratory, British Petroleum, the American Institute of Architects, and the National Association of Home Builders.

2.4 Evaluation and Points in the Ten Contests

Following are the ten different contests, their maximum available points and evaluation methods:[1]

1. Architecture (up to 200 points)

Points are given for designing and building an attractive, high-performance house that integrates solar and energy efficiency technologies seamlessly. Teams can earn up to 200 points, twice the number of points available for other contests. A jury of architects judges this contest.

2. Dwelling (100 points)

Experts from the residential building industry will award points for this contest based on their evaluations of the "livability" and "buildability" of the homes.

3. Documentation (100 points)

This contest awards points based on how well the teams analyze their designs for energy performance and how thoroughly they document the design process. Teams must document all stages of Solar Decathlon project. The Architecture jury and a panel of engineers will evaluate the teams "as-built" drawings and building energy analyses.

4. Communications (100 points)

The Communications contest challenges teams to communicate their experiences to a wide audience through web sites and public tours. Panels of experts will judge the teams' web sites and house tours and award points based on the success of the teams in delivering clear and consistent messages.

5. Comfort Zone (100 points)

Full points for this contest will be awarded for maintaining narrow temperature and relative humidity ranges inside the houses. A panel of judges will also award points based on comprehensive assessments of thermal comfort and indoor air quality.

6. Appliances (100 points)

To earn points, teams must maintain a certain temperature in their refrigerators and freezers, wash and dry clothing, cook meals, use a dishwasher, and operate their televisions for 6 hours a day and a computer for 8 hours a day.

7. Hot Water (100 points)

Teams can score points in the Hot Water contest by successfully completing the "shower tests," which entails delivering 15 gallons of hot water in 10 minutes or less.

8. Lighting (100 points)

To win this contest, teams will have to supply ample interior lighting using as little electrical energy as possible. Lighting levels in each room of a team's house are continuously monitored and recorded.

9. Energy Balance (100 points)

The Energy Balance contest requires teams to use only the energy generated by the solar electric systems on their houses during the competition to provide all the electricity for the contests. Teams earn full points if their

battery systems are not depleted.

10. Getting Around (100 points)

In this contest, student teams use electricity generated by their solar electric systems on their houses to "fuel" their street-legal, commercially available electric vehicles. Teams then must log as many miles as they can to earn points.

3.0 CONSTRUCTIVE CRITIQUE

A questionnaire was sent to all competition team advisors asking them to identify strengths and weaknesses of the existing competition. The responses were not anonymous to the authors, but we have withheld individual identification for this paper.

3.1 Venue

For the first two competitions the venue was Washington D.C. main mall. The location helped attract national attention and a large pool of visitors and journalists. More than 100,000 people visited the event in less than 10 days.

Fig. 4: Visitors descended on the Solar Village, eager to see the homes and learn from the students.

One respondent to the questionnaire noted that the Mall venue was a great choice for sending a message to the government and American public. Another advisor agreed and noted that parking and lodging logistics could be improved. Another respondent suggested that the venue be changed to an empty lot of a large city - and have the teams leave their house there after the event to be sold to a low income family.

By rule, houses were limited to a height of 18 ft (5.5m) and a total building footprint of 800 sq.ft. (74.3 sq.mt.)(including the solar array). One competitor argued that one story buildings require more energy and resources than high-density multistory typologies. The height limit was dictated by the Mall venue, and so a new venue would be needed to allow denser building types.

According to the rules, “to prevent damage to the Mall, insertion of tie-down stakes or screws, or any foundation system is limited to vertical depth of 18 inch (457 mm). This restriction also virtually eliminates the possibility of damage to any part of the irrigation system on the Mall". This rule restricted design freedom for the foundation. Teams were also not allowed to place their houses directly on the grass. Some kind of support element was required to keep the floor section off the grass.

On the Mall there was also not permission from National Park Service (NPS) to drive vehicles on grass or use cranes for assembly. Just before the 2002 event, the regulation interpretations from the NPS changed. Trucks were permitted to drive on the grass as long as plywood was placed under the tires. It was somewhat good news for all participants but, it did result in the rental or purchase of a great deal of 3/4 inch (19mm) plywood and considerable labor moving the sheets of plywood around to act as a road on which the trucks can travel. Eventually, truck-mounted cranes were permitted but these vehicles had to stay on the gravel paths that run along the

north and south boundaries of the Mall.

