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Impact Evaluation of the U.S. Department of Energy's Solar Decathlon Program

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FINAL REPORT

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Executive Summary

The Solar Decathlon

The U.S. Department of Energy (DOE) Solar Decathlon Program challenges teams of college students to design, build, and operate solar-powered houses that are cost-effective, energy-efficient, and attractive, and then demonstrate them to the public.[1] The first Solar Decathlon was held in 2002; the Solar Decathlon has occurred biennially since 2005. This evaluation covers the four Solar Decathlons from 2002 through 2009.

The objectives of the Solar Decathlon Program are to:

- Demonstrate to the public the opportunities presented by cost-effective houses that combine energy-efficient construction and appliances with renewable energy systems that are available today.
- Educate student participants and the public about the many cost-saving opportunities presented by clean-energy products.
- Provide participating students with unique training that prepares them to enter our nation's clean-energy workforce.

The 2002 through 2009 college teams displayed their houses to the public on the National Mall in Washington, D.C. Approximately 500,000 visitors have had the opportunity to tour the houses, see how energy-saving features can help them save money, and gather ideas for applying solar energy and energy efficiency in their own homes.

Impact Evaluation Purpose and Approach

The primary purpose of this evaluation was to determine whether the Solar Decathlon has been meeting its objectives. Secondary purposes include assessing the Solar Decathlon's contributions to DOE's solar-related research and developing recommendations that might improve the effectiveness and operations of future Solar Decathlons.

The Solar Decathlon's objectives apply to four broad target audiences: energy end users, state and local government organizations, the business community, and universities and schools. At the request of the Solar Decathlon program staff, the evaluation focused on two of these audiences: (1) energy end users as represented by residential homeowners, and (2) universities

[1] http://www.solardecathlon.gov/about.html

and schools as represented by college students who participated in a college's Solar Decathlon entry.

The performance of the Solar Decathlon was measured on outcomes representing its objectives. In most instances, the chosen outcomes represent actions that homeowners and former Decathletes would take if the demonstrated opportunities were understood and if the unique training for former Decathletes was effective. Table ES.1 lists the Solar Decathlon's objectives and representative outcomes.

Table ES.1 Solar Decathlon Objectives and the Outcomes Used to Measure Performance on the Objectives

Homeowner Objectives	Relevant Outcomes Measured
Demonstrate to homeowners the opportunities presented by cost-effective houses that combine energy-efficient construction and appliances with renewable energy systems that are available today.	• Homeowners' actions to investigate the feasibility of solar energy systems for their homes. • Homeowners' installations of energy-efficient appliances and lighting for their homes.
Educate homeowners about the many cost-saving opportunities presented by clean-energy products.	• Homeowners' knowledge of the differences between solar homes and traditional homes, including energy costs, construction costs, and use of energy-efficient products.
Participating Student Objectives	**Relevant Outcomes Measured**
Educate participating students about the many cost-saving opportunities presented by clean-energy products.	• Former students' knowledge of the cost-saving opportunities, construction features, purchase prices, applications of solar energy, and use of energy-efficient products in houses with solar energy systems.
Provide participating students with training that prepares them to enter the nation's clean-energy workforce.	• The percent of former students who found employment in the clean-energy workforce and the influence of the Solar Decathlon on the job search of Former Decathletes who found employment in the clean-energy workforce. • The percent of former students who started a clean-energy business. • The influence of the Solar Decathlon on Former Decathletes' success in encouraging installations of solar energy and efficient equipment.

Outcome measurements were analyzed using three methods. The three methods consisted of the following:

1. The analysis comparing *posttest-only* measurements of Solar Decathlon outcomes between treatment and comparison groups. The analysis compared individuals exposed to the Solar Decathlon (the treatment group) and individuals who were not exposed to it (the comparison group). The method is called "posttest-only" because all of the measurements for comparison are made after the treatment has been offered. This method provided evidence of the Solar

Decathlon's potential success, but could not, by itself, support a conclusion of success because it is not able to account for other possible explanations of the observed results.

2. The analysis of measurements made on groups that were similar on their predispositions toward clean energy. A difference in the groups' predispositions toward clean-energy projects and technologies is a major rival explanation. Lacking direct measurements on these, the similar-group method used retrospective self-reports of predispositions in a cluster analysis to create a subset of treatment and comparison individuals who were similar on these predispositions. This weakened the influence of predispositions as a rival explanation and strengthened the evidence about the Solar Decathlon's success.
3. The analysis of *self-reports* of the Solar Decathlon's influence on visitors' and participating students' outcome actions. The analysis of self-reports constituted the third method used to provide evidence on the Solar Decathlon's performance.

The quantitative findings from the three methods were analyzed to develop a conclusion regarding the Solar Decathlon's success in achieving its objectives. This use of multiple methodologies to develop multiple sources of evidence on a program's performance is sometimes called "triangulation." In order to reach a conclusion regarding performance, there must be a "preponderance of evidence" from the three methods supporting the conclusion. Table ES.2 describes the treatment and comparison groups used by the *first* and *second* methods and their associated terminology. The third method was applied exclusively to the Solar Decathlon visitors and students who had participated in one.

Table ES.2 Groups Compared for the Posttest-only and Similar-group Method with Associated Terminology

Homeowner Audience	
Treatment Group	**Compared to /Comparison Groups**
"Visitor Homeowners" - Homeowners who visited a Solar Decathlon	"Aware Homeowners" - Homeowners who learned of the Solar Decathlon through the Media or by word-of-mouth (WOM) without visit.
	"Unaware Homeowners" - Homeowners who had never heard of the Solar Decathlon. These homeowners represented the outcomes if there had never been a Solar Decathlon.
"Aware Homeowners"	"Unaware Homeowners"
Participating Student Audience	
Treatment Group	**Compared to /Comparison Group**
"Former Decathletes" - College or university students who participated in a school's Solar Decathlon entry.	"Non-decathlete Students" - Former college students in the same college cohorts who studied similar majors as the Former Decathletes. These homeowners represented the outcomes if there had never been a Solar Decathlon.

Data were collected for the three Homeowner groups and Non-decathlete Students using a random-digit-dialed telephone survey. An online survey was used to collect data from Former Decathletes.

Findings on the Homeowner Objectives

Findings from the three sources of information indicate that the Solar Decathlon has successfully been meeting its homeowner objectives.

Homeowner Objective #1: Demonstrate the opportunities presented by cost-effective houses that combine energy-efficient construction with appliances with renewable energy systems

The evaluation compared whether homeowners had considered installing a solar energy system for their home and whether they had gone further to actually gather information on the costs of doing so. After accounting for predispositions, the posttest-only method found that 27% more Visitor Homeowners than Unaware Homeowners had considered installing a solar energy system, while the similar-group method produced a 22% advantage after accounting for predispositions. The respective findings for Visitor Homeowners who proceeded to the next decision stage and actually gathered information on the costs of a solar energy system for their house were 16% and 13% more than Unaware Homeowners. Self-report measurements were not used for this outcome. Both sets of findings provide evidence that more homeowners who visit a Solar Decathlon take action to investigate the opportunities in residential solar energy systems than would be the case under a scenario of no Solar Decathlon.

The corresponding percentages of Aware Homeowners (i.e., those who only heard of the Solar Decathlon through the media or by WOM) who considered installing a solar energy system exceeded that for Unaware Homeowners by 16% using the posttest-only method and 12% using the similar-group method. The group differences for actually gathering evidence to judge the feasibility of a solar energy system for their houses were 4% and 1%, respectively. Both sets of findings provide evidence that media and WOM publicity about the Solar Decathlon contribute to achieving its objective. Supplementary anecdotal evidence also indicated that media publicity draws many homeowners to visit the Solar Decathlon.

The findings for installations of appliance products were mixed. The posttest-only and similar-group findings on efficient appliances were inconclusive, but the self-report findings did support

a conclusion of success. Moreover, the posttest-only and similar-group findings on the effect of media and WOM-only supported a conclusion of success in demonstrating the opportunities of efficient appliances. Investigation of the possible reasons for the inconclusive posttest-only and similar-group findings concluded that the long life of appliances, the longer period given to non-visitors to report installations, and uninformed respondents' tendency to overstate the efficiency of their appliances may have influenced these findings. As a consequence of the contradictory findings on the success of the Solar Decathlon on its appliance objective, the evaluation determined that the appliance findings were inconclusive.

The evaluation used actions taken to install efficient appliance and lighting equipment to represent success in demonstrating the opportunities inherent in these products for efficiently built solar-powered houses. The findings from all three analyses for the installations of lighting equipment supported a conclusion that the Solar Decathlon was achieving its objective of demonstrating the opportunities inherent in an efficiently-built house.

The evidence from all three methods, taken as a whole, indicates that the Solar Decathlon has been successful in achieving its objective of demonstrating the opportunities inherent in residential solar energy systems and efficient construction.

Homeowner Objective #2: Educate homeowners about the many cost-saving opportunities presented by clean-energy products

To evaluate the public education objective, homeowners were tested for their knowledge of the differences between houses using solar energy and traditional houses. The results were analyzed using the posttest-only and similar-group methods. On average, Visitor Homeowners tested 35% higher than homeowners who had never heard of the Solar Decathlon by the posttest-only method. After accounting for predispositions, the difference in scores was 25%. Analyses of the Aware Homeowners indicated that publicity for the Solar Decathlon has also been effective.

Visitor Homeowners were asked for a self-report of whether the Solar Decathlon had helped them gain a better understanding of (1) houses that use solar energy and (2) how a house can be made more energy efficient than they had before their visit. Nine (9) out of 10 Visitor Homeowners claimed that the Solar Decathlon had given them a better understanding of houses that use solar energy and how houses can be made more energy efficient than they had before

their visit. These findings indicate that the Solar Decathlon has been meeting its education objectives for the homeowner audience.

The corresponding posttest-only and similar-group findings supported a conclusion that the Solar Decathlon has been achieving its education objectives for homeowners. Self-reports were not used for non-visitors.

Findings on the Participating Student Audience (Former Decathlete) Objectives

Findings from the three sources of information indicate that the Solar Decathlon has successfully been meeting its objectives for participating students.

Former Decathlete Objective #1: Educate participating students about the many cost-saving opportunities presented by clean-energy products

To evaluate the student education objective, Former Decathletes and Non-decathlete Students took an eight-question true-false quiz on the use of solar energy and efficient construction/products for houses. The Former Decathletes scored 11% higher by the posttest-only method than Non-decathlete Students and 10% higher after the similar-group method accounted for predispositions. In addition, 94% of the Former Decathletes claimed by self-report that they learned more about the use of solar power and energy-efficient products in housing design from their Solar Decathlon experience than they would have in the course of their normal classroom work.

Former Decathlete Objective #2: Prepare participating students to enter the nation's clean-energy workforce

The posttest-only and similar-group methods both found that five times as many Former Decathletes have worked in the clean-energy field after leaving college as Non-decathlete Students (76% to 15%). Ninety-two percent (92%) of the Former Decathletes claimed that their Solar Decathlon experience helped them get these jobs. Sixteen percent (16%) of the Former Decathletes have started businesses in the clean-energy field since leaving college compared to 2% of the Non-decathlete Students after accounting for predispositions.

Former Decathletes have more actively influenced the installation of renewable-energy systems since leaving college than Non-decathlete Students, and 89% of the Former Decathletes credit their Solar Decathlon experience with helping them exert their influence.

The evaluation results indicate that the Solar Decathlon has been successfully meeting its education and career-preparation objectives for participating students.

Conclusion

Across the three methods used in the study approach, there were a total of 49 measures of outcome effects. The study found that 43 of 49 measures support the overall conclusion that the Solar Decathlon is achieving its objectives. Six of the measures provided inconclusive results. Considering the findings as a whole, the Solar Decathlon has been successful in satisfying its objectives for the homeowner and participating student audiences.

Additional Findings: Impact of the Solar Decathlon on Solar-related Research

The evaluation team interviewed five members of the DOE staff who were aware of DOE's solar-energy research effort and who had visited a Solar Decathlon. They reported that several research and development ideas have emerged from their Solar Decathlon visits but none have been funded. Staff suggested that the Solar Decathlon collect innovative ideas for dissemination to clean-energy manufacturers participating in related DOE programs.

Additional Findings: Recommendations for Future Solar Decathlons

Comments by participating students and findings from the homeowner survey responses produced a number of recommendations for future Solar Decathlons. Table ES.3 summarizes some of these recommendations in four broad topic areas.

Table ES.3 Recommendations for Future Decathlons

Topic Area	Recommendation*
Vary the Geographic Location of Future Solar Decathlons	Conduct the Solar Decathlon in different regional locations. The following bullets summarize the rationales supporting this recommendation: • New members of each of the Solar Decathlon's four audiences would be exposed to the educational and demonstration benefits of the villages. • If the competition were to require demonstration of houses that were cost-effective for the region in which the Solar Decathlon was conducted, they might attract the attention of more builders, architects, financiers, and homeowners in that region. • Varying the locations would bring in new collegiate teams because it would reduce the costs of transporting the houses. New competitors might produce new ideas and would bring the educational benefits of the Solar Decathlon to students who would not otherwise have the opportunity.
Revise the Competition Criteria	• Add a cost-effectiveness criterion based on the region. This would differ from the current affordability criterion. • Meter light levels rather than use jury scoring for these. • Give credit for innovativeness.

Topic Area	Recommendation*
Promote the Benefits of Net-zero-energy Houses at Solar Decathlons More Aggressively	• Encourage all school entries to provide handouts describing the benefits of the solar and energy-efficiency features of their houses. • Sell Solar Decathlon merchandise such as T-shirts, coffee mugs, caps. • Maintain a list of the innovative ideas developed by the students and demonstrate at each of the Solar Decathlons. Update this list after each Solar Decathlon and make it available to architects, builders, and designers as a way of disseminating the innovative ideas. • Provide information on (1) how to find contractors near where the visitors live who install solar panels, (2) websites that provide information about solar energy and energy efficiency, and (3) how to find a store that sells energy-efficient appliances and lighting products near where the visitors live.
Upgrade Decathlete Services	• Have food services available for decathletes near their building sites, or provide scheduled 24-hour bus transportation to a location where food services are available. • Do not include the night-time lighting required to erect the houses onsite in the energy budget of the houses.

* The Solar Decathlon Program had begun implementing several of these recommendations as this report was being prepared.

1. Introduction

1.1 The Solar Decathlon Program

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Solar Decathlon challenges teams of college students to design, build, and operate solar-powered houses that are cost-effective, energy-efficient, and attractive, and then demonstrate them to the public. The first Solar Decathlon was held in 2002 and has occurred biennially since 2005. The winner of the competition is the team that best blends affordability, consumer appeal, and design excellence with optimal energy production and maximum efficiency.

The objectives of the Solar Decathlon Program are to:

- Demonstrate to the public the opportunities presented by cost-effective houses that combine energy-efficient construction and appliances with renewable energy systems available today;
- Educate student participants and the public about the many cost-saving opportunities presented by clean-energy products; and
- Provide participating students with unique training that prepares them to enter the nation's clean-energy workforce.[2]

The Solar Decathlon strives to achieve these objectives through four audiences: public entities such as state and local governments; universities and schools; the business community, including housing contractors; and end users such as homeowners.

The Solar Decathlon Program selected fourteen college teams to demonstrate their houses in 2002. The number of invited teams was increased to eighteen in 2005, and to twenty for the 2007, 2009, and 2011 Solar Decathlons. For these years, the Solar Decathlons were held on the National Mall in Washington, D.C. DOE will move the demonstration site to Irvine, California for the

2011 Solar Decathlon
Source: U.S. Department of Energy

[2] http://www.solardecathlon.gov/about.html

2013 Solar Decathlon.

Visitors to the Solar Decathlon have the opportunity to tour the houses, learn how energy-saving features can help save money, and gather ideas for applying solar energy and energy efficiency in their own homes. Concurrently, the Solar Decathlon has conducted free workshops on-site for the public and housing contractors. DOE estimates that from 2002 through 2009 approximately 500,000 persons visited a Solar Decathlon.

In addition to demonstrating the use and benefits of clean-energy technologies through public visits, the Solar Decathlon and its houses have received widespread national and international coverage through the media.[3] Media coverage has been a major draw for visits to the Solar Decathlon.[4]

1.2 Purposes of the Impact Evaluation

The impact evaluation team consulted with the Solar Decathlon Program Manager and the EERE Communications Officer at the time the study began to establish the purposes of the Solar Decathlon impact evaluation and the audiences to be included. These stakeholders and the evaluation team determined that the evaluation should examine the extent to which the Solar Decathlon is succeeding in meeting its objectives and to assess the impact, if any, of the Solar Decathlon on DOE renewable energy research efforts. These objectives would be evaluated by measuring (1) changes in solar energy system and energy-efficiency knowledge levels, (2) changes in renewable energy and energy-efficiency actions, and (3) other related outcomes of two of the audiences targeted by the Solar Decathlon. These audiences comprised homeowners, a subset of the end-user audience; and college students who had participated in a Solar Decathlons, a subset of universities and schools audience.

The outcomes that are the focus of this evaluation include the following:

1. Homeowners' knowledge of solar-housing features and energy-efficiency products;

[3] http://www.solardecathlon.gov/about.html.
[4] Janda, K. 2006. "The Eleventh Event: Public Perceptions of the Solar Decathlon." Paper presented at the American Solar Energy Society Annual Conference, (July 12). *Proceedings of the 35th American Solar Energy Society Annual Conference.*

2. Homeowners' awareness of the opportunities that residential solar energy systems and energy-efficient appliances and lighting offer for their residences;
3. Former participating students' (former decathletes) knowledge of solar-powered houses and energy-efficient products; and
4. Former decathletes' preparation for entering the clean-energy workforce.

The study also examined the following secondary outcomes:

5. The contribution of the Solar Decathlon to DOE renewable energy research efforts; and
6. Participating students' assessment of their Solar Decathlon experience.

In addition, the evaluation provides recommendations for future Solar Decathlons.

1.3 Organization of the Evaluation Findings in This Report

Following this Introduction, the report contains the following sections:

- *Section 2: Evaluation Methodology* – This section provides an overview of the research design used for the evaluation. More details of the methodology appear in Appendix A.
- *Section 3: Findings Relevant to Homeowner Objectives* – This section compares the Solar Decathlon treatment and comparison homeowner groups on the outcomes of interest. The comparisons use the full datasets and a subset of households that are similar on the predisposition variables. The section also includes visitors' self-reports of the impact of the Solar Decathlon on them for some of the evaluated outcomes.
- *Section 4: Findings Relevant to Participating-student Objectives* – This section compares former decathletes to comparable non-decathlete students who attended college during the Solar Decathlon treatment period and studied a major similar to those studied by former decathletes. The comparisons are made on outcomes of interest to the participating student audience. The section also includes participating students' self-reports of the Solar Decathlon's impact on them for several of the evaluated outcomes.
- *Section 5: Participating Students' Assessment of Their Solar Decathlon Experience* – This section summarizes former decathletes' comments on their Solar Decathlon experience and consolidates their suggestions for future Solar Decathlons.
- *Section 6: Impact on Solar-related Research* – This section summarizes the results from interviews with five members of the DOE staff involved in DOE-sponsored solar research.
- *Section 7: Recommendations for Future Solar Decathlons* – This section summarizes the recommendations from comments made by surveyed homeowners and the former decathletes and faculty advisors who took the online survey.
- *Appendices* – Five appendices provide: (A) a detailed description of the evaluation methodology; (B) a detailed logic model of the Solar Decathlon; (C) decathletes' open-ended comments on their Solar Decathlon experience and suggestions for future Solar Decathlons; (D) recommendations for future Solar Decathlon evaluations; and (E) the survey questionnaires used for the study.

2. Evaluation Methodology

This section provides an overview of the research plan used for the evaluation of the Solar Decathlon. Appendix A provides a detailed description of the approach and methods used.

2.1 Logic Model of the Solar Decathlon Program

A logic model provides program managers with a plausible and sensible diagrammatic model of how a program will work to solve identified problems.[5] It portrays the theoretical logic by which the program attempts to solve identified problems by showing the linkages between program activities. Besides the program activities, it shows the allocation of resources, the audiences targeted by the program, and the intended outcomes that represent achievement of the Solar Decathlon's objectives. A logic model helps program managers present the theory and logic of the program, and it helps the evaluator identify outcomes and metrics to study for estimating the program's impacts.

The Solar Decathlon Program developed a detailed logic model, which is presented in Appendix B of this report.

2.2 Evaluation Research Design

The evaluation uses three methods to estimate whether the Solar Decathlon is satisfying its objectives. Before describing the methods and how they were used to develop a conclusion regarding the Solar Decathlon's achievements, a pair of concepts must be introduced and the targeted audiences that were studied need to be described.

Two of the methods required estimating the differences between members of the studied audiences who experienced the Solar Decathlon and members who did not. The differences were measured on knowledge and behavior related to the Solar Decathlon's objectives. The members of the studied audiences who experienced a Solar Decathlon are called the "treatment group." Experience of the Solar Decathlon, either through a visit or learning about it through the media or word-of-mouth, constituted the "treatment." Members of a studied audience who had never

[5] Bickman, L. (ed). 1987. "The Functions of Program Theory." *Using Program Theory in Evaluation, New directions for Program Evaluation*, no. 33. San Francisco: Jossey-Bass. http://onlinelibrary.wiley.com/doi/10.1002/ev.1443/abstract

heard of the Solar Decathlon are called a "comparison group." The comparison group represents the outcomes that would have occurred had there never been a Solar Decathlon. The differences in outcome measurements on the treatment and comparison groups developed by two of the methods constituted two of the sources of evidence used by the evaluation.

