

# The Design of a Net-Metering and PV Exhibit for the 2005 Solar Decathlon

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# The Design of a Net-Metering and PV Exhibit for the 2005 Solar Decathlon

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## ABSTRACT

In the 2005 Solar Decathlon competition, 19 collegiate teams will design, build, and operate grid-independent homes powered by photovoltaic (PV) arrays on the National Mall. The prominence of grid-interconnected systems in the marketplace has provided the impetus for the development of a net-metering exhibit to be installed and operated during the competition. The exhibit will inform the visiting public about PV basics and appropriate alternatives to grid-independent systems. It will consist of four interactive components. One will be designed to educate people about the principles of net metering using a small PV array, a grid-interactive inverter, and a variable load. Additional components of the exhibit will demonstrate the effects of orientation, cloud cover, and nighttime on performance. The nighttime component will discuss appropriate storage options for different applications.

### 1. Objectives

The primary objective of this project is to answer the following challenge issued in Section 4.4.2.2 of the *Solar Energy Technology Program Multi-Year Technical Plan* [1]:

“...building community stakeholders (e.g., builders, buyers, operators, financiers, code officials) need to be better informed about those solar technologies that presently compete in today’s marketplace.”

Solar Decathlon is one of the premier demonstrations of building-integrated photovoltaics (BIPV) in the country. The 2002 competition informed thousands of “building community stakeholders” about some of the practical benefits of BIPV. However, the logistics of the competition and the practical limitations of the competition rules and regulations prevent the teams from fully addressing the challenges issued by the technical plan. The exhibit described in this paper is necessary to more fully inform stakeholders of those aspects of BIPV not addressed by the competition houses themselves.

### 2. Technical Approach

The Solar Decathlon houses use closely monitored 2 kW - 8 kW static BIPV arrays. A prime educational opportunity is precluded by the controlled conditions of the competition. Visitors are not able to interact with the arrays as they would in a hands-on exhibit, and, by rule,

the houses are grid-independent so do not demonstrate increasingly popular grid-interconnected BIPV systems. An exhibit consisting of four interactive components is planned to help visitors gain hands-on knowledge about:

- How grid-interconnected, net-metered BIPV systems work
- How orientation affects a BIPV array’s performance
- How an obstruction, such as a cloud, affects a BIPV array’s performance
- How a BIPV system works at night.

The competitors will attempt to explain these concepts to visitors, but the competition organizers believe that the level of understanding afforded by an interactive exhibit that offers direct feedback is worth pursuing.

The organizers have adopted the following multi-step approach to develop the exhibit concept:

1. Meet with Potomac Electric Power Company (PEPCo) regarding an interconnection agreement
2. Work with communications experts to identify audiences and desired results of the exhibit
3. Partner with appropriate Solar Decathlon sponsors
4. Develop a preliminary design and specify equipment that has reasonable costs, meets National Park Service (NPS) requirements, and helps achieve the desired results.

The following section will summarize the results of the implementation of this approach.

### 3. Results and Accomplishments

Any grid-interconnection on the National Mall is contingent upon PEPCo’s approval. Although PEPCo implemented an interconnection tariff in November 2003 [2], there are no streamlined interconnection agreement forms or procedures in place to expedite the approval process. Several of the competition organizers met with PEPCo representatives in July 2004 to establish a special interconnection agreement for the exhibit. The organizers now have verbal and written permission to proceed. The organizers would also like to test the interconnection of a 100 kW - 200 kW generator, which would represent the power generated by an entire grid-interconnected Solar Decathlon “village.” Approval of this test is contingent upon the outcome of a future meeting with PEPCo. In future competitions, the organizers will consider grid-interconnecting all the Solar Decathlon houses in the village on the National Mall.

Several organizers also met with communications experts to develop the exhibit concept. First, the group identified and characterized the exhibit audience. In 2002, the organizers noted that visitors to the Solar Decathlon had a wide range—from almost none to near expert—of knowledge about energy efficiency in buildings and BIPV. (A similar audience is expected for 2005.) Those with little knowledge comprised the majority of the audience. They have heard of “solar energy” but are not aware of the distinction between solar heating and solar electricity, and they are unfamiliar with net metering. Those with more knowledge are interested in topics such as the technical and economic differences among different system options and the steps necessary to install systems. The communications experts proposed that most components of the exhibit target those with very little knowledge, and, assuming availability of personnel, experts staffing the exhibit should be available able to answer the detailed questions of the more knowledgeable audience members.

The following are intended outcomes for visitors of the exhibit experience:

1. Those with less knowledge will leave with a clearer understanding of how a PV module works, and how it differs from a solar thermal panel; an understanding of the amount of power a PV module is capable of generating; the cost of a PV module, and the factors that affect its performance. The exhibit will remove the mystery surrounding PV and will motivate visitors to further explore the possibility of someday having PV installed on their roofs.
2. Those with greater knowledge will leave with a more complete understanding of the less obvious aspects of PV systems such as system efficiency and system sizing. They will gain the tools necessary to make an intelligent decision about the use of PV on their own house and to have a productive conversation with a certified installer.

Sponsors are critical to the success of the Solar Decathlon. They have experience with and an inherent interest in educating the general public about their products on display at the competition. BP Solar, one of the title sponsors of the Solar Decathlon, and Sunny Boy, a leading manufacturer of grid-interconnected inverters, are partnering in the exhibit through the loan of PV modules and an inverter, respectively. A communications expert at BP also contributed to the audience identification effort.

Although the Solar Decathlon provides an opportunity to discuss residential energy efficiency and solar energy (thermal and PV), the preliminary design for the exhibit focuses on PV. The preliminary design incorporates the following four components:

1. Grid-interconnection and net metering: This component includes a three-module array, a grid-

interactive inverter, a variable load, and displays showing generated power, consumed power, and net power as the user changes the variable load. This component will be connected to the PEPCo grid via a bi-directional meter.

2. PV orientation: This component includes a single module, a PV tracker, a manual override joystick, and displays showing instantaneous PV power generation as the PV orientation is changed by the user.
3. Nighttime: This component includes a single module, a user-controlled retractable opaque awning that simulates nighttime conditions, a battery backup, and displays showing instantaneous power to load, instantaneous power to backup, and instantaneous backup power to load as the user operates the awning.
4. Cloud-cover: This component includes a single module, one or more semi-transparent retractable awnings to represent varying cloud cover, and displays showing instantaneous PV power generation as the user changes the “cloud cover.”

Plans include mounting each component on one of the four vertices of an open, square structure constructed of metal piping. The structure will comply with NPS regulations. Ideally, the structure will either be rented or designed for ease of assembly, disassembly, and shipping.

#### 4. Conclusions

The exhibit concept described in this paper will greatly enhance the educational value of the 2005 Solar Decathlon competition and, in so doing, advance the outreach objectives described in the multi-year technical plan. The exhibits will use a hands-on approach to teach visitors about the fundamentals of PV power, to suggest ways they can use solar power in their own lives, and to make them more aware of the sun’s behavior and the ways it can enhance quality of life, if it is more fully understood. In future months, the exhibit design will be refined in preparation for the installation and operation of the exhibit at the Solar Decathlon in fall 2005.

#### REFERENCES

- [1] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Solar Energy Technologies Program Multi-Year Technical Plan, 2004*, Washington, DC, pp. 128.
- [2] Interstate Renewable Energy Council, *Database of State Incentives for Renewable Energy (DSIRE), 2004*, <http://www.dsireusa.org>.

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