The first two Solar Decathlon competitions have been sited in Washington DC. It may be reasonable to suggest moving the venue to other locations to attract a wider audience. Other cities might enjoy the chance to see the proposals, and the competition can be used by local sponsors to increase awareness of energy efficient design. Residents of states that have had serious energy problems (like the blackouts in California) would likely be receptive to such events.

Transportation costs are unfairly distributed to distant teams, resulting in uneven participation. In the 2002 event, there was not a single participant from west coast.

3.2 Design Brief

While there are clear advantages to maintaining the same building proposal, there is the potential for diminished interest if the design brief is static for successive competitions. Using the same design brief is helpful for evaluators but provides a disadvantage to new participants. Those who have participated with the same design brief will find it easier to compete because they will have significant specific knowledge about the pitfalls. Organizers might consider awarding bonus points for first-time participants or changing the design brief and rules enough to reduce the advantage. The changes to the brief must be kept within a reasonable range so that competitors can build on the knowledge gained in previous years.

3.3 Rules, Regulations, and Evaluation

In any competition some competitors will be declared winners. Because there are several smaller "contests" within the framework of the overall competition, many participants will get the opportunity to be "winners." Some participants have indicated that they felt that there was a judging bias towards entries with more technical equipment. Some faculty advisors said that they felt the judging favored projects that 'sold the idea to the general public' rather than projects that were truly innovative.

In addition to NREL and DOE staff, the competition could be judged by noted international architects and engineers, and the websites could be judges by noted web designers.

In response to the survey, advisors offered ideas for the constitution and redefinition of some competition points. There was general enthusiasm for rewarding innovation in passive design strategies. There was disagreement between advisors about removing contests like the solar car and refrigerator contests. They argued that the solar car contest is heavily dependent upon the number of PVs and the refrigerator contest involves primarily the selection of an efficient refrigerator. One advisor suggested using a full year of performance monitoring to truly measure building systems efficiently and solar powered work-live-work.

One advisor recommended that 40% of the points should be given to architecture; 40% to engineering (including hot water, comfort zone, lighting, energy balance, and appliances), and the remaining 20% to communication. Points for passive design strategies should be included in both the architecture and engineering categories. Points could be awarded for efficient transportation of the homes to the site and efficient construction practices.

It might also be reasonable to place a financial limit on projects, with allowances for differences in transportation distances.

3.4 Timing

The frequency of consecutive Solar Decathlon competitions should high to maintain the interest of the public and policy makers. The current schedule results in some graduate students missing the opportunity to participate.

3.5 Funding

One of the biggest issues competitors faced was funding. The technologies being employed are often "cutting edge" and therefore expensive. Several participants in the 2002 competition indicated that funding was a primary reason for not participating in the second competition. Product sponsorships were sometimes easier to obtain than funding for transportation, on-site labor costs and housing of the competitors in Washington. Some faculty indicated that they had spent significant amounts of their own money to participate.

There was a perception among the 2002 advisors that the DOE captured some obvious sponsors, who were then not interested in supporting individual teams. The rules preventing recognition signage also discouraged sponsorship. Individual sponsors were disappointed to see so many DOE sponsors' logos (which were required to be included on the team's websites), while their contributions were not publically acknowledged on the Mall.

4.0 CONCLUSION

Participants felt that the Solar Decathlon was an outstanding event and achieved tremendous success. They were confident that future competitions would also be highly successful. One faculty representative expressed disappointment because "... most of the teams were shocked that NREL did not follow up the competition with any survey of the teams as to what worked and what did not. NREL was good about making rules then changing them but not about listening to feedback from the teams."

With moderate improvements with regard to venue, time, rules and regulations, and evaluation methods, the competition could be greatly improved.

5.0 REFERENCES

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3. www.eere.energy.gov/solar_decathlon/team_southern_california.html

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6. Photo credits: www.eere.energy.gov/solar_decathlon