The third method consisted of asking visitors and participating students to self-report the degree to which the Solar Decathlon influenced their actions and knowledge. This method is described later in this chapter.

Section 2.2.2 and Appendix A describe in more detail how these methods and the evidence they produced were used to evaluate the success of the Solar Decathlon in achieving its objectives. In order to better understand these descriptions, the studied audiences are described below.

2.2.1 Solar Decathlon Audiences Selected for the Evaluation

For project resource reasons, and in consultation with the Solar Decathlon Program Manager, the evaluation focused on outcomes associated with subsets of two of the Solar Decathlon's audiences. These consisted of homeowners who owned single-family attached and detached homes—a subset of the "end users" audience, and students who participated on the college teams that sent solar-powered houses to a Solar Decathlon—a subset of the "universities and schools" audience. The program treatments for these audiences consisted of the four Solar Decathlons that occurred from 2002 to 2009.

a. Homeowners

The homeowner audience included owners of occupied single-family detached and attached houses. Although the evaluation examined energy-efficiency outcomes, it focused on these homeowners' actions and knowledge because they had the ability to install solar energy systems and buy their own appliances and lighting equipment. Renters were excluded because very few renters have a right to install solar energy systems for their residences and most rely on the lessor to install the appliances and lighting equipment. Limiting the interviews to owners of single-family detached and attached houses focused the research on residential end users who were more likely to have control over what is placed on their roof or the permanent energy-using equipment in their residences. The research further limited homeowners to those 18 years of age

or older as a screen for homeowners who would be more likely to have the financial resources to invest in clean energy technology products.

For evaluation purposes, the homeowner audience was divided into the following three groups:

1. "Visitor Homeowners"— Homeowners who visited a Solar Decathlon. These homeowners constituted the visit-treatment group. They may also have learned about the Solar Decathlon through word-of-mouth and the media, but their primary experience of the Solar Decathlon was a visit the Solar Decathlon village.
2. "Aware Homeowners" — Homeowners who were aware of the Solar Decathlon but had never visited one. These homeowners represented homeowners who experienced the Solar Decathlon only through the media or by word-of-mouth. They served as a second treatment group for estimating the impact of media and word-of-mouth, and also served as one of the comparison groups for the Visitor Homeowners.
3. "Unaware Homeowners" — Homeowners who had never heard of the Solar Decathlon. The Unaware Homeowners served as a comparison group for both Visitor and Aware Homeowners. Their measurements represent the homeowner outcomes that would have occurred had there never been a Solar Decathlon.

The evaluation limited the geographic research area for homeowners to the Washington, D.C. and Baltimore, Maryland Metropolitan Statistical Areas (MSAs). These two MSA regions represented the geographic areas offering the highest probability of interviewing homeowners who had been exposed to the Solar Decathlon by virtue of their proximity to Washington, D.C.

Beyond this geographic criterion, each of the homeowner groups were selected for their surveys on criteria intended to make them as similar as possible. The survey screening criteria were:

- Owned their own home;
- Lived in single-family attached or detached houses owner-occupied houses; and
- Were 18 years of age or older.

b. Participating Students

The student audience was divided into two groups for evaluation purposes:

1. "Former Decathletes"—College students who had participated in at least one of the Solar Decathlons between 2000 and 2009.[6] This group served as the treatment group for the participating student objectives.

[6] Although the first Solar Decathlon was held in 2002, publicized team preparations for it began two years before the actual demonstration on the National Mall.

2. "Non-decathlete Students"—Former college students who had never been a decathlete but attended a college during the same period as the Former Decathletes and majored in an area of study similar to one of the areas of study typically undertaken by decathletes. This group served as the comparison group for the Former Decathletes; their outcome-related actions represent the actions that their college cohort would have taken had there never been a Solar Decathlon.

The Solar Decathlon teams included in the evaluation came from colleges throughout the United States; therefore, the Non-decathlete Students studied also resided in the United States. However, the latter were restricted to the 48 contiguous states due to evaluation project resource limitations. Beyond this geographic criterion, the Non-decathlete Students were selected for their survey on criteria intended to make them as similar to decathletes as possible. The survey screening criteria were:

- Attended a four-year college for at least one year since the year 2000 (first year that work on a Solar Decathlon would have been publicized);
- Not currently enrolled in an undergraduate degree program; and
- Majored in a course of studies similar to those used by many decathletes; these consisted of engineering, architecture, marketing, physics, communications, and computer-aided design.

c. Summary of the Treatment and Comparison Group Audiences

Table 1 summarizes how the selected audiences were divided into treatment and comparison groups for the purpose of estimating the Solar Decathlon's impacts. All measurements on the groups were made in 2011.

Table 1: Groups Compared for the Posttest-only and Similar-group Method with Associated Terminology

Homeowner Audience	
Treatment Group	**Compared to /Comparison Groups**
"Visitor Homeowners" (Homeowners who visited a Solar Decathlon)	"Aware Homeowners" (Homeowners who learned of the Solar Decathlon through the Media or by word-of-mouth (WOM) without visit)
	"Unaware Homeowners" (Homeowners who had never heard of the Solar Decathlon. These homeowners represented the outcomes if there had never been a Solar Decathlon)
"Aware Homeowners"	"Unaware Homeowners"

(Continued)

Participating Student Audience	
Treatment Group	**Compared to /Comparison Groups**
"Former Decathletes" (College or university students who participated in a school's Solar Decathlon entry)	"Non-decathlete Students" (Former college students in the same college cohorts, but not necessarily the same colleges, who studied similar majors as the Former Decathletes. These students represented the outcomes if there had never been a Solar Decathlon.)

The beginning of the treatment and subsequent comparison period for Visitor Homeowners was the year the visitors attended a Solar Decathlon. The comparison period extended from that year to 2011. The period for comparing the Aware and Unaware Homeowners to the Visitor Homeowners extended from 2000, the first year competing college teams would have been announced and started work on the first (2002) Solar Decathlon and the first year DOE and these teams would have publicized the Solar Decathlon, to 2011. The beginning of the treatment and subsequent comparison period for the Former Decathletes was the year they began working on their college team's Solar Decathlon entry. The comparison period for Non-decathlete Students was the same as that for Aware and Unaware Homeowners, from 2000 to 2011.

2.2.2 Research Design Issues and the Use of Multiple Sources of Evidence

The evaluation used multiple methods to estimate whether the Solar Decathlon achieved its objectives for the studied audiences. Success in achieving its objectives was represented by findings that the outcomes for the Solar Decathlon's targeted audiences were greater because of the Solar Decathlon than they would have been had there never been a Solar Decathlon. The evaluation's judgment of the Solar Decathlon's success or failure in achieving its objectives is then based on the evidence derived from these methods.

The three methods used to develop evidence for the judgments consist of:

1. Comparisons of all members of the treatment and comparison groups on measurements made after the Solar Decathlon of outcomes related to the Solar Decathlon's objectives. In evaluation terminology, these comparisons are called a "posttest-only non-equivalent group" research design. This label will be shortened to "posttest-only" in this report. This comparison is used to determine if the treatment outcomes were greater than the comparison outcomes; however, it cannot be used to estimate whether the Solar Decathlon *caused* the greater outcomes because it does not account for other influences that might have produced the treatment outcomes.
2. Comparisons of a subset of the treatment and comparison groups consisting of members with similar predispositions to favor clean-energy. This is a variant of the posttest-only research

design that increases the equivalence of the treatment and comparison groups by using a retrospective pretest measurement on their members' predispositions. In doing so, it accounts for some of the influence of self-selection, one of the strongest rival explanations for the outcome findings, and strengthens a conclusion that the comparison result is due to the Solar Decathlon. This method is called the "similar-group" method in this report.

3. Self-report measurements by Visitor Homeowners and Former Decathletes that were made on selected outcomes related to the Solar Decathlon's objectives. These measurements asked the Visitor Homeowners and Former Decathletes to rate the influence of the Solar Decathlon compared to other possible influences on selected behaviors and knowledge. This method is called the "self-report" method in this report.

Three methods were used because each of the methods alone possesses design issues that affect the validity of their findings. In combination, however, they may produce enough evidence to reasonably conclude that a treatment produced a measured impact. In program evaluation practice where a single source of evidence cannot suffice to produce a conclusive judgment regarding a program's impacts, it is an accepted practice to use multiple sources of evidence derived from multiple methodologies to develop a conclusion regarding the program's impacts. This practice is often called "triangulation".[7] To reach a conclusion of probable causation, the researcher must find a "preponderance of evidence" from the multiple sources of evidence that the treatment caused the outcome.[8]

The following subsections describe the methodologies used to generate the three sources of evidence for the Solar Decathlon's impacts.

a. The Posttest-only Research Design and Its Findings

The posttest-only design, also called an ex post facto design, measures the differences in outcomes between the "treatment" group and the "comparison" groups using data collected after the treatment has occurred. The comparison group measurements represent the outcomes that would have occurred had the Solar Decathlon never existed. With this design, the outcome differences between the treatment and comparison groups serve to indicate whether the Solar Decathlon might have had a positive impact on the outcomes, but they do not, by themselves,

[7] TecMarket Works Team. 2006. "California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals," 144, 156. Prepared for the State of California Public Utilities Commission. (April). *These protocols are the result of an extensive investigation of the issues associated with evaluating energy-related programs. They have been widely accepted within the state and utility evaluation industry;* Greene, J., and C. McClintock. 1985. "Triangulation in Evaluation: Design and Analysis Issues. Evaluation Review, v9, no. 5. (October): 523-45.

[8] TecMarket Works Team. 2006, 144, 156.

provide conclusive evidence that the Solar Decathlon caused the differences. The posttest-only calculations of treatment-comparison differences use all of the randomly collected data; therefore, the findings can be tested for statistical significance.

Several research design issues affect the validity of the impact findings from a posttest-only research design. For an ideal impact evaluation using treatment and comparison groups, the group members would be assigned randomly by the evaluator to program treatment and comparison groups from the same population. Outcome measurements would be made on both groups simultaneously both before and after the treatment. Random assignment provides reason to believe that the treatment and comparison groups were equivalent prior to the treatment and, therefore, in combination with the pretest measurements, the evaluator may conclude that any differences in the groups' pre-post measurements were caused by the treatment. The evaluator would then attribute the post-treatment differences (impact findings) to the only difference between the two groups, namely the treatment.

In the case of the Solar Decathlon's posttest-only research, these ideal conditions could not be met. No measurements on the relevant outcomes or audience characteristics had been made prior to any of the Solar Decathlons and, as is the case with virtually every energy program, the "treated" homeowners who visited (or heard of without visiting) the Solar Decathlon and the Former Decathletes were self-selected (i.e., they visited or participated in a Solar Decathlon of their own volition).[9] Visitors' names were not recorded and current contact information for all of the Former Decathletes does not exist. These realities necessitated that the measurements be made after the Solar Decathlon treatment period (i.e., after 2009), and that the outcome comparisons of treatment and comparison groups represent the post-2009 period only. These departures from the ideal impact evaluation design meant that no knowledge exists on whether the treatment and comparison groups were similar prior to the treatment or how they would have tested pre-treatment on the outcomes.

As a consequence, the posttest-only research design cannot detect whether pre-treatment differences may have caused the observed post-treatment differences. Examples of pre-treatment differences include education, major life experiences undergone by one of the groups,

[9] The Aware Homeowners constituted another type of treated homeowners for this study. These homeowners were exposed to the Solar Decathlon through media or word-of-mouth but never visited one.

differential exposure to clean-energy through means other than the Solar Decathlon, interaction of the measurement method with the audiences or outcome being measured, and age.[10] Of particular concern, some of these rival influences may predispose an individual to take actions that an individual without these predispositions would be unlikely to take. In particular, such predispositions may cause them to "self-select" themselves to undergo a learning experience such as the Solar Decathlon and then take the preferred actions afterward.

In these circumstances, comparing the treatment group to the comparison group on program-related outcomes may overstate or understate the treatment's effects. The evaluator cannot claim certainty in the impact findings because it is impossible to claim that the treatment and comparison individuals were similar before the treatment. The fact that homeowners who visited a Solar Decathlon and Former Decathletes self-selected themselves creates the possibility that they had predispositions not shared (at least, to the same degree) by the comparison group individuals. These differences before their treatment may have had more influence on the observed outcome differences than the Solar Decathlon itself had. If such were the case, the post-Solar-Decathlon impacts should not be attributed solely to the Solar Decathlon.[11]

b. The Need for Additional Sources of Evidence

If posttest-only research provides evidence of a possible positive program impact, expert evaluators advise collecting supplementary evidence that will aid the evaluator in judging whether the differences may reasonably be attributed to the treatment.[12] The evidence from several sources of information can be used collectively to "draw conclusions about the presence and attribution" of a treatment's effects. When evaluators use such triangulation of the findings from mixed methods, they look for a preponderance of evidence supporting a conclusion about a program's impact.[13]

[10] Campbell, D. T., and J. C. Stanley. 1963. *Experimental and Quasi-Experimental Designs for Research.* Chicago: Rand McNally. In theory, external, non-treatment influences supporting an outcome being measured should not constitute a rival influence if both the treatment and comparison groups experience them. The influences would have to impact the groups differently to be a rival factor in the outcome.

[11] Cook, T. D., and D. T. Campbell. 1979. Quasi-Experimentation: Design & Analysis for Field Settings. Boston: Houghton Mifflin, 98-99; Campbell, D. T., and J. C. Stanley. 1963, 5-12.

[12] Cook, T. D., and D. T. Campbell. 1979, 65; TecMarket Works Team. 2006, 144, 156.

[13] TecMarket Works Team. 2006, 144, 156.

As described at the beginning of Section 2.2.2, the evaluation supplemented the posttest-only method with two additional methods to produce multiple sources of evidence with which to develop a conclusion regarding the Solar Decathlon's impact. These additional sources consisted of the following:

1. Similar-group findings; and
2. Self-report findings.

The following subsections describe these additional sources of evidence and the methods that produced them in more detail and suggest how they may be interpreted to help judge the evaluation's findings.

c. Similar-group Research and Its Findings

To develop subsets of similar homeowners, the evaluation first used the following variables in a cluster analysis[14] to establish a homeowner's predisposition toward clean energy:[15]

- Whether the homeowner had attended an event that discussed solar energy or energy efficiency for a home before visiting a Solar Decathlon (prior to 2000 for non-visitors).
- Whether the homeowner had installed solar panels on his or her own house before visiting a Solar Decathlon (prior to 2000 for non-visitors).
- Whether the homeowner had visited an Internet site that described the availability of utility or state incentives for solar energy systems to generate electricity or heat in the home.
- The highest level of education attained by the homeowner as an indicator of educational aspiration prior to visiting a Solar Decathlon (prior to 2000 for non-visitors).

For the development of the subsets of similar Former Decathletes and Non-decathlete Students, the evaluation established these former students' predispositions toward clean energy using the following variables:[16,17]

[14] Cluster analysis is a statistical method for creating clusters of similar objects in a set of objects. The objects are not perfectly matched; rather they are grouped into clusters based on their similarity across several variables. Objects within a cluster are more similar to each other than to other objects in a set. Appendix A describes the use of cluster analysis in this study to identify similar homeowners.

[15] Some of these variables are not strictly *pre*disposition variables. They were added for technical reasons to aid in the separation of clusters (see Appendix A).

[16] Some of these variables are not strictly *pre*disposition variables. They were added for technical reasons to aid in the separation of clusters (see Appendix A).

- College major.
- Whether the Former Decathlete had participated in any activity that encouraged people to conserve energy or help the environment prior to participating in a Solar Decathlon (for Non-decathlete Students, prior to college).
- Whether the Former Decathlete and Non-decathlete Students were aware of an Internet site, called the Database of State Incentives for Renewables and Efficiency (DSIRE), where the availability of utility or state incentives for installing solar energy systems and energy-efficient equipment are listed.
- Whether the Former Decathlete had written about energy conservation or the environment in a school paper, a blog, a tweet, or a letter to the editor before participating in a Solar Decathlon (for Non-decathlete Students, prior to college or while in college).
- Whether anyone living in the household had ever had any formal technical training or engineering education.
- The highest level of education attained by the Former Decathlete and former Non-decathlete Students as a measure of educational aspiration prior to participating in a Solar Decathlon (prior to the year 2000 for Non-decathlete Students).

By creating a subset of treatment and comparison groups having similar predispositions, the similar-group methodology accounts for at least some of the influence of self-selection on the findings. Because the analyzed group members are similar to each other on their predispositions prior to treatment, the predispositions account for less of the observed impact findings between the similar groups.[18] The influence of self-selection will be removed, or at least weakened, when the outcome-difference (impact) calculations used in the posttest-only design are repeated on the subset of similar treatment and comparison groups. This strengthens a judgment about whether the impact findings can be attributed to the Solar Decathlon.[19]

Because the similarity-grouping methodology does not involve random selection, the comparisons of the similar treatment and comparison groups cannot be tested for statistical significance.

[17] The variables used to measure predispositions for Former Decathletes and Non-decathlete Students were slightly different from those used for the homeowners because the experiences were different and for certain other technical reasons. Appendix A describes the cluster analysis design in detail.

[18] This statement is valid only insofar as the variables chosen to represent predispositions exhaust all aspects of predisposition. Whether the method can be used to represent interactions between predispositions and other variables affecting the impacts is unknown. This study did not attempt to account for such interactions.

[19] This does not mean the Solar Decathlon is the only possible remaining influence. There may be other influences not represented by the predisposition variables.

The following will help the reader interpret the results of the similar-group analyses. If predispositions account for some of the impact findings from the posttest-only analysis, the reader should expect the impact findings from the similar-group analysis to be less than those from the posttest-only analysis while retaining the impact polarity (positive or negative). In nine of the ten (90%) homeowner posttest-only impact findings (see Chapter 3) this, in fact, occurs. The tenth similar-group analysis shows no reduction in the posttest-only impact findings.

The similar-group method provides a second source of evidence supporting a conclusion about the Solar Decathlon's impact.

It must be acknowledged that this source of supplementary evidence relies on the use of retrospective self-report to measure predispositions. The issues raised by reliance on self-report are discussed in the next section.

d. Self-report Research and Its Findings

Self-reported data contribute twice to the evaluation. First, the predispositions to perform outcomes favorable to clean energy (favorable to the Solar Decathlon's objectives) rely on self-reported recall of prior events. Second, self-reported data on the influence of the Solar Decathlon on certain treatment-group outcomes provide the third source of evidence for judging the impact of the Solar Decathlon. Like the two previous methods, self-reported evidence is subject to issues that affect its validity.

Predisposition Recall

Generally, retrospective self-reports such as those used to measure the predispositions are subject to recall error. Memory is inaccurate when recall of an event must be based on specific dates. A common technique when an event must be recalled before or after a certain date is to benchmark the recall to a salient occurrence that will aid the respondent recall whether the event of interest occurred before or after the benchmark. For visitors to a Solar Decathlon and Former Decathletes, the Solar Decathlon constituted the benchmark used in the interviews. This was considered to be a salient event providing a strong benchmark. Non-visitors and Non-decathlete Students were asked to recall their actions relative to the year 2000. In addition to the year when students began publicized working on the first Solar Decathlon, this was the millennium year. It was characterized with a large amount of publicity and for some, concern. This year was not

considered to be a strong benchmark, but was judged to be better than the alternative for pre-treatment retrospective measurements (i.e., 2002, the year of the first Solar Decathlon).

Socially Desirable Answers

Self-reported data also provide a third source of supplementary evidence for triangulation and for judging the validity of the posttest-only findings. When asked questions about attitudes or actions that have a normative cultural context, respondents may provide what they perceive to be a socially desirable answer.[20] The tendency to provide socially desirable answers becomes a particular concern when the research includes questions whose answers might embarrass a respondent, for example, questions about culturally unacceptable behavior such as drug use.[21] In the opinion of the evaluators, the research for this evaluation included no questions whose answers might embarrass a respondent; however, it did ask questions about the respondent's prior actions reflecting environmental or energy-conscious behavior. Some of those questions were used in the cluster analysis to group similar homeowners and former students; the tendency to provide socially desirable answers may have influenced those responses.

The research also included questions rating the importance, or influence, of the Solar Decathlon on selected actions (e.g., the ability to get a job in the clean-energy field, the importance of certain types of information, the installation of a solar energy system). In some of these rating questions, the respondent was asked to consider other sources of influence before rating the Solar Decathlon's influence. This encouraged the respondent to avoid unduly crediting the Solar Decathlon's influence. Most of these rating questions used a 0-10 point scale, and the results are used to develop numerical averages. This provides the respondent with a degree of flexibility in providing truthful answers and may attenuate the tendency to provide a socially desirable answer by allowing the respondent to "hedge" the response up or down a scale point from what he or she really thinks. This ability to hedge on a small incremental basis may reduce the effect of the socially desirable tendency while affecting the results only slightly.

On occasion, a telephone interviewer's tone of voice will cue the respondent to provide a socially desirable answer. Approximately twenty surveys by different interviewers were monitored by

[20] Fishbein, M., and I. Ajzen. 1975. Beliefs, Attitudes and Behavior. Reading, MA: Addison Wesley, 108.
[21] Dillman, D.A. 2000. *Mail and Internet Surveys*, 2nd edition. New York: John Wiley & Sons, 226.

different members of the evaluation team. None of the monitors reported noting interviewer voice inflections or other hints that would stimulate the respondent to respond in a specific way.

The precautions taken helped to minimize the number of self-reported responses that could contain recall and social desirability errors of unknown magnitude.

e. Summary of Posttest-only Design Considerations and How Multiple Methods Were Used to Address Them.

Table 2 summarizes the issues associated with the posttest-only research design and the actions taken to address them.

Table 2: Summary of the Issues Associated with the Posttest-only Design and How They Were Addressed

Research Design & Measurement Issues	Homeowners (How Addressed Issues)	Participating Students (How Addressed Issues)
Research Design Issues:		
Rival Influences		
Self-selection	• An alternative calculation of outcomes using treatment and comparison groups matched on predisposition variables reduced the effects of rival influences represented by these variables. • Visitors' self-reports were used for selected impacts as an alternative source of impact evidence.	• An alternative calculation of outcomes using treatment and comparison groups matched on predisposition variables reduced the effects of rival influences represented by these variables. • Former Decathletes' self-reports were used for selected impacts as an alternative source of impact evidence.
Exposure to external influences (e.g., education, viewed publicity on a related event or read a relevant report, participated in a utility incentive program)	• Treatment & control homeowners drawn from the same populations. • Treatment & control homeowners live in the same type of owner-occupied houses. • States and district differed in influences such as state incentives and utility advertising, however, correlations using state/district and solar energy system installations found no significant associations. • Comparisons of treatment and controls were offered on demographic variables, giving the reviewer an opportunity to judge the differences, which were small. • Multiple sources were used to develop a judgment of success.	• Treatment & control students drawn from populations having college educations in similar disciplines. • Treatment & control students drawn from populations attending college during approximately the same period of time. • Multiple sources were used to develop a judgment of success.

(Measurement Issues are continued on the next page.)

Research Design & Measurement Issues	Homeowners (How Addressed Issues)	Participating Students (How Addressed Issues)
Measurement Issues:		
Self-report		
Recall errors for retrospective data	• Benchmark events and dates were used to establish a reference date for the respondent's recall.	• Benchmark events and dates were used to establish a reference date for the respondent's recall.
Social desirability	• No questions about culturally objectionable behavior were included. • For importance and influence ratings, a 0-10 scale was used to give respondents incremental options rather than force them to select a socially desirable rating from a scale with three or five options. The quantitative averages produced from these ratings may be less affected by the tendency for socially desirable answers than would be the case with scales of three to five options. • Telephone interviews for inadvertent voice cues by the interviewers were monitored.	• No questions about culturally objectionable behavior were included. • For importance and influence ratings, a 0-10 scale was used to give respondents incremental options rather than force them to select a socially desirable rating from a scale with three or five options. The quantitative averages produced from these ratings may be less affected by the tendency for socially desirable answers than would be the case with scales of three to five options. • Telephone interviews for inadvertent voice cues by the interviewers were monitored.

In judging the potential effects of these issues on the findings reported in the impact sections of the report (Chapters 3 and 4), it is important to keep in mind the following:

- The Solar Decathlon's objectives do not require that specific quantitative outcome targets be met; therefore, the evaluation does not require specific quantitative findings that equal or exceed a quantitative goal. It requires only that enough of the desired treatment-group outcomes *be greater* than the corresponding comparison group outcomes to support a conclusion that the Solar Decathlon has been meeting its objectives.
- The evaluation provides multiple sources of evidence to indicate the likelihood that the desired outcomes are greater because of the Solar Decathlon than they would have been without a Solar Decathlon.
- The evaluation was not tasked to estimate (1) the cost-effectiveness of the Solar Decathlon; (2) comparison of the Solar Decathlon to alternative approaches to achieving user demonstrations and science, technology, engineering, and mathematics (STEM) education; and (3) comparison of technical investments to media investments.

2.3 Research Questions

The evaluation team developed research questions with which it operationally defined and measured outcomes representing the Solar Decathlon's objectives. Table 3, on the following

page, describes the types of research questions used to measure the outcomes for homeowners. Table 4 describes the types of questions used to measure the outcomes for participating students. In addition, the research included self-report questions, not listed in the tables, to provide supplementary evidence for the findings. These questions are provided when their results are described in the report. Appendix E.1 contains the full questionnaires used for the three homeowner groups. Appendices E.2 and E.3 contain the full questionnaires used for the Former Decathletes and Non-decathlete Students.

Table 3: Research Questions Used to Define and Measure Outcomes for the Solar Decathlon Homeowner Objectives Evaluated

Solar Decathlon Objectives and Outcomes	Research Questions
Objective: Demonstrate to homeowners the opportunities presented by cost-effective houses that combine energy-efficient construction and appliances with renewable energy systems **Outcome:** Homeowner behaviors that represent their awareness of the opportunities	**Question**: *Did the Visitor and Aware Homeowners take more actions than the Unaware Homeowners because of their visit to a Solar Decathlon?* "Demonstrating opportunities" was translated to "awareness of opportunities," and awareness of opportunities was measured using questions about *actions* that would be expected to proceed from such awareness. Such results-oriented questions, although indirect measurements of awareness of opportunities, provide more powerful measures of the awareness outcome. 1. For solar energy systems, a multi-stage decision model was established, and each treatment and comparison group was asked a battery of questions designed to measure whether they had accomplished certain activities that represented selected stages of the model. 2. Each research group was asked whether they had installed any energy-efficient appliance that they knew to be more efficient than the typical appliance product. The evaluation included energy-efficient lighting to represent the opportunities available in cost-effective houses and energy-efficient construction. Each research group was asked whether they had installed any energy-efficient appliance or lighting that they knew to be more efficient than the typical appliance or lighting product. A follow-up question asked the respondent to describe the product; any descriptions that did not qualify as an efficient appliance or lighting product resulted in a correction to the installation response provided the respondent.

(Continued)

Solar Decathlon Objectives and Outcomes	Research Questions
Objective: Educate homeowners about the cost-saving opportunities of clean energy products **Outcome:** Homeowners' knowledge of the features, including cost-savings features, of solar-powered houses and energy-efficient products, compared to houses without these features	Asked the treatment and comparison groups the following open-ended, unaided question to measure what they knew about solar-powered, energy-efficient houses: **Question:** *Please think for a moment about what you know about houses that collect energy from the sun and use it for electricity or heating. What would you say are the ways in which houses that collect energy from the sun for electricity or heating are different from houses that do not collect energy from the sun for electricity or heating?*

Table 4, below, presents the types of research questions used for the student-participant outcomes. All of the Former Decathletes were invited to take the former-decathlete online survey; however, only responses to these questions from the 2002, 2005, 2007, and 2009 Former Decathletes were used for the impact analyses. Responses from the 2011 decathletes were excluded from the impact analyses because most were still in school when the data were collected and would not be able to answer the questions about post-college outcomes. However, their answers to questions about their Solar Decathlon experience and an open-ended satisfaction question are included in the report.

Table 4: Research Questions Used to Define and Measure Outcomes for the Solar Decathlon Participating Student Objectives Evaluated

Objectives/Outcomes	Research Questions
Objective: Education **Outcome:** Former Decathletes' knowledge of solar-home features and energy-efficient products	1. Asked eight true-false questions developed for use as a knowledge test. These questions asked about the characteristics and structure of solar-powered homes and energy-efficient products as well as their cost-savings features. The questions were asked of both the Former Decathletes and Non-decathlete Students. The questions used to measure how knowledge of the former students differed from those used for the homeowners because an online survey was used for the Former Decathletes. Comparing an open-ended list of differences from an online survey to such a list from a telephone interview will produce differences that are as much influenced by the measurement method and relative respondent burden as by actual knowledge. 2. Asked the Former Decathletes to self-rate how much more they believe they learned about clean energy from their Solar Decathlon experience compared to what they learned in their classroom courses.

(Continued)

Objectives/Outcomes	Research Questions
Objective: Preparation for entering the nation's clean-energy workforce. **Outcome:** • Changes in college major • Career choices • Start-up of clean-energy businesses • Clean-energy installations influenced since leaving undergraduate studies with the Solar Decathlon's contribution to the ability to influence	1. Asked the Former Decathletes whether they changed majors to a clean-energy-related major after participating in a Solar Decathlon. 2. Asked Former Decathletes and Non-decathlete Students: *Since your undergraduate college studies, have you been employed in work involving the design, manufacture, sales, installation, research, or use in buildings of renewable energy or energy-efficient products?* 3. Asked Former Decathletes and Non-decathlete Students whether they had begun a business related to clean energy since graduating. 4. Asked Former Decathletes to self-rate the degree to which the Solar Decathlon helped them get their job in the clean-energy workforce. 5. Asked Former Decathletes and Non-decathlete Students if they influenced any solar, efficient-appliance, or efficient-lighting installations in buildings. Then asked a follow up self-rating question about how much their Solar Decathlon experience contributed to their influence on the installations.

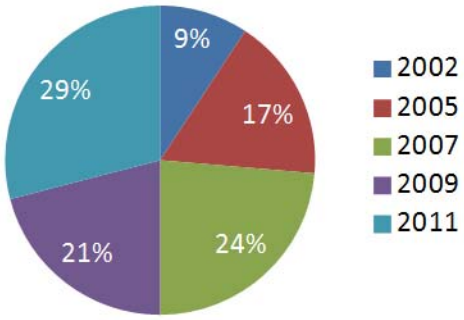
The differences between treatment and comparison groups on these and other questions in the surveys provide the findings from the posttest-only and similar-group analyses of the Solar Decathlon's impact. The statistical significance of the posttest-only differences developed using the full, randomly selected data sets are reported at the 0.1 level of probability (alpha) for a one-tailed test that there might have been no difference at all or that it might have been negative. The actual probabilities that there might have been no difference or that it might have been negative are reported in italics in the tables of posttest-only findings for homeowners in Chapter 3. Statistical significance tests were not performed on the findings from the analysis of the subsets of similar treatment and comparison homeowner groups because these subsets were not randomly selected. No statistical significance tests were performed on any of the comparisons of Former Decathlete and Non-decathlete Students because the Former Decathlete data were not randomly-collected.

2.4 Data Collection

The Homeowner and Non-decathlete Student data-collection surveys used random-digit-dialed (RDD) telephone samples of Homeowners and Non-decathlete Students. The Marketing Services Group provided the RDD samples. Eastern Research Services conducted the telephone interviews. The evaluation team monitored approximately twenty of the telephone interviews for quality.

The survey of Former Decathletes used an online survey hosted by the Solar Decathlon Alumni Association (SDAA). The evaluation team worked with the SDAA to develop the sample frame of Former Decathletes. SDAA managed the invitations to them to take the survey.[22] A total of 334 Former Decathletes took at least some part of the online survey. Figure 1 shows the distribution of respondents by the Solar Decathlon year in which they participated. After removing the 2011 decathletes and incomplete surveys, 174 useable surveys were available for the impact analysis.[23]

Figure 1: Distribution of Former Decathletes Responding by Solar Decathlon Participation Date



An accurate count of the total number of Former Decathletes was not available. The evaluation estimated the average number of decathletes per team in the later years (for which lists are available) and multiplied that number by the total number of participating teams to estimate that about 4,100 students participated in a Solar Decathlon between 2002 and 2009. On the basis of this estimate, approximately 8% of the Former Decathletes took the online survey.

Table 5, on the following page, summarizes sample design for the data-collection activities. The Homeowner groups' sample sizes were developed from considerations of cost and the desired power (0.8 or greater) of the tests of differences between the Homeowner groups, consistent with a 90% confidence level.

[22] The U.S. Office of Management and Budget (OMB) reviewed and approved all surveys in accordance with the Paperwork Reduction Act of 1995 (44 U.S.C. §3501 et seq).
[23] The 2011 decathletes were included in analyses that did not require that several years had elapsed since participation for impact outcomes to develop.

Table 5: Sample Design for the Solar Decathlon Impact Evaluation

Audience	Group	Interviews	Sample Design
End-users	Visitor Homeowners	200	Random-digit-dialed (RDD) sample of landline phones in the Baltimore and Washington D.C. MSAs
	Aware Homeowners	280	RDD sample of landline phones in the Baltimore and Washington, D.C., MSAs
	Unaware Homeowners	400	RDD sample of landline phones in the Baltimore and Washington, D.C., MSAs
Participating Students	Former Decathletes	174	The SDAA, with assistance from DOE, developed a sample frame consisting of all Former Decathletes for whom it could obtain contact information. SDAA invited all in the frame by e-mail or phone to take an online survey and provided the link. DOE also published a general invitation on the Solar Decathlon website, which provided the link and invited Former Decathletes to take the survey.
Non-decathlete former college students	Non-decathlete Students	110	RDD sample of landline phones in the 48 contiguous U.S. states.

2.5 A Word about the Terminology Used in This Report

Because the evaluation uses multiple methods to triangulate on the Solar Decathlon's success in meeting its objectives, the words "differences" and "comparisons" occur in multiple contexts. To help avoid confusion certain words, such as "impact," have been given specific meanings for the purpose of describing the results. This report uses the following conventions described in Table 6, on the following page. By using these conventions the report can use other common words, such as "differences" and "comparisons," to describe results with less opportunity for confusion.

Table 6: Definitions of Certain Words Used in the Evaluation Report

Term	Meaning in This Report
Outcome	A variable that represents a desired result of a Solar Decathlon.
Impact	A calculated difference between the outcomes of treatment and comparison groups representing one of the methodologies. As used in this report, "impact," when used to describe a stand-alone finding, does not imply true attribution to the Solar Decathlon of a calculated difference in an outcome between treatment and comparison groups. It can apply to any of several stand-alone findings that, together, are used to support a conclusion that the Solar Decathlon is meeting its objectives.
Posttest-only findings	Impact or outcome results from analyses of the post-treatment-only measurements using the complete homeowner and student datasets.
Similar-group findings	Impact or outcome results from analyses of the measurements on the subset of similar homeowners and former students created by clustering on predisposition variables.
Self-report findings	Results from analyses of Visitor Homeowner and Participating Student self-reports indicate the effect the Solar Decathlon had on their knowledge or outcome behaviors. "Effect" in this sense is equivalent to "impact" but is a one-person-reported "difference" in an outcome rather than a calculated difference between treatment and comparison group outcomes.

3. Findings Relevant to the Homeowner Objectives

This section reports the findings of the Solar Decathlon's impacts on visiting homeowners and on those who experience the Solar Decathlon only through the media or word-of-mouth. The Solar Decathlon has two objectives that apply to these audiences:

1. Demonstrate the opportunities that residential solar energy systems and energy-efficient appliances offer for the public's own residences.
2. Educate the public about the many cost-saving opportunities presented by clean-energy products.

The findings on these objectives are described in subsections covering:

- Actions denoting awareness of the opportunities that solar energy systems offer for houses (Section 3.1);
- Actions denoting awareness of the opportunities that energy-efficient appliance and lighting products offer for houses (Section 3.2); and
- Knowledge of the features of solar houses and energy-efficient products (Section 3.3).

An overall summary of the homeowner impact findings appears in Section 3.4. The summary provides a side-by-side comparison of the posttest-only findings, the similar-group findings after accounting for predispositions, and the self-reported findings. Taken together, the results provide evidence that the Solar Decathlon successfully achieved its objectives for its homeowner audience.

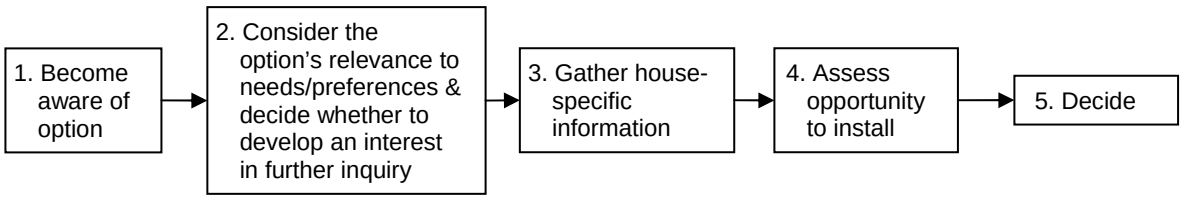
3.1 Actions Denoting Awareness of the Opportunities that Solar Energy Systems Offer for Houses

One of the end-user objectives of the Solar Decathlon consists of demonstrating to the visitors the opportunities presented by cost-effective houses that combine energy-efficient construction and appliances with renewable energy systems that are available today. This section describes the findings on this objective for solar energy systems. Section 3.2 reports the results for efficient appliances and lighting.

A residential solar energy system is a major investment involving several decision steps and an increasing number of considerations at each step. Therefore, the evaluation chose to seek evidence for the Solar Decathlon's effectiveness in demonstrating the opportunities of solar energy systems by using a decision-process model that represents the steps, or stages, a

homeowner would go through in the process of making a decision to install a solar energy system. Treatment and comparison groups were measured and compared on how far they had processed through the stages. The evaluation used the model to measure the degree to which an awareness of the opportunities of solar-systems stimulated Visitor and Aware Homeowners to explore the feasibility of installing their own solar energy system. Figure 2 portrays the decision-process model.

Figure 2: Stages of the Decision-making Process[24]



Stage 1:	The Solar Decathlon had accomplished this for all Visitor and Aware Homeowners at the time of the survey interview. It is irrelevant for Unaware Homeowners.
Stage 2:	Having learned about the solar option, the homeowner subjectively decides whether he/she has an interest in pursuing a solar energy system for his/her own house. No information specific to the home has been gathered yet. The surveys measured progress to Stage 2 by asking whether the respondent had given any thought to the advantages and disadvantages of installing solar panels to generate electricity or to heat water for his/her own house.
Stage 3:	If the homeowner develops an interest in installing a solar energy system, he/she will proceed to Stage 3 to gather information specific to the homeowner's house. Such information includes names of qualified contractors, contractor bids, payback periods, orientation of the roof, and consideration of specific risks. The surveys measured progress to Stage 3 by asking whether the respondent had sought information about the cost of installing solar panels. This was used as an indicator of serious intent to gather information by which the feasibility of installing a solar energy system could be judged.
Stage 4:	The homeowner assesses the information gathered during Stage 3 and considers whether a solar energy system is actually feasible for his/her house. This includes determining whether the necessary financial resources are available at a reasonable cost, whether the payback period is within the homeowner's expected tenure in the house, and whether the proposed physical location of the panels is acceptable. This is the final go/no-go stage. Progress to this stage was not measured by the evaluation because Stage 5 is the outcome of Stage 4 and provides adequate evidence that the homeowner went through this stage.
Stage 5:	The homeowner decides whether to install the solar energy system. The surveys measured progress to this stage by asking visitor respondents whether they had installed any solar panels on his/her home to generate electricity or to heat rooms or hot water since visiting the Solar Decathlon, and for non-visitors, since 2000.

[24] The model is a composite of other decision models (e.g., Rogers, 2003, p.170; Fishbein and Ajzek, 1975, p.47; Opinion Dynamics, 2011, p.15-19). The fourth stage, Assess Opportunity, is not included in many models; however, it is an essential consideration for this evaluation.

With this model as a framework, the evaluation examined the proportions of each homeowner group that,

- Completed Stage 2;
- Completed Stage 3; and
- Completed Stage 4 and decided at Stage 5 to install a solar energy system.

All of the questions used to gather data for this part of the evaluation specified that the decision action occurred *after* exposure to the Solar Decathlon (for Visitor Homeowners) or after 2000 (for Aware and Unaware Homeowners). The period between these benchmark dates and 2011 constitutes the "respective comparison periods," as described in Chapter 2. The results exclude homeowners who had already installed a solar energy system prior to these periods unless they also installed an additional solar energy system after the measurement periods. The evaluation assumed these homeowners would not re-enter the market again; otherwise, their inclusion in the analysis would have biased the findings downward. However, those that did re-enter the market were retained for the analysis.

Section 3.1.1 presents the results for Visitor Homeowners, and Section 3.1.2 presents the results for Aware Homeowners. The findings in both subsections include the following:

- The statistical findings from the posttest-only analysis; and
- The findings from the similar-group analysis.

3.1.1 Impact of a Visit to the Solar Decathlon on the Homeowner Decision Process for Installing a Solar Energy System

This section reports the assessment of whether a visit to a Solar Decathlon affected decision-making for the installation of residential solar energy systems. The evidence suggests that a visit leads Visitor Homeowners to more actively consider installing a solar energy system on his or her own house (Stage 2) and gather information on its feasibility (Stage 3) than Aware and Unaware Homeowners, but that visits have not had a significant impact on actual installations (Stages 4-5).[25] The comparison of homeowners with similar predispositions supports this finding.

[25] The evaluation notes that installing a solar energy system is not a stated objective of the Solar Decathlon.

a. Stage 2—Visitor Homeowners Who Considered the Advantages and Disadvantages of Installing a Solar Energy System on Their Home

Table 7 shows and compares the percentages of the Visitor Homeowners who completed Stage 2 and the two non-visitor comparison groups after their respective comparison periods. The posttest-only findings show that 11% more Visitor Homeowners than Aware Homeowners considered the advantages and disadvantages of installing a solar energy system on their home and 27% more Visitor Homeowners than Unaware Homeowners considered the advantages and disadvantages. The results from the comparisons of the similar homeowner groups were 10% and 22%, respectively. As described in Section 2, these results could be interpreted as indicating that 1% (11% – 10%) of the posttest-only Visitor-Aware Homeowner impact finding and 5% (27% – 22%) of the posttest-only Visitor-Unaware Homeowner impact finding can be attributed to similarities in the predisposition motivations of visitors. The findings of the similar-group analyses, (10% and 22%, respectively), which have accounted for predispositions, provide evidence that a visit to the Solar Decathlon influences more homeowners to consider installing a solar energy system than would otherwise occur.[26]

Table 7: Impact of a Visit to the Solar Decathlon on Consideration by Homeowners of Installing a Solar Energy System–Percentages Completing Stage 2

Posttest-only Impacts Using the Full Homeowner Dataset

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Percent**	**Homeowner Group**	**Percent**
Treatment Group	Visitor (n=192)	74%	Visitor (n=192)	74%
Comparison Group	Aware (n=278)	63%	Unaware: (n=397)	47%
Difference (Evidence of potential impact)		11%		27%
Statistically Significant?		Yes *P=0.0097*		Yes *p<0.0001*

(Comparison of Similar Groups is on the next page.)

[26] Throughout this report, the comparisons of the posttest-only findings and similar-group findings provide evidence of the effects of self-selection based on predispositions and the net impacts after accounting for these predispositions. Other factors not accounted for by the predisposition-similarity grouping may also influence the findings. Examples include systematic errors in self-reporting of predispositions and differences in state and local financial incentives.

Similar-group Impacts Using the Subset of Similar Homeowners*

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Percent**	**Homeowner Group**	**Percent**
Treatment Group	Visitor (n=142)	75%*	Visitor (n=156)	76%*
Comparison Group	Aware (n=164)	65%	Unaware (n=231)	54%
Difference (Evidence of impact after accounting for predispositions)		10%		22%

*Note: The cluster analysis described in Section 2 captures different subsets of Visitors in the Aware and the Unaware clusters; therefore the percentages can differ between comparisons.

b. Stage 3—Visitor Homeowners Who Sought Information on the Costs of Installing a Solar Energy System

Table 8, on the next page, shows and compares the proportions of homeowners who completed Stage 3 after their respective comparison periods. The evaluation used the effort to gather information on the cost of a solar energy system for their house to indicate completing Stage 3. As expected, the proportions of each group expending effort to investigate the feasibility of a solar energy system for their home decreased sharply from simply "considering a solar energy system." However, the posttest-only *impact* findings did not vary as much. Twelve percent more Visitor Homeowners than Aware Homeowners investigated the feasibility, while 16% more Visitor Homeowners than Unaware Homeowners investigated the feasibility. The comparable Stage 3 impact results from the similar-group comparisons were 12% and 13%, respectively.

Table 8: Impact of a Visit to the Solar Decathlon on the Decision by Homeowners to Seek Home-specific Cost Information for Installing a Solar Energy System—Percentages Completing Stage 3

Posttest-only Impacts Using the Full Homeowner Dataset

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Percent**	**Homeowner Group**	**Percent**
Treatment Group	Visitor (n=192)	25%	Visitor (n=192)	25%
Comparison Group	Aware (n=278)	13%	Unaware (n=397)	9%
Difference (Evidence of potential impact)		12%		16%
Statistically Significant?		Yes *p<0.0015*		Yes *p<0.0001*

Similar-group Impacts Using the Subset of Similar Homeowners

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Percent***	**Homeowner Group**	**Percent***
Treatment Group	Visitor (n=142)	26%	Visitor (n=156)	26%
Comparison Group	Aware (n=164)	14%	Unaware (n=231)	13%
Difference (Evidence of potential impact after accounting for predispositions)		12%		13%

*Note: The cluster analysis described in Section 2 and Appendix A captures different subsets of Visitors in the Aware and the Unaware clusters; therefore the percentages can differ between comparisons.

Comparison of these impact findings suggests that predispositions accounted for none of the posttest-only difference between the Visitor and Aware Homeowners (12% – 12%), and that all of the posttest-only impact finding of 12% may be attributable to the Solar Decathlon. On the other hand, the comparisons of the Visitor and Unaware Homeowner impacts provide evidence that, while predispositions may have accounted for 3% of the difference (16% – 13%), the Solar Decathlon could have accounted for as much as 13% of the difference between the Visitor and Unaware Homeowners. This result provides evidence that a visit to the Solar Decathlon influences more Visitor Homeowners to investigate the specifics of installing a solar energy system on their home than would otherwise occur.

c. Stages 4 and 5—Visitor Homeowners Who Actually Installed a Solar Energy System

The Solar Decathlon's stated objectives do not include stimulating visitors to install solar energy systems on their homes, although that is an ultimate outcome. However, the decision model includes this outcome, so it was investigated.

A residential solar energy system has many attributes that a homeowner must consider in view of all of the circumstances that will affect its purchase and installation. Stage 4 constitutes the stage at which the homeowner weighs the information gathered during Stage 3 and considers all of the attributes and circumstances related to his or her home before making a decision. At Stage 4 the homeowner weighs attributes such as initial cost, maintenance cost, payback, appearance of the house after installation as well as personal circumstances such as expected tenure in the house, the ability to obtain funding, the effect of loan payments on cash flow, the effect on real estate values, his/her risk tolerance, and other home-specifics.

The posttest-only impact findings in Table 9, on the following page, indicate that approximately 1% more homeowners in each of the comparison groups installed solar energy systems on their homes than did homeowners in the Visitor Homeowner group. The differences are not statistically significant, however, meaning there is a high probability that no difference exists between the two groups. The comparisons of similar homeowners are also small, with no difference between Visitor and Aware Homeowners and 1% more for the Unaware Homeowners compared to Visitor Homeowners.

Table 9: Impact of a Visit to the Solar Decathlon on Installations of a Solar Energy System—Stages 4 and 5: Percentages of Homeowners Installing a Solar Energy System for Their Home after Visiting a Solar Decathlon

Posttest-only Impacts Using the Full Homeowner Dataset

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Percent of Group**	**Homeowner Group**	**Percent of Group**
Treatment Group	Visitor (n=192)	2%	Visitor (n=192)	2%
Comparison Group	Aware (n=278)	3%	Unaware (n=397)	3%
Difference (Evidence of potential impact)		-1%		-1%
Statistically Significant?		No *p=0.70*		No *p=0.74*

Similar-group Impacts Using the Subset of Similar Homeowners

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Percent of Group***	**Homeowner Group**	**Percent of Group***
Treatment Group	Visitor (n=150)	3%	Visitor (n=164)	2%
Comparison Group	Aware (n=166)	2%	Unaware (n=234)	4%
Difference (Evidence of potential impact after accounting for predispositions)		0%**		-1%**

*Note: The cluster analysis described in Section 2 captures different subsets of Visitors in the Aware and the Unaware clusters; therefore the proportions can differ between comparisons.
**The differences result from rounding the treatment and comparison group percentages.

As an additional measure of the Solar Decathlon's impact on actual decisions, Visitor Homeowners were asked to self-report whether they had installed a solar energy system on their house to generate electricity or heat rooms or hot water since they visited a Solar Decathlon. Only four (4) of those surveyed (out of 200) had done so. The survey then asked these Visitor Homeowners the following question to have them self-rate the influence of their visit to the Solar Decathlon on their decision to install solar panels on their house:

> *How would you rate the influence of your visit to the Solar Decathlon on your decision to install these solar panels? Please answer on a scale of 0 to10, where 0 means your visit to the Solar Decathlon had no influence on your decision and 10 means your visit was the main influence on your decision to install solar-electric panels.*

Two of the installers rated the Solar Decathlon's influence at 6 out of a possible 10, while the other two reported that it had no influence at all. The average of these four self-ratings, 3, provides another source of evidence regarding the impact of the Solar Decathlon on residential installations of solar energy systems. Although the self-reported result is slightly more optimistic than the posttest-only and similar-group impact findings, the average rating is low and supports a finding of no impact by the Solar Decathlon on residential solar-system installations.

These results, considered together, provide evidence that Visitor Homeowners are more likely to investigate the feasibility of a solar energy system, but they are no more likely than non-visitor homeowners to actually install one.

3.1.2 Impact of the Media and Word-of-mouth-alone on Decisions to Install Solar Energy Systems by Aware Homeowners

This section reports the assessment of whether media or word-of-mouth coverage of the Solar Decathlon—without a visit—affected decision-making for the installation of residential solar energy systems. The evidence suggests that media and word-of-mouth had a positive impact on Aware Homeowners' consideration of installing a solar energy system (Stage 2), had a small impact on gathering feasibility information (Stage 3), but has not had a significant impact on actual installations (Stages 4-5). The comparison of homeowners with similar predispositions supports this finding.

a. Stage 2—Aware Homeowners Who Considered the Advantages and Disadvantages of Installing a Solar Energy System on Their Home

Table 10, on the following page, shows that 16% more homeowners in the Aware group considered installing a solar energy system than in the Unaware group. The same comparison performed on the Aware and Unaware Homeowners who are similar on predisposition variables shows that a higher proportion of these groups considered installing a solar energy system, but the impact decreased from 16% to 12%. This suggests that predispositions may account for 4% (16% – 12%) of the difference, leaving potentially 12% to the Solar Decathlon.

Table 10: Impact of Media and Word-of-mouth-alone on Consideration of Installing a Solar Energy System—Percentages of Homeowners Completing Stage 2

Posttest-only Impacts Using Full Homeowner Dataset

	Homeowner Group	Percent of Group
Treatment Group	Aware (n=278)	63%
Comparison Group	Unaware (n=397)	47%
Difference (Evidence of potential impact)		16%
Statistically Significant?		Yes *p<0.0001*

Similar-group Impacts Using the Subset of Similar Homeowners

	Homeowner Group	Percent of Group
Treatment Group	Aware (n=188)	66%
Comparison Group	Unaware (n=232)	54%
Difference (Evidence of potential impact after accounting for predispositions)		12%

b. Stage 3—Aware Homeowners Who Sought Cost Information for Installing a Solar Energy System

Table 11, on the following page, shows the posttest-only impact findings for Stage 3 of the decision-process model. Four percent more Aware Homeowners than Unaware Homeowners sought information about the cost of a solar energy system for their home. The same comparison performed on the Aware and Unaware Homeowners who are similar on predisposition variables shows that higher proportions of these groups considered installing a solar energy system, but the difference between the similar groups decreased from 4% to 1%. This suggests that predispositions may account for 3% (4% – 1%) of the difference, indicating 1% may be attributed to the Solar Decathlon. The impact results suggest that information from media and word-of-mouth about the Solar Decathlon has a small positive influence on whether homeowners make the effort to gather information on the feasibility of a solar energy system in their home.

The findings for Stages 2 and 3 suggest that information about the Solar Decathlon from the media and word-of-mouth-alone has a positive influence on whether homeowners consider and investigate a solar energy system for their home.

Table 11: Impact of Media and Word-of-mouth Alone on Decision to Gather Home-specific Information for Installing a Solar Energy System—Percentages of Homeowners Completing Stage 3

Posttest-only Impacts Using Full Homeowner Dataset

	Homeowner Group	Percent of Group
Treatment Group	Aware (n=278)	13%
Comparison Group	Unaware (n=397)	9%
Difference (Evidence of potential impact)		4%
Statistically Significant?		Yes *P=0.0533*

Similar-group Impacts Using the Subset of Similar Homeowners

	Homeowner Group	Percent of Group
Treatment Group	Aware (n=188)	14%
Comparison Group	Unaware (n=232)	13%
Difference (Evidence of potential impact after accounting for predispositions)		1%

c. Stages 4 and 5—Aware Homeowners Who Installed a Solar Energy System on Their Home

The posttest-only impact findings indicate that information from the media and word-of-mouth alone did not stimulate a greater number of residential solar installations than would have occurred otherwise. The same impact comparison performed on the Aware and Unaware Homeowners who are similar on predisposition variables shows a higher proportion of Unaware Homeowners installing a solar energy system. These findings provide further evidence that the Solar Decathlon has not influenced homeowners to install residential solar energy systems. Table 12 presents these results.

Table 12: Impact of Media and Word-of-mouth Alone on Installations of a Solar Energy System—Stages 4 and 5: Percentages of Homeowners Installing a Solar Energy System for Their Home

Posttest-only Impacts Using the Full Homeowner Dataset

	Homeowner Group	Percent of Group
Treatment Group	Aware (n=278)	3%
Comparison Group	Unaware (n=397)	3%
Difference (Evidence of potential impact)		0%
Statistically Significant?		No *p=0.5434*

Similar-group Impacts Using the Subset of Similar Homeowners

	Homeowner Group	Percent of Group
Treatment Group	Aware (n=190)	2%
Comparison Group	Unaware (n=235)	4%
Difference (Evidence of impact after accounting for predispositions)		-2%*

* Negative impacts indicate that the comparison group provides more of the desired outcome than the treatment group. When the impact of predispositions is removed from both groups, the larger comparison group percentage may indicate that predispositions interact with another influence and that accounting for predispositions increases the influence of the other influence. Or it may be the result of the protocols used to select the similar-group clusters (see Appendix A). These possible causes were not investigated. The impacts are small and consistently support a finding of no impact.

3.2 Actions Denoting Awareness of the Opportunities that Energy-efficient Appliance Products and Lighting Equipment Offer for Houses

The second part of the Solar Decathlon's end-user demonstration objective consists of showing the opportunities presented by the use of energy-efficient appliances and efficient construction. The evaluation used residential lighting equipment to represent efficient construction and estimated the impact of the Solar Decathlon on the purchase and installation of energy-efficient appliance and lighting equipment.

The evaluation determined that application of the decision model used for solar energy systems to equipment with which homeowners are highly familiar and which cost much less than a solar

energy system would invite socially responsible answers.[27] As a consequence of this determination, the evaluation chose to measure "demonstration of opportunity" outcomes with installation actions that denoted whether homeowners had exploited the opportunities. It assumed that if the homeowner installed efficient products, then the homeowner would have been aware of their opportunities. Installation equated to "awareness of the opportunities" inherent in the products and "awareness" was a result of the demonstration. Accordingly, the evaluation measured whether the treatment groups installed more efficient products than the comparison group. For appliances, it was further assumed that incidence of the need for replacement was randomly distributed across the groups.[28]

The measurements of installation outcomes consisted of asking homeowners in each group if they had installed appliances or lighting products that they knew to be more efficient than typical appliances and lighting products after the beginning of their respective comparison periods. A follow-up question asked them to describe the product. Descriptions that did not appear to match an efficient appliance or lighting equipment (e.g., "two stoves") resulted in a deletion of the installation response.

The evaluation estimated efficient appliance and lighting product impacts using the following:

- Posttest-only differences between the percentage of:
    - Visitor Homeowners and Aware Homeowners who installed efficient appliances and lighting products
    - Visitor Homeowners and Unaware Homeowners who installed efficient appliances and lighting products
    - Aware Homeowners and Unaware Homeowners who installed efficient appliances and lighting products
- Similar-group differences between the percentage of:
    - Visitor Homeowners and Aware Homeowners who installed efficient appliances and lighting products
    - Visitor Homeowners and Unaware Homeowners who installed efficient appliances and lighting products

[27] A typical residential solar energy system can cost $35,000. The most expensive residential appliance, usually a refrigerator, typically will cost less than $2,000.

[28] Appliances usually are replaced only when an existing appliance reaches end-of-life. The assumption justified ignoring age of the appliance as a rival explanation for the findings during the design of the evaluation.

  - Aware Homeowners and Unaware Homeowners who installed efficient appliances and lighting products
- Visitors' self-report of the influence of the Solar Decathlon on their purchase decision.

Section 3.2.1 describes the impacts of a visit to the Solar Decathlon on appliance and lighting installations. Section 3.2.2 describes the impacts of Solar Decathlon media or word-of-mouth alone on appliance and lighting installations.

3.2.1 Impact of a Visit to the Solar Decathlon on Installations of Energy-efficient Products

a. Energy-efficient Appliances Installed by Visitor Homeowners

Tables 13 and 14 show the posttest-only and similar-group findings for the installations of efficient appliance products. At face value, the results indicate that a visit to the Solar Decathlon did not inspire more homeowners to install energy-efficient appliance products than non-visitors. Rather, when considered with the similar-group results it suggests that more of the comparison group homeowners installed energy-efficient appliances than Visitor Homeowners (16% more Aware Homeowners and 7% more Unaware Homeowners).

Table 13: Impact of a Visit to the Solar Decathlon on the Percentages of Homeowners Installing Energy-efficient Appliances

Posttest-only Impacts Using the Full Homeowner Dataset

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Percent of Group**	**Homeowner Group**	**Percent of Group**
Treatment Group	Visitor (n=200)	54%	Visitor (n=200)	54%
Comparison Group	Aware (n=280)	70%	Unaware (n=401)	61%
Difference (Evidence of potential impact)		-16%		-7%
Statistically Significant?		No *p=0.9999**		No *p=0.9475**

* For a one-tailed test of significance, these probabilities indicate that the visitor percentages are less than or not significantly different from the comparison group percentages. See the text for possible explanations for these findings.

(Comparison of Similar Groups is on the next page.)

Similar-group Impacts Using the Subset of Similar Homeowners

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Percent of Group**	**Homeowner Group**	**Percent of Group**
Treatment Group	Visitor (n=164)	56%	Visitor (n=164)	56%
Comparison Group	Aware (n=190)	74%	Unaware (n=235)	69%
Difference (Evidence of impact after accounting for predispositions)		-18%		-13%

The evaluation also compared the *average number* of efficient appliance installations by each group since visiting a Solar Decathlon or since the beginning of the non-visitors' comparison period and found similar results. Table 14 reports the posttest-only findings for this outcome and indicates that Aware Homeowners installed 48% (0.48/0.98) more efficient appliances than Visitor Homeowners, and Unaware Homeowners installed 19% (0.19/0.98) more efficient appliances.

The comparisons of similar homeowner groups support these unexpected findings.

Table 14: Impact of a Visit to the Solar Decathlon on Average Number of Energy-efficient Appliances Installed during the Comparison Periods

Posttest-only Impacts Using the Full Homeowner Dataset

	Homeowner Group	**Average No. of Installations**	**Homeowner Group**	**Average No. of Installations**
Treatment Group	Visitor (n=200)	0.98	Visitor (n=200)	0.98
Comparison Group	Aware (n=280)	1.46	Unaware (n=401)	1.17
Difference (Evidence of potential impact)		-0.48		-0.19
Statistically Significant?		No *p=0.9999**		No *p=0.9574**

* See the note to Table 13.

(Comparison of Similar Groups is on the next page.)

Similar-group Impacts Using the Subset of Similar Homeowners

	Homeowner Group	Average No. of Installations	Homeowner Group	Average No. of Installations
Treatment Group	Visitor (n=150)	0.97*	Visitor (n=164)	0.96*
Comparison Group	Aware (n=166)	1.55	Unaware (n=234)	1.36
Difference (Evidence of potential impact after accounting for predispositions)		-0.58		-0.40

Note: The cluster analysis captures different subsets of Visitors in the Aware and the Unaware clusters; therefore the proportions can differ between comparisons.

Because the Solar Decathlon works to achieve the opposite result from that seen in these impact findings, and nothing is done during a Solar Decathlon to discourage visitors from installing efficient appliances, the evaluation sought an explanation for the appliance results. Four circumstances provided potential rival explanations and led to a conclusion that the posttest-only and similar-group appliance awareness findings are inconclusive regarding the impact of the Solar Decathlon on awareness of the opportunities inherent in efficient appliances.

1. Predispositions may have led Visitor Homeowners to install most of the efficient appliances they thought were appropriate for their household before their visit. Appliances typically last longer than the comparison periods for Visitor Homeowners, so if they had installed an efficient appliance before their Solar Decathlon visit, they would not return to the market after their visit. The fact that the similar-group findings are even more negative supports this possible explanation.[29]
2. The comparison period for the Aware and Unaware Homeowners began in 2000, whereas the comparison period for Visitor Homeowners began after they visited a Solar Decathlon. Therefore, the Aware and Unaware Homeowners had a longer period during which to install efficient appliances. This may have resulted in higher installation counts.
3. The evaluation considered the year 2000 a weaker benchmark for the purposes of minimizing recall error than the year of a visit to a Solar Decathlon (see Section 2.2.2d). Therefore, Aware and Unaware Homeowners' recall may have been subject to more error than that of Visitor Homeowners.
4. It is possible that a key assumption underlying the research questions for the appliance measurements did not apply for Visitor Homeowners, and that this resulted in *fewer* Visitor Homeowners reporting the installation of energy-efficient appliances than either Aware or

[29] The similar-group findings account for predispositions. The fact that they are more negative suggests that, after the influence of predispositions is weakened, some other influence is producing even more negative results. The evaluation did not measure pre-Solar Decathlon installations.

Unaware Homeowners even though *more* Visitor Homeowners may have actually installed them. The following paragraphs explain why this may have a bearing on the findings.

Evaluation research performed for state and utility energy efficiency has shown that respondents to phone interviews overstate the existence of energy-efficient appliances in their homes.[30] When designing the research questions for installations of efficient appliance and lighting products, the evaluation assumed that, although the individual group measurements might be overstated, the overstatement bias would be approximately equal and in the same direction across treatment and comparison groups so that the *differences* between the measurements would be relatively unbiased. It is the differences that the evaluation uses to assess impacts. Visitor predispositions, in combination with the effectiveness of the Solar Decathlon in educating visitors to the characteristics of efficient appliances, may have rendered the application of this assumption to the Visitor Homeowners' responses inappropriate.

If the Solar Decathlons were successful in educating visitors to the opportunities offered by energy-efficient appliances, then Visitor Homeowners would have a more accurate knowledge of what constitutes an efficient appliance than homeowners in the other two groups. When asked on the phone whether they had installed an energy-efficient appliance, they would be less likely to overstate their efficient-product installations. If this were true, the assumption of overstatement would produce misleading results. It would be possible that *fewer* Visitor Homeowners might report installing energy-efficient appliances than either Aware or Unaware Homeowners even though *more* Visitor Homeowners had actually installed them. Such a possibility would explain the observed findings.[31]

Two additional sources of evidence from the evaluation findings offer support for this fourth possible explanation of the negative findings. First, Visitor Homeowners acknowledged the effectiveness of the Solar Decathlon in educating them about making a household more efficient.

[30] West Hill Energy & Computing. 2003. "Vermont Residential New Construction 2002: Baseline Construction Practices, Cole Compliance, and Energy Efficiency," Section 9.3 and Table 9.1. Prepared for the Vermont Department of Public Service (January 2). http://www.cee1.org/eval/db_pdf/368.pdf. This study also mentions that similar studies in other states have found that phone respondents overstate their appliances' efficiency, but provides no citations.

[31] West Hill Energy & Computing 2003. This study compared telephone and on-site survey results for efficient refrigerators, clothes washers, and dishwashers. The percentage of households claiming these efficient appliances by phone ranged from 24% to 41% (absolute) higher than was verified by on-site ENERGY STAR® measurements. However, the on-site survey also found that 10% of the ENERGY STAR refrigerators and dishwashers were understated by phone. Nonetheless, the differences are large enough to support the offered interpretation.

A self-report question, used as the third source of evidence for the evaluation of the Solar Decathlon's education objective, asked Visitor Homeowners whether the Solar Decathlon had helped them gain a better understanding of how a home can be made more energy efficient *than they had before*. Ninety-one percent (91%) responded that it had (see section 3.3.1, Figure 6). Visitor Homeowners claimed they took a better understanding of efficient appliances away from their visit.

Second, the posttest-only and similar-group impact findings for efficient-appliance installations by Aware and Unaware Homeowners show a *positive* impact for the media and word-of-mouth-alone exposure to the Solar Decathlon. Neither of these two groups had ever visited a Solar Decathlon and would not have experienced the education provided by such a visit. Further, both had the same comparison period. As a result both groups would have been likely to overstate their efficient appliance installations over the same period of time. Their result is in the direction anticipated: in both findings a greater percentage of Aware Homeowners installed efficient appliances than did Unaware Homeowners (see Table 17, Section 3.2.2a). These Aware and Unaware Homeowner results lend support to the fourth explanation above.

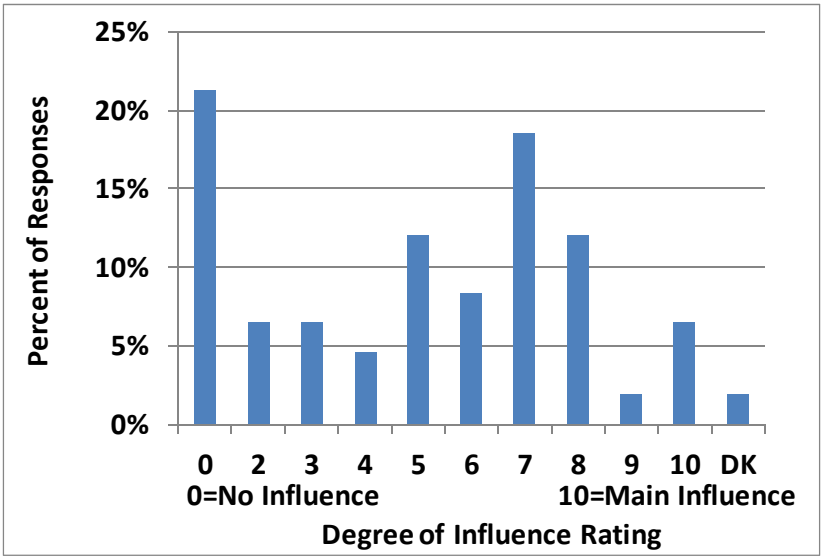
As a consequence of these considerations, the evaluation concluded that the posttest-only and similar-group findings on the Solar Decathlon's objective of demonstrating the opportunities inherent in efficient appliances are inconclusive.

For the third source of evidence on the appliance demonstration objective, Visitor Homeowners who reported installing one or more energy-efficient appliance(s) subsequent to visiting a Solar Decathlon were asked the following self-report question:

> *How would you rate the influence of your visit to the Solar Decathlon on your decision to install this (these) energy-efficient appliance(s)? Please answer on a scale of 0 to 10, where 0 means your visit to the Solar Decathlon had no influence on your decision, and 10 means your visit was the main influence on your decision to install this (these) efficient appliance(s).*

Figure 3 shows the percentages of Visitor Homeowners claiming each rating on the scale. The average rating was 4.8.[32] This evidence suggests that the Solar Decathlon contributes to Visitor Homeowner's decisions to install energy-efficient appliances.

Figure 3: Self-reported Degree of Influence of the Solar Decathlon on Visitor Homeowners' Subsequent Installations of Energy-efficient Appliances



"DK" = Don't Know

The foregoing review of the findings on the Solar Decathlon's effectiveness in achieving its efficient-appliance awareness-of-opportunities objective led the evaluation to conclude that the Solar Decathlon is probably satisfying its objective of raising homeowners' awareness of the opportunities inherent in efficient appliances, but that the findings are inconclusive.

b. Energy-efficient Lighting Installed by Visitor Homeowners

Table 15 and 16, on the following pages, present the posttest-only and similar-group impact findings on efficient-lighting installations during the respective group comparison periods. The posttest-only impact findings show that 11% more Visitor Homeowners installed efficient lighting after visiting a Solar Decathlon than did Unaware Homeowners. On the other hand, 3% more Aware Homeowners installed efficient lighting than Visitor Homeowners. However, the

[32] In some energy-program evaluations, this average, divided by 10, would be interpreted as the proportion of the gross energy savings from the efficient-appliance installations to *attribute* to the program without making a claim that the program was solely responsible for influencing a specific number of homeowners to install efficient appliances. The question that produces the influence rating implicitly accounts for rival influences. Of course, the issues associated with self-reporting apply.

difference was not statistically significant; suggesting a visit to the Solar Decathlon had no greater effect than media or word-of-mouth exposure.

Table 15: Impact of a Visit to the Solar Decathlon on the Percentages of Homeowners Installing Energy-efficient Lighting Products Installed during the Comparison Periods

Posttest-only Impacts Using the Full Homeowner Dataset

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Percent of Group**	**Homeowner Group**	**Percent of Group**
Treatment Group	Visitor (n=200)	77%	Visitor (n=200)	77%
Comparison Group	Aware (n=280)	80%	Unaware (n=401)	66%
Difference (Evidence of potential impact)		-3%		11%
Statistically Significant?		No *p=0.7853**		Yes *p=0.00025*

ᵏ For a one-tailed test of significance, this probability indicates that the Visitor percentages are less than or not significantly different from the comparison group percentages.

Similar-group Impacts Using the Subset of Similar Homeowners

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Percent of Group**	**Homeowner Group**	**Percent of Group**
Treatment Group	Visitor (n=164)	79%	Visitor (n=164)	79%
Comparison Group	Aware (n=190)	84%	Unaware (n=234)	70%
Difference (Evidence of potential impact after accounting for predispositions)		-5%		9%

These findings also hold for the differences between the average numbers of efficient-lighting products installed. The average Solar Decathlon Visitor Homeowner installed about the same number of energy-efficient lighting products as the Aware Homeowner, but installed 26% more (0.23/0.88) than an Unaware Homeowner. Table 16, on the following page, summarizes the posttest-only and similar-group impacts in the average installations of the Visitor Homeowner

and respective comparison homeowner groups. The impacts from the similar-group analysis were in the same directions as their respective posttest-only impact findings.

Table 16: Impact of a Visit to the Solar Decathlon on the Average Number of Energy-efficient Lighting Products Installed during the Comparison Periods

Posttest-only Impacts Using the Full Homeowner Dataset

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Average No. of Installations**	**Homeowner Group**	**Average No. of Installations**
Treatment Group	Visitor (n=200)	1.11	Visitor (n=200)	1.11
Comparison Group	Aware (n=280)	1.13	Unaware (n=401)	0.88
Difference (Evidence of potential impact)		-0.02		0.23
Statistically Significant?		No *p=0.4097**		Yes *p=0.0042*

* The note to the posttest-only results in Table 15 also applies to Table 16.

Similar-group Impacts Using the Complete Homeowner Dataset

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Average No. of Installations**	**Homeowner Group**	**Average No. of Installations**
Treatment Group	Visitor (n=150)	1.14**	Visitor (n=164)	1.15**
Comparison Group	Aware (n=166)	1.24	Unaware (n=234)	0.96
Difference (Evidence of potential impact after accounting for predispositions)		-0.10		0.19

** The cluster analysis described in Section 2 captures different subsets of Visitors in the Aware and the Unaware clusters; therefore the outcome results for a group can differ between comparisons.

The posttest-only and similar-group evidence suggests that the Solar Decathlon could have contributed to more Visitor Homeowners installing efficient lighting and more installations (0.19) than would be the case without the Solar Decathlon (as represented by the Unaware Homeowner result).

It can be noted that the rival explanations offered in Section 3.2.1a for the appliance impacts do not apply with the same strength for lighting. Lighting has multiple applications in a home and

some have a shorter useful life compared to appliances (e.g., occupancy sensors, fixtures, and replacement CFLs); therefore, there are more opportunities to purchase them after treatment. No evidence exists that they are overstated in phone interviews. Compact fluorescent light bulbs, motion sensors, fixtures, day-lighting and other efficient-lighting opportunities look different from the corresponding traditional lighting products; therefore, they are less likely to be overstated.

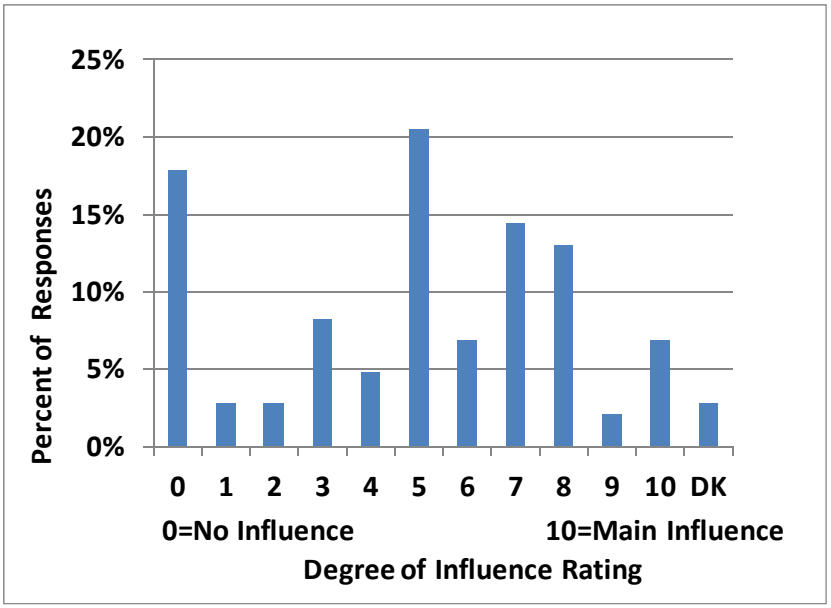
Self-reported evidence provides a third source of evidence on the influence of the Solar Decathlon on Visitors' awareness of the opportunities in efficient-lighting. This evidence provides reason to believe that the Solar Decathlon influences Visitor Homeowners' installations subsequent to a visit. Visitor Homeowners who reported installing one or more energy-efficient-lighting product(s) subsequent to visiting a Solar Decathlon were asked,

> *How would you rate the influence of your visit to the Solar Decathlon on your decision to install this (these) energy-efficient lighting? Please answer on a scale of 0 to 10, where 0 means your visit to the Solar Decathlon had no influence on your decision, and 10 means your visit was the main influence on your decision to install efficient lighting.*

Figure 4, on the following page, shows the percentage of Visitor Homeowners claiming each rating on the scale. The average rating was 4.9.[33] This evidence suggests that the Solar Decathlon contributes to a Visitor Homeowner's decisions to install energy-efficient-lighting products and lends support the posttest-only and similar-group impact findings for Visitor Homeowners compared to Unaware Homeowners.

[33] In some energy-program evaluations, this average, divided by 10, would be interpreted as the proportion of the gross energy savings from the efficient-lighting installations to *attribute* to the program without making a claim that the program was solely responsible for influencing a specific number of homeowners to install efficient lighting products. The question that produces it implicitly accounts for other influences. Of course, the issues associated with self-reporting apply.

Figure 4: Self-reported Degree of Influence of the Solar Decathlon on Visitor Homeowners' Subsequent Installations of Energy-Efficient Lighting



"DK" = Don't Know

3.2.2 Impact of the Media and Word-of-mouth-alone on Installations of Energy-efficient Products

a. Energy-efficient Appliances Installed by Aware Homeowners

The posttest-only analyses for media and word-of- mouth-alone impacts shown in Table 17 indicate that 9% more Aware Homeowners installed energy-efficient appliances than Unaware Homeowners. The installation percentages from the similar-group analyses suggest that 4% (9% – 5%) of the installations may be attributable to predispositions, leaving up to 5% potentially attributable to media and word-of-mouth information about the Solar Decathlon.

Table 17: Impact of Media and Word-of-mouth Alone on the Percentages of Homeowners that Installed Energy-efficient Appliances during the Comparison Periods

Posttest-only Impact Using the Full Homeowner Dataset

	Homeowner Group	Percent of Group
Treatment Group	Aware (n=280)	70%
Comparison Group	Unaware (n=401)	61%
Difference (Evidence of potential impact)		9%
Statistically Significant?		Yes *P=0.0053*

(Comparison of Similar Groups is on the next page.)

Similar-group Impact Using the Subset of Similar Homeowners

	Homeowner Group	Percent of Group
Treatment Group	Aware (n=190)	74%
Comparison Group	Unaware (n=235)	69%
Difference (Evidence of impact after accounting for predispositions)		5%

Table 18 compares the average numbers of efficient appliances installed by Aware and Unaware Homeowners after the beginning of their comparison period. The impact findings in Table 18 indicate that 0.07 (0.29 – 0.22) of the average Aware Homeowner's installations may be attributable to predispositions, leaving 0.22 of the average Aware Homeowner's installations attributable to the Solar Decathlon and, possibly, to other influences not investigated by the evaluation. These findings are consistent with the findings of Table 17.

Table 18: Impact of the Media and Word-of-Mouth-alone on Average Numbers of Energy-efficient Appliances Installed by Aware Homeowners after the Beginning of Their Comparison Period

Posttest-only Impact Using the Full Homeowner Dataset

	Homeowner Group	Average Number of Installations
Treatment Group	Aware (n=280)	1.46
Comparison Group	Unaware (n=401)	1.17
Difference (Evidence of potential impact)		0.29
Statistically Significant?		Yes *P=0.0039*

Similar-group Impacts Using the Subset of Similar Homeowners

	Homeowner Group	Average Number of Installations
Treatment Group	Aware (n=190)	1.57
Comparison Group	Unaware (n=235)	1.35
Difference (Evidence of impact after accounting for predispositions)		0.22

b. Energy-efficient Lighting Installed by Aware Homeowners

The posttest-only impact findings reported in Table 19, on the following page, show that 14% more Aware Homeowners installed efficient-lighting after the beginning of their comparison

period than did Unaware Homeowners. The result of the comparison of homeowners that are similar on predispositions shows the same percentage, suggesting that, in the case of lighting products, predispositions do not reduce the posttest-only findings for these two groups.

Table 19: Impact of the Media and Word-of-Mouth Alone on Installations of Energy-efficient Lighting Products during the Comparison Period

Posttest-only Impact Using the Full Homeowner Dataset

	Homeowner Group	Percent of Group
Treatment Group	Aware (n=280)	80%
Comparison Group	Unaware (n=401)	66%
Difference (Evidence of potential impact)		14%
Statistically Significant?		Yes *P<0.0001*

Similar-group Impact Using the Subset of Similar Homeowners

	Homeowner Group	Percent of Group
Treatment Group	Aware (n=190)	84%
Comparison Group	Unaware (n=235)	70%
Difference (Evidence of impact after accounting for predispositions)		14%

Table 20, on the following page, compares the average numbers of efficient-lighting products installed after the beginning of their comparison period by Aware and Unaware Homeowners. The posttest-only findings indicate that Aware Homeowners installed 28% (1.13 – 0.88 / 0.88) more efficient lighting products than did the Unaware Homeowners. The similar-group impact results provide evidence that 0.02 of these installations may be attributable to the predispositions, leaving 0.23 installations attributable to the Solar Decathlon and, possibly, to other influences not investigated by the evaluation.

Tables 19 and 20 provide evidence that media coverage of the Solar Decathlon and word-of-mouth-alone could have resulted in more homes having efficient lighting and more efficient-lighting products installed in them than would have occurred otherwise.

Table 20: Impact of the Media and Word-of-Mouth Alone on the Average Numbers of Energy-efficient Lighting Installed after the Beginning of the Comparison period

Posttest-only Impact Using the Complete Homeowner Dataset

	Homeowner Group	Average No. of Installations
Treatment Group	Aware (n=280)	1.13
Comparison Group	Unaware (n=401)	0.88
Difference (Evidence of potential impact)		0.25
Statistically Significant?		Yes *p=0.0007*

Similar-group Impact Using the Subset of Similar Homeowners

	Homeowner Group	Average Number of Installations
Treatment Group	Aware (n=190)	1.19
Comparison Group	Unaware (n=235)	0.96
Difference (Evidence of potential impact after accounting for predispositions)		0.23

3.3 Knowledge of Solar House Features and Energy-efficient Products

One of the objectives of the Solar Decathlon consists of educating the public about the many cost-saving opportunities presented by clean-energy products. The evaluation used visits to a Solar Decathlon and media coverage of the Solar Decathlon through television, newspapers, social media, and word-of-mouth (without a visit) as the program activities promoting such public education.

The outcomes used to assess the success of the Solar Decathlon on this objective consisted of directly measuring homeowners' knowledge of how solar-powered houses differed from traditional houses and asking Visitor Homeowners a pair of self-report questions about the effects of their visit on their knowledge of solar-powered houses and energy-efficient houses.

The findings on these questions appear in Section 3.3.1 for a visit and Section 3.3.2 for awareness gained through the media and word-of-mouth only.

3.3.1 Impact of a Visit to the Solar Decathlon on Knowledge of Residential Solar Energy Systems and Energy-efficient Products

The posttest-only and similar-group analyses used homeowners' knowledge of residential solar energy systems and the energy-efficient products used in such houses to develop findings on the knowledge objective. The evaluation asked all homeowners to describe how *houses that collect energy from the sun for electricity or heating are different from houses that do not collect energy from the sun for electricity or heating.* The question was open-ended and unaided, and respondents could provide as many differences as they could bring to mind. The evaluation did not limit the responses to cost-savings answers in order to capture a broad range of knowledge of solar-powered houses and because respondents might have had trouble differentiating cost-savings from affordability, thereby producing misleading results.[34] The Solar Decathlon demonstrates the architectural and environmental features of solar-powered houses as well as their cost-savings features, and the evaluation sought to measure knowledge of all the beneficial features.

After recording a respondent's initial responses, the interviewer asked if the respondent could think of other differences. This encouraged each respondent to try and think of multiple differences and thereby measure his or her knowledge more completely. The number of correct responses defined a respondent's knowledge score.[35] The individual scores were averaged for each homeowner group to provide a knowledge score for the group. The posttest-only and similar-group impacts of the Solar Decathlon on visitor knowledge consisted of the differences in the average knowledge scores for the respective treatment and comparison groups.

The posttest-only and similar-group impact evidence suggests that a visit to the Solar Decathlon has the intended educational effect. Homeowners who have visited the Solar Decathlon have greater knowledge about houses that collect energy from the sun than either of the two comparison groups. Table 21, on the following page, shows these results.

Visitor Homeowners were able to describe 34% (0.35/1.04) more differences between houses that collect energy from the sun and houses that do not than Unaware Homeowners using the

[34] The questions with possible responses may be found in Appendix E.1 at question V8 for Visitor Homeowners and question N3 for Aware and Unaware Homeowners.

[35] Correct responses were judged by the evaluation team and are listed in an addendum to Appendix E.1.

posttest-only impact analysis.[36] The corresponding difference in Visitor Homeowner knowledge compared to Aware Homeowners was 15% (0.18/1.21). The results for the groups of similar homeowners were 25% (0.28/1.14) and 10% (0.13/1.29) more differences, respectively. These posttest-only and similar-group impact findings provide evidence that Visitor Homeowners have a broader knowledge of houses using solar energy than homeowners in either of the two comparison groups.

Table 21: Impact of a Visit to the Solar Decathlon on Homeowners' Knowledge of the Differences between Solar-powered Houses and Other Houses

Posttest-only Impacts Using the Full Homeowner Dataset

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Average No. of Correct Responses**	**Homeowner Group**	**Average No. of Correct Responses**
Treatment Group	Visitor (n=200)	1.39	Visitor (n=200)	1.39
Comparison Group	Aware (n=280)	1.21	Unaware (n=401)	1.04
Difference (Evidence of potential impact)		0.18		0.35
Statistically Significant?		Yes *p=0.0146*		Yes *p<0.0001*

Similar-group Impacts Using the Subset of Similar Homeowners

	Visitor versus Aware Comparison		Visitor versus Unaware Comparison	
	Homeowner Group	**Average No. of Correct Responses**	**Homeowner Group**	**Average No. of Correct Responses**
Treatment Group	Visitor (n=164)	1.42	Visitor (n=164)	1.42
Comparison Group	Aware (n=190)	1.29	Unaware (n=234)	1.14
Difference (Evidence of impact after accounting for predispositions)		0.13		0.28

[36] The knowledge percentage differences are relative to the specified comparison group. All other outcome percentage differences presented in this report are absolute.

In addition to these posttest-only and similar-group impact measures of the potential impact of the Solar Decathlon on Visitors' knowledge of solar-powered houses, the evaluation asked Visitor Homeowners to state whether they agree, disagree, or neither agree nor disagree with a pair of questions related to the educational objective:

- *The Solar Decathlon helped me gain a better understanding of homes that use solar energy than I had before.*
- *The Solar Decathlon helped me gain a better understanding of how a home can be made more energy efficient than I had before.*

Figures 5 and 6 show Visitor Homeowners' overwhelming agreement that they learned more about solar-powered and energy-efficient houses than they knew before they visited. Eighty-eight percent (88%) of the Visitor Homeowners reported that the Solar Decathlon gave them better understanding of the use of solar energy in homes, while 91% claimed they gained a better understanding of how homes can be made more energy efficient. Even if they started with more knowledge of solar-powered and energy-efficient houses because they were predisposed to learn about them, their self-reported findings suggest that the Solar Decathlon raised its visitors' knowledge of solar-powered and energy-efficient houses above what it would have been if there were no Solar Decathlon.

Figure 5: The Solar Decathlon gave me a better understanding of homes that use solar energy than I had before*

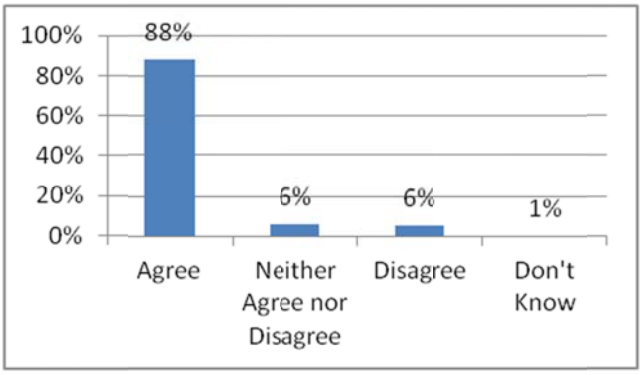
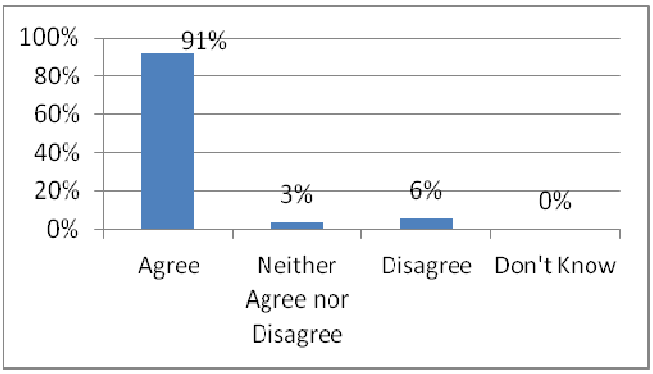


Figure 6: The Solar Decathlon helped me gain a better understanding of how a home can be made more energy efficient than I had before*



*Note: n for these charts = 198.

The findings from Table 21 and Figures 5 and 6 provide strong evidence that the Solar Decathlon has been achieving its objective of educating visiting homeowners about the benefits of solar-powered, energy-efficient houses.

3.3.2 Impact of the Media and Word-of-mouth Alone on Knowledge of Residential Solar Energy Systems and Energy-efficient Products

The evaluation also examined the effect of media and word-of-mouth on the knowledge of homeowners who did not visit a Solar Decathlon. This section reports the posttest-only and similar-group impact findings developed from the open-ended questions described at the beginning of Section 3.3.1 (i.e., describe how *houses that collect energy from the sun for electricity or heating are different from houses that do not collect energy from the sun for electricity or heating).*[37]

The posttest-only impact findings in Table 22 indicate that Aware Homeowners may have greater knowledge of solar-powered houses and energy efficiency in such houses than Unaware Homeowners. Aware Homeowners could correctly identify 16% more (0.17/1.04) differences than Unaware Homeowners. After accounting for the potential impact of predispositions, Aware Homeowners could correctly identify 13% more (0.15/1.14) differences than homeowners unaware of the Solar Decathlon.

Table 22: Impact of Media and Word-of-mouth Alone on Homeowner Knowledge of the Differences between Solar-powered Houses and Other Houses

Posttest-only Impacts Using the Full Homeowner Data

	Homeowner Group	Average No. of Correct Responses
Treatment Group	Aware (n=280)	1.21
Comparison Group	Unaware (n=401)	1.04
Difference (Evidence of potential impact)		0.17
Statistically Significant?		Yes *p<0.004*

Similar-group Impacts Using the Subset of Similar Homeowners

	Homeowner Group	Average Number of Correct Reponses
Treatment Group	Aware (n=190)	1.29
Comparison Group	Unaware (n=235)	1.14
Difference (Evidence of potential impact after accounting for predispositions)		0.15

[37] As noted earlier, the homeowners were encouraged to supply all differences that they could think of, including differences in the use of energy efficiency in houses.

3.4 Findings Relevant to the Homeowner Objectives—Conclusions

The evaluation considered three sources of quantitative information to develop a conclusion regarding the Solar Decathlon's success in meeting its objectives for homeowners.

1. The first source consisted of posttest-only measurements on Solar Decathlon outcomes. This research provided evidence of the Solar Decathlon's potential success but could not, by itself, support a conclusion of success because a posttest-only research design is not able to account for other possible explanations of the observed impacts.
2. A potentially strong rival explanation consists of homeowners' predispositions to satisfy the Solar Decathlon's objectives. Lacking pre-Solar Decathlon homeowner measurements on predispositions, the second source was developed from subsets consisting of (1) Visitor and Aware Homeowners and (2) Visitor and Unaware Homeowners who were similar on their self-reported predispositions to favor the Solar Decathlon's objectives. The impact results from these similar-group subsets at least partially accounted for some of the effect of predispositions, leaving only the effects of the Solar Decathlon (and possibly other unknown and unaccounted-for characteristics) in the impact results.
3. Finally, Visitor Homeowners provided self-reported ratings of the Solar Decathlon's influence on selected activities representing the Solar Decathlon's objectives.

The evaluation's conclusion on the Solar Decathlon's success in achieving its homeowner objectives is based on a qualitative evaluation of the quantitative findings from these three sources of information. Tables 23 and 24, on the following pages, summarize these quantitative findings. The findings are presented for the two types of treatment considered—for a visit (Table 23) and for learning about the Solar Decathlon from the media or word-of-mouth alone (Table 24).[38] The tables include a judgment of each quantitative finding's contribution to the evaluation of the Solar Decathlon's success in achieving its homeowner objectives. The following defines the types of judgments offered:

- Supports: The quantitative findings on the outcome support a finding that the Solar Decathlon has satisfied the associated objective.
- Inconclusive: The quantitative findings on the outcome are inconclusive with respect to a finding that the Solar Decathlon has satisfied the associated objective. The reasons for such an evaluation are referenced with the finding.
- N.A.: This notation is found in the column describing the amount of the posttest-only impacts that were accounted for by predispositions as calculated by subtracting the similar-group findings from the posttest-only findings. It is provided for information only and does not contribute to a judgment of the Solar Decathlon's success in achieving its homeowner objectives.

[38] Tables 23 and 24 omit outcomes included in this report that were not used as indicators of success or failure on the objectives (e.g., installations of residential solar energy systems by Visitor and Aware Homeowners).

Table 23: Findings of Potential Impacts on Homeowner End-users from a Visit to a Solar Decathlon (SD) (Visitor Homeowners) as Measures of Success in Achieving the Solar Decathlon's Objectives
(Evaluative judgments: "Supports" = supports achievement of objective; "Inconclusive" = is inconclusive regarding achievement of the objective; "N.A." = not applicable for judgment)

Solar Decathlon's Objectives	Outcomes Representing Objectives	Comparison Groups Measured on Same Outcome	Posttest-only Impacts on Outcomes Not Accounting for Rival Explanations	Potential SD Impacts after Accounting for Predispositions as a Rival Explanation	Amount of Posttest-only Impacts Potentially Accounted for by Predispositions	Self-reported Influence of the SD on the Visitors' Decisions to Take the Specified Action
1. Demonstrate to the public the opportunities presented by cost-effective houses that combine energy-efficient construction and appliances with renewable energy systems that are available today	Percent of Visitor Homeowners that *considered installing a solar energy system on their houses* compared to–	Unaware Homeowners	+27% Supports	+22% Supports	+5% N.A.	Visitor Homeowners' self-reports of Solar Decathlon influence were not measured on this outcome.
		Aware Homeowners (no visit)	+11% Supports	+10% Supports	+1% N.A.	
	Percent of Visitor Homeowners that *actually gathered solar energy system cost information for their house* compared to—	Unaware Homeowners	+16% Supports	+13% Supports	+3% N.A.	Visitor Homeowners' self-reports of Solar Decathlon influence were not measured on this outcome.
		Aware Homeowners (no visit)	+12% Supports	+12% Supports	0% N.A.	

NOTE: Italicized text refers to quotes from questionnaires

(Continued)

Solar Decathlon's Objectives	Outcomes Representing Objectives	Comparison Groups Measured on Same Outcome	Posttest-only Impacts on Outcomes Not Accounting for Rival Explanations	Potential SD Impacts after Accounting for Predispositions as a Rival Explanation	Amount of Posttest-only Impacts Potentially Accounted for by Predispositions	Self-reported Influence of the SD on the Visitors' Decisions to Take the Specified Action
1. (Continued) Demonstrate to the public the opportunities presented by cost-effective houses that combine energy-efficient construction and appliances with renewable energy systems that are available today	Percent of Visitor Homeowners that *installed an energy-efficient appliance* compared to—	Unaware Homeowners	-7% Inconclusive*	-13% Inconclusive*	+6% N.A.	Using a scale of 0 (no influence) to 10 (main influence), purchasing visitors on average credited the SD's influence on their decision at 4.8.
		Aware Homeowners (no visit)	-16% Inconclusive*	-18% Inconclusive*	+2% N.A.	
	Percent of Visitor Homeowners that *installed an energy-efficient lighting product* compared to—	Unaware Homeowners	+11% Supports	+9% Supports	+2% N.A.	Using a scale of 0 (no influence) to 10 (main influence), purchasing visitors on average credited the SD's influence on their decision at 4.9.
		Aware Homeowners (no visit)	-3% Inconclusive**	-5% Inconclusive**	+2% N.A.	
2. Educate the public about the many cost-saving opportunities presented by clean-energy products	Relative percent difference in Visitor Homeowners' ability to *identify differences between a home that uses energy from the sun and one that does not* relative to—	Unaware Homeowners	+35% Supports	+25% Supports	+10% N.A.	88% of the visiting homeowners claimed the SD gave them a better understanding of homes that use solar energy than they had before. 91% claimed the SD gave them a better understanding of how a home can be made more efficient than they had before.
		Aware Homeowners (no visit)	+15% Supports	+10% Supports	+5% N.A.	

* Investigation of potential explanations for these results strongly suggested that the results may have been the effect of a combination of rival explanations. These include, (1) the fact that appliances can last longer than a decade and visitors may already have installed an efficient appliance prior to visiting a Solar Decathlon, (2) the longer comparison period that was allowed to non-visitors (giving them more time to install an appliance than visitors had), (3) choice of benchmark dates and recall error, and (4) a measurement-design issue. These interpretations, in combination with the self-reported results, suggest that a visit to the Solar Decathlon could actually have had a positive impact on installations of efficient appliances. For these reasons, and the fact that the post-test-only findings are not significant statistically, the findings are judged to be inconclusive. Section 3.2.1 describes these rival explanations in more detail.

* The posttest-only findings are not significant statistically.

Table 24: Findings of Potential Impacts on Homeowner End Users from Learning about the Solar Decathlon (SD) only by Media or Word-of-Mouth (Aware Homeowners) as Measures of Success in Achieving Objectives
(Evaluative judgments: "Supports" = supports achievement of objective; "Inconclusive" = is inconclusive regarding achievement of the objective; "N.A." = not applicable for judgment)

Solar Decathlon's Objectives	Outcomes Representing Objectives	Comparison Group Measured on Same Outcome	Posttest-only Impacts on Outcomes Not Accounting for Rival Explanations	Potential SD Impacts after Accounting for Predispositions as a Rival Explanation	Amount of Posttest-only Impacts Potentially Accounted for by Predispositions	Self-reported Influence of the SD on the Aware Homeowners' Decisions to Take the Specified Action
1. Demonstrate to the public the opportunities presented by cost-effective houses that combine energy-efficient construction and appliances with renewable energy systems that are available today	Percent of Aware Homeowners that *considered installing a solar energy system on their house* compared to—	Unaware Homeowners	+16% Supports	+12% Supports	+4% N.A.	Aware Homeowners' self-reports of Solar Decathlon influence were not measured on this outcome.
	Percent of Visitor Homeowners that *actually gathered solar energy system cost information for their house* compared to—	Unaware Homeowners	+4% Supports	+1% Supports	+3% N.A.	Aware Homeowners' self-reports of Solar Decathlon influence were not measured on this outcome.
	Percent of Visitor Homeowners that *installed an energy-efficient appliance* compared to—.	Unaware Homeowners	+9% Supports	+5% Supports	+4% N.A.	Aware Homeowners' self-reports of Solar Decathlon influence were not measured on this outcome.
	Percent of Visitor Homeowners that *installed an energy-efficient lighting product* compared to—	Unaware Homeowners	+14% Supports	+14% Supports	0% N.A.	Aware Homeowners' self-reports of Solar Decathlon influence were not measured on this outcome.

(Continued)

Solar Decathlon's Objectives	Outcomes Representing Objectives	Comparison Group Measured on Same Outcome	Posttest-only Impacts on Outcomes Not Accounting for Rival Explanations	Potential SD Impacts after Accounting for Predispositions as a Rival Explanation	Amount of Posttest-only Impacts Potentially Accounted for by Predispositions	Self-reported Influence of the SD on the Aware Homeowners' Decisions to Take the Specified Action
2. Educate the public about the many cost-saving opportunities presented by clean-energy products	Relative percent difference in Visitor Homeowners' ability to *identify differences between a home that uses energy from the sun and one that does not* relative to—	Unaware Homeowners	+16% Supports	+13% Supports	+3% N.A.	Aware Homeowners' self-reports of Solar Decathlon influence were not measured on this outcome.

NOTE: Italicized text refers to quotes from questionnaires.

Table 25 summarizes the findings on the homeowner objectives from Tables 23 and 24. The evaluation's conclusion on the Solar Decathlon's success in achieving its homeowner objectives is based on a qualitative consideration of the quantitative results summarized in Table 25.

Table 25: Summary of Quantitative Findings on the Solar Decathlon's Homeowner Objectives

Findings on the Solar Decathlon's Homeowner Awareness-of-Solar-System-Opportunities Objective	
Treatment and Comparison Scenarios	**Summary of Quantitative Findings**
Visit versus the no-Solar-Decathlon scenario (Visitor Homeowners versus Unaware Homeowners)	• 4 of 4 outcome comparison impacts support successful achievement of the Solar Decathlon's solar energy systems objective
Visit versus exposure to media or word-of-mouth alone (Visitor Homeowners versus Aware Homeowners)	• 4 of 4 outcome comparison impacts support successful achievement of the Solar Decathlon's solar energy systems objective
Exposure to media or word-of-mouth alone versus the no-Solar Decathlon scenario (Aware Homeowners versus Unaware Homeowners)	• 4 of 4 outcome comparison impacts support successful achievement of the Solar Decathlon's solar energy systems objective
Summary of findings for the Solar Decathlon's solar energy systems objective	• 12 of 12 outcome comparison impacts support successful achievement of the Solar Decathlon's solar energy systems objective
Findings on the Solar Decathlon's Homeowner Awareness-of-Efficient-Product-Opportunities Objective	
Treatment and Comparison Scenarios	**Summary of Quantitative Findings**
Visit versus the no-Solar-Decathlon scenario (Visitor Homeowners versus Unaware Homeowners plus Visitor Homeowner self-report)	• 2 of 4 outcome comparison impacts support successful achievement of the Solar Decathlon's efficient products objective for lighting • 2 of 4 outcome comparison impacts are inconclusive for efficient appliances • 2 of 2 outcome self-report impacts support successful achievement of the Solar Decathlon's efficient products objective for lighting and appliances
Visit versus exposure to media or word-of-mouth alone (Visitor Homeowners versus Aware Homeowners)	• 2 of 2 outcome comparison impacts are inconclusive with respect to successful achievement of the Solar Decathlon's efficient products objective for lighting • 2 of 2 outcome comparison impacts are inconclusive for efficient appliances

(Continued)

Exposure to media or word-of-mouth alone versus the no-Solar Decathlon scenario (Aware Homeowners versus Unaware Homeowners)	• 4 of 4 outcome impacts support successful achievement of the Solar Decathlon's efficient products objective for lighting and appliances
Summary of findings for the Solar Decathlon's efficient products objective	• 8 of 14 outcome impacts support successful achievement of the Solar Decathlon's efficient products objective • 2 of 14 are inconclusive with respect to the lighting objective • 2 of 14 are inconclusive for the appliances objective
Findings on the Solar Decathlon's Homeowner Education Objective	
Treatment and Comparison	**Summary of Quantitative Findings**
Visit versus the no-Solar-Decathlon scenario (Visitor Homeowners versus Unaware Homeowners plus Visitor Homeowner self-report)	• 2 of 2 outcome comparison impacts support successful achievement of the Solar Decathlon's education objectives • 2 of 2 outcome self-report impacts support successful achievement of the Solar Decathlon's education objectives
Visit versus exposure to media or word-of-mouth alone (Visitor Homeowners versus Aware Homeowners)	• 2 of 2 outcome comparison impacts support successful achievement of the Solar Decathlon's education objectives
Exposure to media or word-of-mouth alone versus the no-Solar Decathlon scenario (Aware Homeowners versus Unaware Homeowners)	• 2 of 2 outcome comparison impacts support successful achievement of the Solar Decathlon's education objectives
Summary of findings for the Solar Decathlon's education objectives	• 8 of 8 outcome impacts support successful achievement of the Solar Decathlon's education objectives

Table 25 shows that a preponderance of the findings developed from the three sources of evidence point to a judgment that the Solar Decathlon's has been successfully achieving its homeowner objectives of increasing awareness of the opportunities in residential solar energy systems and educating homeowners to the opportunities inherent in solar-powered houses and efficient products. These conclusions apply whether the exposure to a Solar Decathlon occurs through a visit or through the media or word-of-mouth only.

The evidence with respect to increasing awareness of the opportunities in efficient appliances is mixed. The visitor self-reported evidence supports a judgment that the Solar Decathlon has successfully achieved its objective of demonstrating the opportunities in efficient appliances but the posttest-only and similar-group comparisons do not. The negative findings for efficient

appliances required an exploration of possible rival explanations. The resulting investigation pointed to several possible explanations, none of which involved the Solar Decathlon. As a result of this investigation and the fact that the negative findings were not statistically significant, the evaluation judged that the posttest-only and similar-group findings for efficient appliances were inconclusive. The evaluation used this finding and the positive visitor self-reported findings to conclude that the Solar Decathlon probably did influence homeowners' decision-making for efficient appliances but that the evidence is not preponderant.

The evidence supporting success of the Solar Decathlon in demonstrating the opportunities in efficient lighting indicates that the Solar Decathlon has been successful relative to what would have occurred had there been no Solar Decathlon.

The evaluation of the Solar Decathlon's success in achieving its homeowner objectives concludes the following:

- The Solar Decathlon has met its objectives in demonstrating the opportunities available in efficient lighting;
- The Solar Decathlon's success in building awareness of the opportunities in efficient appliances is inconclusive; and
- The Solar Decathlon is achieving its homeowner objectives for building awareness of the opportunities in residential solar energy systems and in educating homeowners to the cost-savings and other opportunities in solar-powered houses.

4. Findings Relevant to the Participating-student Objectives

This section reports the Solar Decathlon impacts, with respect to its objectives, on university and college students who participated in a Solar Decathlon. The Solar Decathlon has two objectives with respect to these students:

1. Educate student participants about the many cost-saving opportunities presented by clean-energy products; and
2. Provide participating students with unique training that prepares them to enter the nation's clean-energy workforce.

The findings on these objectives are described in subsections covering:

- Education about opportunities presented by clean-energy products (Section 4.1); and
- Preparation of Decathletes to enter the clean-energy workforce (Section 4.2).

A summary of the Solar Decathlon's quantitative findings on the outcomes that were used to measure the objectives appears in Section 4.4. The summary provides a side-by-side comparison of the posttest-only findings, the findings after accounting for predispositions, and the self-reported findings. Taken together, the results provide evidence that the Solar Decathlon has been successfully achieving its objectives of educating participating students and preparing them to enter the nation's clean-energy workforce.

4.1 Education Findings Related to the Opportunities Presented by Clean-energy Products

One of the Solar Decathlon's objectives for participating-students is to educate student participants about the many cost-saving opportunities presented by clean-energy products. The evaluation assessed education using two types of questions about clean energy.

- For Former Decathletes and Non-decathlete Students: The evaluation presented the Former Decathletes and Non-decathlete Students the same battery of eight true-false questions regarding the costs and other features of solar-powered houses and energy-efficient products. The questions included "opportunities" beyond those that save costs. The two groups were compared on the average percentages of the questions they answered correctly.[39]

[39] The eight questions may be found in Appendix E.2 starting at question 29 for Former Decathletes and Appendix E.3 starting at question 26A for Non-decathlete former college students. An addendum to Appendix E.2 contains the correct answers to the questions.

- For Former Decathletes: Former Decathletes were asked how much more they learned about using solar energy and energy efficiency in residential housing from their Solar Decathlon experience compared to what they would have learned taking their regular college courses.

The following two sections report the results on these questions. Together, the findings indicate that the Solar Decathlon has had a major impact on the education of its participating students about the many opportunities presented by clean-energy products.

4.1.1 Comparative Knowledge

The evaluation asked Former Decathletes and Non-decathlete Students the same battery of eight true-false questions. The questions covered costs, construction features, and electricity usage characteristics of solar-powered houses and efficient appliances and lighting. The Former Decathletes and Non-decathlete Students were compared on the average proportions of the questions that they answered correctly. Appendices E.2 and E.3 contain the Former-Decathlete and Non-decathlete Student questionnaires.

Former Decathletes have better knowledge of the opportunities for cost-savings and other beneficial features of solar-powered houses and energy efficiency than Non-decathlete Students from the same college cohort and academic disciplines. The posttest-only results show that Former Decathletes answered an average of 90% of the questions correctly. That is 11% higher than the proportion answered correctly by the Non-decathlete Students. The similar-group findings show a slightly smaller impact but one that still indicates the greater knowledge of the Former Decathletes. Table 26 presents these findings.

Table 26: Impact of the Solar Decathlon on Knowledge of Cost-saving and Other Opportunities Presented by Clean-energy Products—Average Group Percentages of Correct Answers to True-False Questions

Posttest-only Impact Using the Full Dataset

	Group	Average Percent of Correct Answers
Treatment Group	Former Decathletes (n=160)	90%
Comparison Group	Non-decathlete Students (n=110)	79%
Difference (Evidence of potential impact)		11%

(The comparison of similar groups is on the next page)

Similar-group Impact Using the Dataset of Similar Decathletes and Non-decathlete Students

	Group	Average Percent of Correct Answers
Treatment Group	Former Decathletes (n=69)	91%
Comparison Group	Non-decathlete Students (n=49)	81%
Difference (Evidence of impact after accounting for predispositions)		10%

4.1.2 Learning from the Solar Decathlon Compared to Regular Coursework

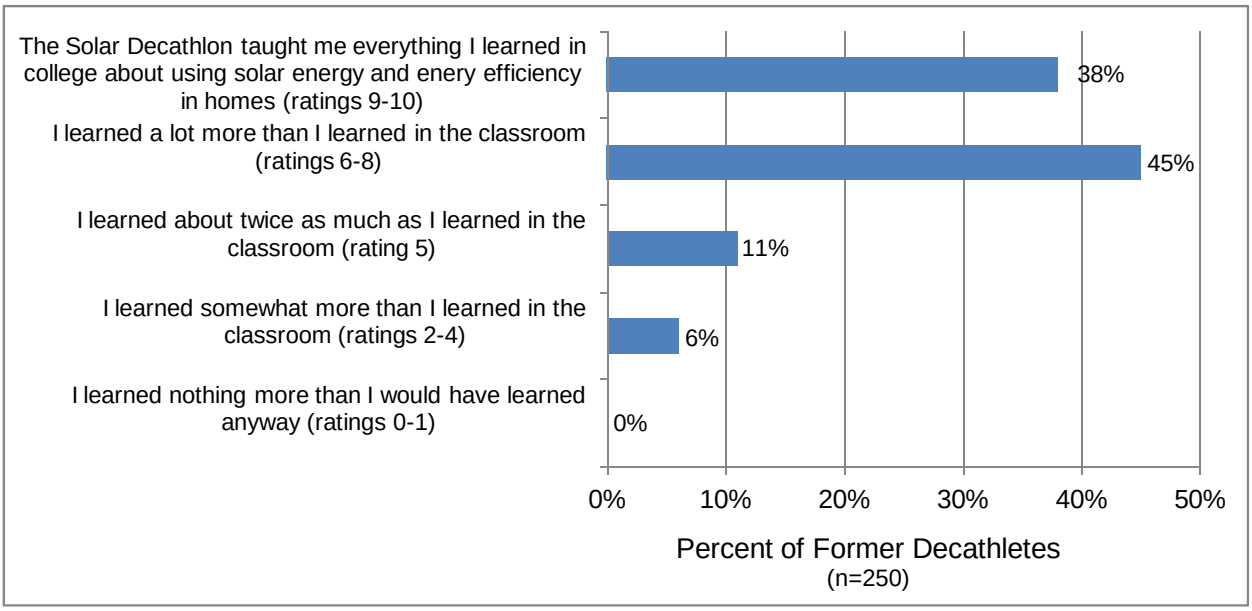
For the third source of evidence on the Former Decathletes' education objective, all of the Former Decathletes were asked to rate, on a scale of 0 to 10, *how much more you learned about using solar energy and energy efficiency for homes from your Solar Decathlon experience than you would have learned just from taking your regular college courses?*

A rating of 0 meant they learned nothing more than they would have learned anyway, 5 meant the Solar Decathlon experience taught them about twice as much as they would have learned otherwise, and 10 meant that their Solar Decathlon experience taught them everything that they learned in college about using solar energy and energy efficiency in houses.

Figure 7, on the following page, presents the results from the 250 decathletes who answered this question. It includes the responses of the 2011 decathletes. Ninety-four percent (38%+45%) of the Former Decathletes recognized that they learned more about using solar energy and energy efficiency in residential housing design, construction, and operation from their participation in the Solar Decathlon than they would have from their regular classrooms.[40]

[40] These findings do *not* mean that classroom training in solar-energy subjects in colleges and universities is inadequate. The solar houses could not have been designed without strong, successful classroom training in the relevant engineering, architecture, and ecological subjects. However, there are many college majors that would not normally provide education in solar-house design, but are needed for the Solar Decathlon competition. Examples include marketing, interior design, and business management. Students taking these majors would have gotten most of what they learned in college about solar houses from their Solar Decathlon experience. Further, practical construction and project management skills may not be included in many relevant college majors, but are required for the Solar Decathlon. Several participating-students commented on the value they received from the Solar Decathlon in these skills (see Appendix C).

Figure 7: Opinions of Former Decathletes on How Much More They Learned about Using Solar Energy and Energy Efficiency in Home Design from Their Solar Decathlon Experience Compared to Their Classroom Experiences



4.2 Preparation of Decathletes to Enter the Clean-energy Workforce

The second Solar Decathlon objective for participating students consists of providing them with unique training that prepares them to enter our nation's clean-energy workforce. As with other outcome measures used for this evaluation, preparation to enter the workforce was measured by actions that preparation might produce. The actions include education choices, career choices, and personal roles in clean-energy choices. The following findings are reported:

- Percentage of Former Decathletes that changed their college majors after participating in a Solar Decathlon;
- Percentage of Former Decathletes and Non-decathlete Students who have worked in the clean-energy field since leaving college;
- Percentage of Former Decathletes and Non-decathlete Students who started a business in the clean-energy field;
- Former Decathletes' self-rated influence of the Solar Decathlon on getting a job in the clean-energy workforce;
- Percentage of Former Decathletes and Non-decathlete Students who claimed they influenced clean-energy installations; and
- Degree of credit that Former Decathletes give to their Solar Decathlon experience for their ability to influence clean-energy installations.

Together, the findings on these outcomes provide evidence that the Solar Decathlon has had a major impact on the preparation of decathletes to enter the nation's clean-energy workforce.

4.2.1 Changing to a Major Related to Clean Energy

The Former Decathletes were asked what major they were taking when they participated in a Solar Decathlon. Most of the decathletes (94%) were enrolled in college majors that could broadly be related to the clean-energy industry. However, in response to a follow-on self-report question, 16% reported that they had changed their major to one that more specifically prepared them for a career in the clean-energy industry. This indicates a conversion from original career goals to preparation for future employment in the clean-energy industry.

4.2.2 Career Choices

The evaluation asked Former Decathletes and Non-decathlete Students whether they *have been employed in work involving the design, manufacture, sales, installation, research, or use in buildings of renewable energy or energy-efficient products since leaving college?*

A little over three quarters (76%) of the Former Decathletes, or five times as many as Non-decathlete Students, reported that they had been employed in the clean-energy workforce since they left their college studies. Table 27 presents the posttest-only and similar-group results from this question.

Table 27: Impact of the Solar Decathlon on Employment in the Clean-energy Workforce—Percent of Former Decathletes and Non-decathlete Students Who Have Worked in the Clean-energy Field since Leaving College

Posttest-only Impact Using the Full Dataset

	Group	Percent Having Worked in the Clean-energy Field
Treatment Group	Former Decathletes (n=160)	76%
Comparison Group	Non-decathlete Students (n=110)	15%
Difference (Evidence of potential impact)		61%

(Comparison of similar former students is on the next page.)

Similar-group Impact Using the Dataset of Similar Decathletes and Non-decathlete Students

	Group	Percent Having Worked in the Clean-energy Field
Treatment Group	Former Decathletes (n=69)	87%
Comparison Group	Non-decathlete Students (n=49)	18%
Difference (Evidence of impact after accounting for predispositions)		69%

The difference between the groups increased after accounting for predispositions. This finding for the similar-group analysis suggests that accounting for predispositions "uncovered" more of the effects of the Solar Decathlon or of another influence not accounted for. This result may be due to an interaction of predispositions with another variable not included in the analysis, social-responsibility-response errors, or to a characteristic of the cluster analysis algorithm used. Both analyses, however, suggest a highly positive impact by the Solar Decathlon on employment in the clean-energy field.

Sixteen percent (16%) of the Former Decathletes reported having started their own business related to the clean-energy field since leaving college. The posttest-only results, shown in Table 28, indicate that this is sixteen times the number of Non-decathlete Students who started a business in the clean-energy field. After accounting for predispositions, the similar-group results show that eight times more Former Decathletes than Non-decathlete Students started a business in the clean-energy field. The data shown in Table 28 supports a finding that the Solar Decathlon is a major contributor to the start-up of new clean-energy enterprises in the United States.

Table 28: Percent of Former Decathletes and Non-decathlete Students Who Have Started a Business Related to Clean Energy since Leaving College

Posttest-only Impact Using the Full Dataset

	Group	Percent Having Started a Clean-energy Business
Treatment Group	Former Decathletes (n=160)	16%
Comparison Group	Non-decathlete Students (n=110)	1%
Difference (Evidence of potential impact)		15%

(Comparison of similar groups is on the next page.)

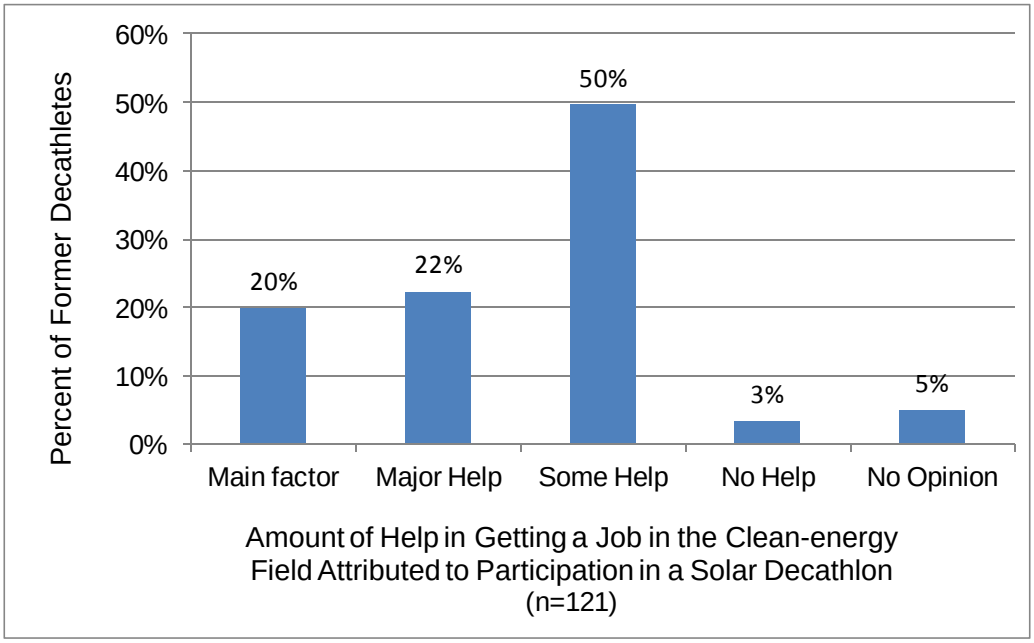
Similar-group Impact Using the Datasets of Similar Decathletes and Non-decathlete Students

	Group	Percent Having Started a Clean-energy Business
Treatment Group	Former Decathletes (n=69)	16%
Comparison Group	Non-decathlete Students (n=49)	2%
Difference (Evidence of impact after accounting for predispositions)		14%

4.2.3 Impact of Participation in a Solar Decathlon on Getting a Job in the Clean-energy Workforce

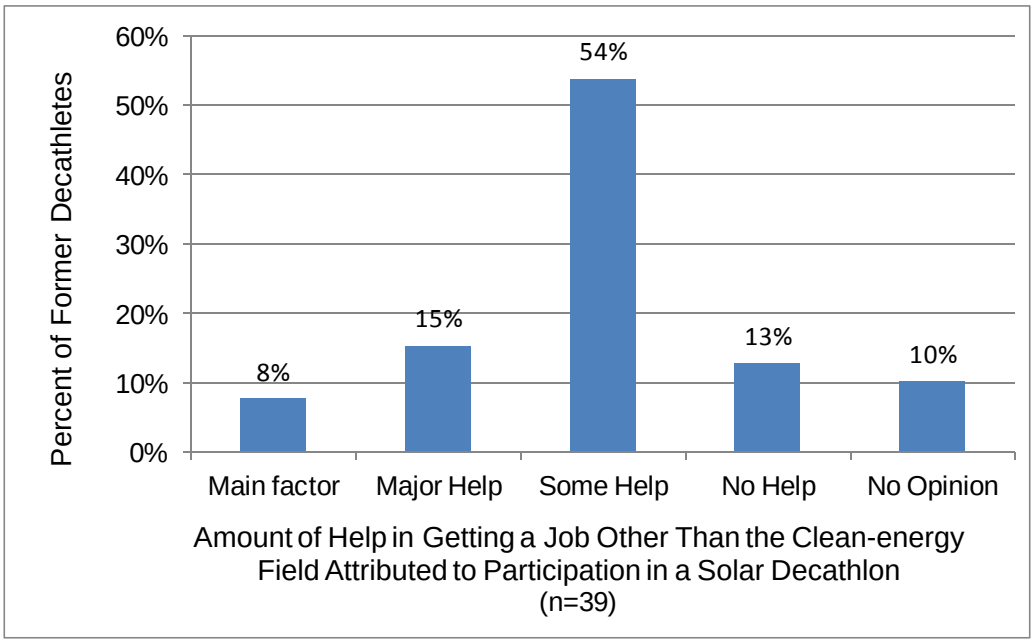
Those Former Decathletes who obtained employment in the clean-energy field after graduation (see Table 27) were asked to rate how much their Solar Decathlon experience helped them get the work. Figure 8 shows their responses. Ninety-two percent (20%+22%+50%) reported that the Solar Decathlon helped them in some way to find a job in the clean-energy workforce. One-fifth (20%) of them said it was the main factor in obtaining employment in the clean-energy field.

Figure 8: Impact of Solar Decathlon on Helping Former Decathletes Obtain a Job in the Clean-energy Field



The Solar Decathlon experience also helped Former Decathletes who did not find work in the clean-energy field gain employment. Figure 9 shows that, of the Former Decathletes who found work in a field other than clean energy, 77% (8%+15%+54%) credit their Solar Decathlon experience with help in obtaining employment.

Figure 9: Impact of Solar Decathlon on Helping Former Decathletes Obtain a Job in a Field Other Than Clean Energy



4.3 Influence of Former Decathletes on Clean-energy Installations

This section first compares Former Decathletes' claims to have influenced someone to install renewable-energy equipment and energy-efficient equipment since participating in a Solar Decathlon to the claims of similar influence made by Non-decathlete Students. It then reports the results of a question asked of the Former Decathletes regarding the degree to which their Solar Decathlon experience helped them exert their influence. The findings show that more Former Decathletes have influenced someone to install renewable-energy and energy-efficient equipment than Non-decathlete Students and that the Former Decathletes heavily credit their Solar Decathlon experience with their ability to exert this influence on clean-energy installations.

Section 4.3.1 reports the findings for installations of renewable-energy equipment. Section 4.3.2 reports the findings for installations of energy-efficient equipment.

4.3.1 Influence on the Installation of Renewable-energy Equipment

The evaluation asked whether the Former Decathletes had personally influenced someone to install renewable-energy equipment since they participated in a Solar Decathlon. The question was also asked of Non-decathlete Students for installations they have influenced since 2000. This question served as a lead-in to a self-report question for the Former Decathletes about the degree to which the Former Decathletes' Solar Decathlon experience had contributed to their ability to exert that influence.

a. Percent Who Have Influenced an Installation of Renewable-energy Equipment

The posttest-only analysis shows that 56% of the Former Decathletes, or almost three times as many as Non-decathlete Students, have helped to convince someone to install renewable-energy equipment on a building or house during the respective comparison periods. Using the similar-group dataset, this impact ratio drops to two-and-a-quarter. Table 29 presents these findings.

Table 29: Impact of the Solar Decathlon on Actions to Influence Someone to Install Renewable-energy Equipment for a Home or Business—Percent of Former Decathletes and Non-decathlete Students Who Have Influenced Someone to Install Renewable-energy Equipment Since Leaving College

Posttest-only Impact Using the Full Dataset

	Group	Percent that Helped Convince Someone to Install Renewable-energy Equipment since Leaving College
Treatment Group	Former Decathletes (n=164)	56%
Comparison Group	Non-decathlete Students (n=110)	20%
Difference (Evidence of potential impact)		36%

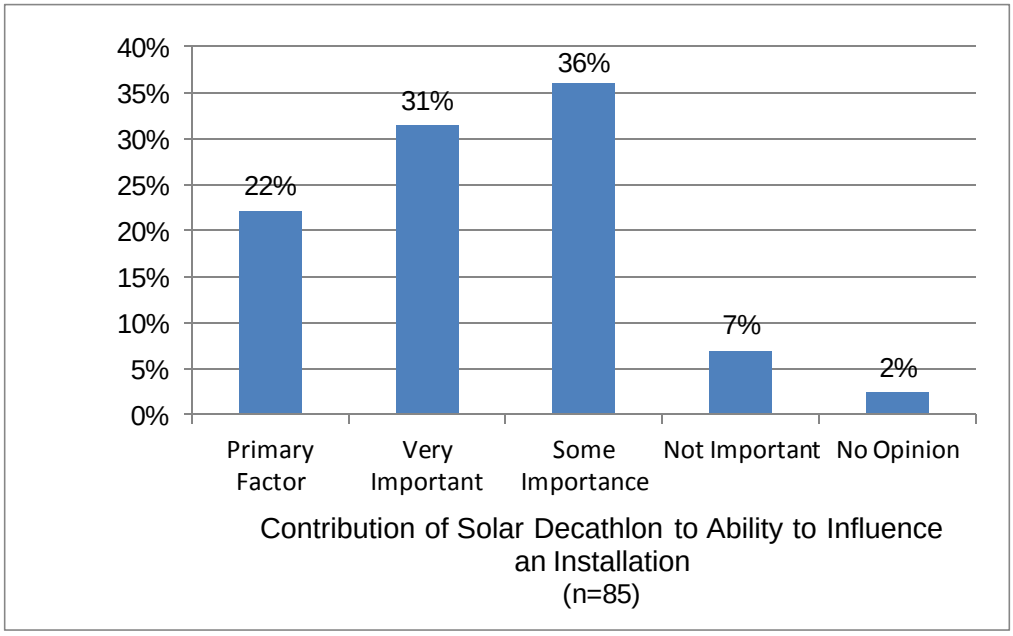
Similar-group Impact Using the Dataset of Similar Decathletes and Non-decathlete Students

	Group	Percent that Helped Convince Someone to Install Renewable-energy Equipment Since Leaving College
Treatment Group	Former Decathletes (n=69)	59%
Comparison Group	Non-decathlete Students (n=49)	27%
Difference (Evidence of impact after accounting for predispositions)		32%

b. Solar Decathlon's Contribution to the Influence Exerted by Former Decathletes

Figure 10 shows that 89% (22%+31%+36%) of the decathletes who have influenced someone to install renewable-energy equipment on their home or a building credit the Solar Decathlon with helping them influence that installation decision. A little over one-fifth of them (22%) claim the Solar Decathlon was the primary factor in their influence. These self-reported results support a finding that the Solar Decathlon is successfully meeting its objective of providing decathletes with training that would help them enter the clean-energy workforce.

Figure 10: Impact of the Solar Decathlon on Former Decathletes' Ability to Influence the Installation of Renewable-energy Equipment



4.3.2 Impact on the Installation of Energy-efficient Equipment

The evaluation asked whether the Former Decathletes had personally influenced someone to install energy-efficient equipment since they participated in a Solar Decathlon. The question was also asked of Non-decathlete Students for installations they have influenced since 2000. This question served as a lead-in to a self-report question for the Former Decathletes about the degree to which the Former Decathletes' Solar Decathlon experience had contributed to their ability to exert that influence.

a. Percent Who Have Influenced an Installation of Energy-efficient Equipment

Compared to Non-decathlete Students, 25% more Former Decathletes have helped to convince someone to install energy-efficient equipment on a building or home. Using the similar-group dataset this impact increases to 34%. Table 30 presents these findings.

Table 30: Impact of the Solar Decathlon on Actions to Influence Someone to Install Energy-efficient Equipment in a Home or Business—Percent of Former Decathletes and Non-decathlete Students Who Have Influenced Someone to Install Energy-efficient Equipment Since Leaving College

Posttest-only Impact Using the Complete Datasets

	Group	Percent that Helped Convince Someone to Install Energy-efficient Equipment Since Leaving College
Treatment Group	Former Decathletes (n=160)	92%
Comparison Group	Non-decathlete Students (n=110)	67%
Difference (Evidence of potential impact)		25%

Similar-group Impact Using the Datasets of Similar Decathletes and Non-decathlete Students

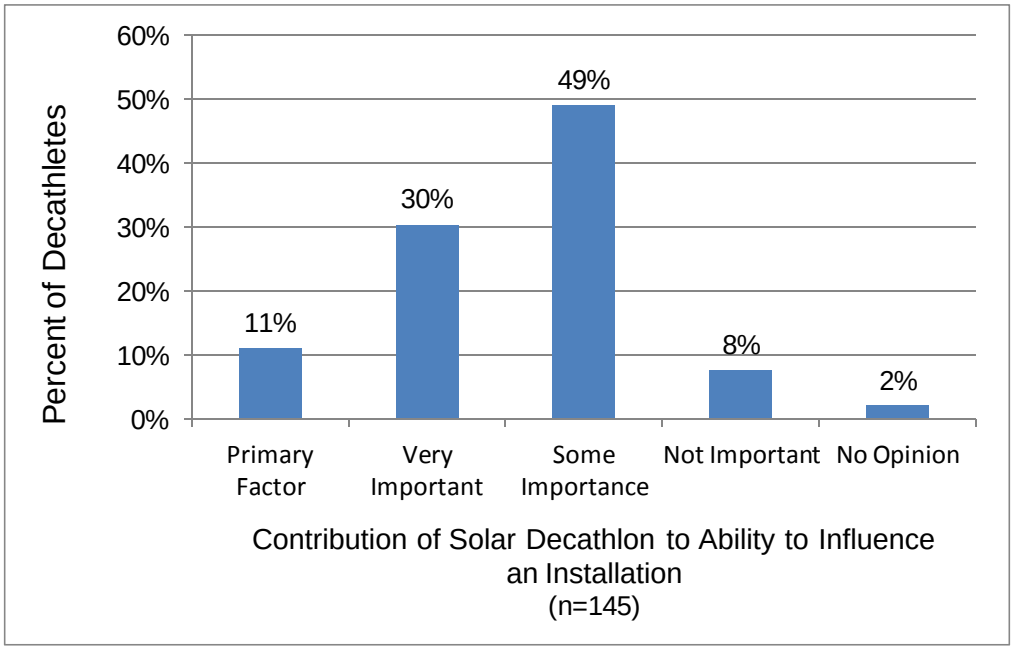
	Group	Percent that Helped Convince Someone to Install Energy-efficient Equipment Since Leaving College
Treatment Group	Former Decathletes (n=69)	97%
Comparison Group	Non-decathlete Students (n=49)	63%
Difference (Evidence of potential impact)		34%

The difference between the groups increased after accounting for predispositions. This finding for the similar-group analysis suggests that accounting for predispositions either "uncovered" more of the effects of the Solar Decathlon or of another influence not accounted for. This result may be due to an interaction of predispositions with another variable not included in the analysis, self-reporting errors, or to a characteristic of the cluster analysis algorithm used. Both analyses, however, suggest a positive impact by the Solar Decathlon on actions to influence someone to install energy-efficient equipment since leaving college.

b. Solar Decathlon's Contribution to the Influence Exerted by Decathletes

Figure 11 shows that 90% (11%+30%+49%) of the decathletes who have influenced someone to install energy-efficient equipment on their house or a building credit their Solar Decathlon experience with helping them influence that installation decision. These self-reported results support a finding that the Solar Decathlon is successfully meeting its objective of providing decathletes with training that will help them enter the clean-energy workforce.

Figure 11: Impact of Solar Decathlon on Ability of Former Decathletes to Influence the Installation of Energy-efficiency Equipment



4.4 Findings Relevant to the Participating-student Objectives—Conclusions

The evaluation considered three sources of quantitative information to develop a conclusion regarding the Solar Decathlon's success in meeting its objectives for participating students:

1. The first source consisted of posttest-only measurements on Solar Decathlon outcomes. This research provided evidence of the Solar Decathlon's potential success but could not, by itself, support a conclusion of success because a posttest-only research design is not able to account for other possible explanations of the observed impacts.
2. A potentially strong rival explanation consists of Former Decathletes' predispositions to satisfy the Solar Decathlon's objectives. Lacking pre-Solar Decathlon homeowner measurements on predispositions, the evaluation used retrospective self-reports of predispositions in a cluster analysis to create subsets consisting of (1) Former Decathletes and (2) Non-decathlete former college students who were similar on their predispositions that

would favor the Solar Decathlon's objectives. The impact results from these similar-group subsets at least partially accounted for the effect of predispositions, leaving only the effects of the Solar Decathlon (and possibly other unknown and unaccounted-for characteristics) in the impact results.

3. Finally, Former Decathletes provided self-reported ratings of the Solar Decathlon's influence on selected activities representing the Solar Decathlon's objectives.

The evaluation's conclusion on the Solar Decathlon's success in achieving its participating student objectives is based on a qualitative evaluation of the quantitative findings from these three sources of information. Table 31, on the following page, summarizes these quantitative findings. The findings are presented for the one type of treatment examined—for participation in a Solar Decathlon as a decathlete. The table includes a judgment of each quantitative finding's contribution to the evaluation of the Solar Decathlon's success in achieving its homeowner objectives. The following defines the types of judgments offered:

- Supports: The quantitative findings on the outcome support a finding that the Solar Decathlon has satisfied the associated objective.
- Inconclusive: The quantitative findings on the outcome are inconclusive with respect to a finding that the Solar Decathlon has satisfied the associated objective. The reasons for such an evaluation are referenced with the finding.
- N.A.: This notation is found in the column describing the amount of the posttest-only impacts that were accounted for by predispositions as calculated by subtracting the similar-group findings from the posttest-only findings. It is provided for information only and does not contribute to a judgment of the Solar Decathlon's success in achieving its homeowner objectives.

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Table 31: Findings of Potential Impacts on Former Decathletes from Participating in a Solar Decathlon (SD) as Measures of Success in Achieving the Solar Decathlon's Objectives

(Evaluative judgments: "Supports" = supports achievement of objective; "Inconclusive" = is inconclusive regarding achievement of the objective; "N.A." = not applicable for judgment)

Solar Decathlon Objectives	Outcomes Representing Objectives	Comparison Groups Measured on Same Outcome	Posttest-only Impacts on Outcomes Not Accounting for Rival Explanations	Potential SD Impacts after Accounting for Predispositions as a Rival Explanation	Amount of Posttest-only Impacts Potentially Accounted for by Predispositions	Self-reported Influence of the SD on the Visitors' Decisions to Take the Specified Action
1. Educate student participants about the many cost-saving opportunities presented by clean-energy products	Average percent of Former Decathletes' correct answers to a battery of *true-false questions on construction costs, construction features, and electricity usage of solar-powered homes and efficient appliances and lighting products* compared to—	Non-decathlete Students from same college cohorts who majored in similar disciplines	+11% Supports	+10% Supports	+1% N.A.	94% of the Former Decathletes reported that they learned more about using solar energy and energy efficiency in home design, construction and operation from participating in the SD than they would have learned in the course of their regular classroom work.
	Percent of Former Decathletes that *changed their major to one related to clean energy after participating in a SD*	N.A.	Not measured using posttest impacts	Not measured using posttest impacts	Not measured using posttest impacts	16% Supports
2. Prepare Former Decathletes to enter the nation's clean energy workforce (Continued on next page)	Percent of Former Decathletes that *have worked in the clean-energy workforce since leaving college* compared to—	Non-decathlete Students from same college cohorts who majored in similar disciplines	+61% Supports	+69%* Supports	-8% N.A.	92% percent of the Former Decathletes that have worked in the clean-energy field since graduation claimed *their SD experience helped them get a job in the clean-energy field*

(Continued)

Solar Decathlon Objectives	Outcomes Representing Objectives	Comparison Groups Measured on Same Outcome	Posttest-only Impacts on Outcomes Not Accounting for Rival Explanations	Potential SD Impacts after Accounting for Predispositions as a Rival Explanation	Amount of Posttest-only Impacts Potentially Accounted for by Predispositions	Self-reported Influence of the SD on the Visitors' Decisions to Take the Specified Action
2.(Continued) Prepare Former Decathletes to enter the nation's clean energy workforce	Percent of Former Decathletes that *started a business in the clean-energy field after graduation* compared to—	Non-decathlete Students from same college cohorts who majored in similar disciplines	+15% Supports	+14% Supports	+1% N.A.	Not measured using self-report
	Percent of Former Decathletes that *have influenced someone to install renewable equipment on a home or business* compared to—	Non-decathlete Students from same college cohorts who majored in similar disciplines	+36% Supports	+32% Supports	+4% N.A.	89% of the Former Decathletes who influenced a renewable-energy installation claimed their SD experience helped them do so.
	Percent of Former Decathletes that *have influenced someone to install energy-efficient equipment in a home or business* compared to—	Non-decathlete Students from same college cohorts who majored in similar disciplines	+25% Supports	+34%* Supports	-9% N.A.	90% of the Former Decathletes who influenced an efficient-equipment installation claimed their SD experience helped them do so.

* The similar-group impacts that are larger than that the posttest-only impacts may be the result of an interaction of predispositions with another variable not included in the analysis, self-reporting errors, or to a characteristic of the subset created by the cluster analysis. They also suggest a positive impact by the Solar Decathlon on employment in the clean-energy field.

NOTE: Italicized text refers to quotes from questionnaires.

Table 32 summarizes the findings on the participating student objectives from Table 31. The evaluation's conclusion on the Solar Decathlon's success in achieving its participating student objectives is based on a qualitative consideration of the quantitative results. Table 32 summarizes these results.

Table 32: Summary of Quantitative Findings on the Solar Decathlon's Participating Student Objectives

Findings on the Solar Decathlon's Participating Student Education Objective	
Treatment and Comparison Scenarios	**Summary of Quantitative Findings**
Participation in a Solar Decathlon versus no-Solar-Decathlon scenario plus self-report (Former Decathletes versus Non-decathlete Student plus Former Decathlete self-report)	• 2 of 2 outcome comparison impacts support successful achievement of the Solar Decathlon's participating student education objective • 2 of 2 outcome self-report impacts support successful achievement of the Solar Decathlon's participating student education objective
Summary of findings for the Solar Decathlon's participating student education objective	• 4 of 4 outcome impacts support successful achievement of the Solar Decathlon's participating student education objective
Findings on the Solar Decathlon's Preparation-to-enter-the-clean-energy-Workforce Objective	
Treatment and Comparison Scenarios	**Summary of Quantitative Findings**
Participation in a Solar Decathlon versus no-Solar-Decathlon scenario plus self-report (Former Decathletes versus Non-decathlete former college student plus Former Decathlete self-report)	• 8 of 8 outcome comparison impacts support successful achievement of the Solar Decathlon's education objectives • 3 of 3 outcome self-report impacts support successful achievement of the Solar Decathlon's education objectives
Summary of findings for the Solar Decathlon's education objectives	• 11 of 11 outcome impacts support successful achievement of the Solar Decathlon's objective of preparing participating students to enter the clean-energy work force

Table 32 shows that a preponderance of the findings developed from the three sources of information point to a judgment that the Solar Decathlon's has been successful on each of its objectives evaluated by this study for the participating student audience.

5. Participating Students' Assessment of Their Solar Decathlon Experience

The evaluation's online survey and a visit by the evaluation team to the 2009 Solar Decathlon gave Former Decathletes an opportunity to offer comments on their experiences and to make suggestions for future Solar Decathlons. Seventy-seven Former Decathletes and four faculty advisors offered open-ended comments in the online survey. The following subsections summarize these comments as (1) comments about the impact of the Solar Decathlon on the Former Decathletes and (2) suggestions for future Solar Decathlons. The latter comments contributed to the suggestions for future Solar Decathlons that are summarized in Section 8 of this report.

The comments from informal in-person interviews with some of the 2009 decathletes follow the comments from the online survey.

5.1 Summary of Former Decathlete Comments from the Online Survey

The tables in the following subsections summarize the highlights of the Former Decathletes' comments. Appendix C lists all of the comments provided in the online survey.

5.1.1 Comments about the Impact of the Solar Decathlon on the Former Decathletes

Table 33, on the following page, summarizes the Former Decathletes' general comments about the impacts the Solar Decathlon has had on them and tabulates the number of times each was offered. These comments were offered through the online survey and include the comments of the 2011 decathletes. Section 5.1.2 summarizes the Former Decathletes' suggestions for future Solar Decathlons.

Table 33: Comments by Former Decathletes Posted to the Online Survey about the Impact the Solar Decathlon Has Had on Them

Topic	Comment	Number Citing in Topic
Appreciation & praise	• Superlative compliments on the experience (see Appendix C for a full set of the remarks)	48
Learning	• Learned about design strategies that reduce building energy usage. • Taught me the importance of integrated design. • Opportunity to interact with different disciplines and work as a team. • Cannot be replicated by classroom work (e.g., taught me more about leadership and project management than I could have gotten in class). • Heavily influenced my education. • Opportunity to get hands-on construction experience.	47
Career influences	• Caused me to pursue a career in solar energy or sustainability. • Helped me get my first job; • Will be the most outstanding item on my resume. • Was the start for many projects we generated in this field • Created career-related bonds. • With other decathletes, I set up a company designing sustainable buildings. • I now have hired staff because they were Former Decathletes. • I met my first home-design client at the Solar Decathlon	7
Leadership	• Never have I experienced such pressure to work so hard together to produce so much. • The SD is crucial to igniting the next generation of the EERE workforce, in line with what the President called for in his 2012 State of the Union address.	2
Influence on school	• It influenced my college to take a serious look at the need for sustainable energy education	1
Miscellaneous	• Now I design simple cycle gas cycle power plants for utilities that need spinning reserve to account for the wind they are building.	1

5.1.2 Suggestions for Future Solar Decathlons

Several Former Decathletes offered suggestions for future Solar Decathlons. Many of these suggestions represented the viewpoint of just one of the decathletes and therefore are listed rather than tabulated with frequencies. The single comments stand for consideration by themselves

rather than because of the number of times they were offered. Table 34, on the following page, presents these suggestions categorized into topics.

Table 34: Suggestions for Future Solar Decathlons Posted to the Online Survey by Former Decathletes

Topic	Suggestion
Geographic location	• Move it to other areas where it is accessible to other audiences.
School advisor	• Advisor makes a big difference. Evaluate leadership and project management experience of team advisors.
Safety	• Re-examine onsite safety procedures when working at night. We needed to shut down construction boom lighting at night to avoid penalizing team energy usage, but this creates a safety hazard for night work.
Competition	• Competition needs to be open-minded. Ingenuity comes from thinking outside the box, but is not rewarded in the competition. Rules are confusing to interpret. • The competition should be urban-focused. Nobody lives in villages any longer. • The competition point system leads to questionable scoring. Need to adapt a jury system with more well-defined criteria for deducting points. Would be fairer. • The point structure changed during the two-year period leading up to the first competition. The point instability impacted some of the teams. • Promote sustainability more strongly in the future. Create a sustainability factor whereby teams are judged on the energy embodied in their homes. The homes should be about more than buying solar panels. • Judges should be qualified well enough in the specific area they are judging to be able to recognize and give credit for innovative ideas. • Houses should be designed to be part of a real-world community where their performance can be monitored over time.
Decathlete services	• Need better food services, especially during construction. Make sure the Great Park at Irvine has access to good food services. • Unhappy with the location and shuttle bus service for the 2011 SD. Had to walk to metro station after work hours. Irvine should be better.
Collegiate teams' costs	• Such an effort and cost went into shipping the project and limited the design's market relevance. A consortium of local academic design-build specialists might be as effective and would reduce collegiate teams' costs to ship the houses long distances. • Our team incurred a lot of debt.
DOE – School communications & rules	• Adhere to the announcement dates posted on the DOE website. • Changing the rules that made a community college team with another school was a disservice. • The Solar Decathlon should work more closely with the collegiate teams to get the collegiate teams to support the faculty that are involved in the SD. This will help the students engage faculty advisors.

Topic	Suggestion
Promotion	• Sell Solar Decathlon merchandise during the Solar Decathlon (e.g., T-shirts, water bottles, umbrellas, solar-powered toys). • Audience is limited because houses are sold to private buyers afterward and public can't access them locally.

5.2 Summary of Faculty Advisor Comments from the Online Survey

Several faculty advisors to their school's Solar Decathlon teams also took the opportunity to complete the online survey and offer comments.[41] Table 35 summarizes their open-ended comments and suggestions. Appendix C presents the full set of their comments in a separate section after the Former Decathletes' comments.

Table 35: Faculty Advisor Comments from the Online Survey

Topic	Comment/Suggestion
Geographic location	• It's a great program, please keep up the good work! Even better, put it back on the mall where it is more easily accessible and/or move it around the country to reach out to as much of the American public as possible.
Competition	• As a result of the Solar Decathlon experience, I designed a new home that is a true net-zero solar powered home and is cost competitive with neighboring homes. The primary difficulties to overcome to encourage net-zero-energy are: (1) education and awareness of the cost and performance of solar energy, (2) an improved appraisal process that recognizes value of house efficiency and solar collection system for increased bank mortgages to cover the up-front costs, (3) improved marketing to turn renewable energy from a "like" to a "want." These barriers could be addressed in the competition.
Collegiate teams' costs	• It was an excellent experience. We ran into funding problems, yet we did get to the competition and the students had a unique experience. Overall, this is a wonderful opportunity for the students and is helpful for the general population to reflect upon what can be done today.

5.3 Summary of Informal Discussions with at the 2009 Solar Decathlon

The evaluation team conducted nine informal in-person interviews with decathletes during the 2009 Solar Decathlon.[42] Table 36, on the following page, summarizes the 2009 decathletes general comments and Table 37, on the following page, summarizes their suggestions for future Solar Decathlons.

[41] Their responses were excluded from the analyses of Solar Decathlon impacts.

[42] Nine is the maximum number of interviews using a structured data collection instrument permitted by the Paperwork Reduction Act without OMB approval.

Table 36: General Comments from the 2009 Solar Decathlete

Topic Area	Comments
Communication between DOE and the decathletes	• The communications between DOE and our team were good.
Other	• Allow more time for teams to visit other teams' houses.

Table 37: Suggestions for Future Solar Decathlons from the 2009 Solar Decathletes

Topic Area	Suggestions
Fairness of competition and realism of houses	• The competition is unrealistic in that whoever has the largest budget has the advantage. The program should focus on costs and usability to make the competition and the houses more realistic for visitors. The 2011 Solar Decathlon added an affordability competition criterion to address this. • Add a cost-effectiveness metric to the competition criteria. If you want to sell this type of house, you have to have a reasonable cost. The team with the most solar panels will win the net metering metric. • Put a cap on construction costs to level the competitive playing field. • Put more weight on architectural design. The competition is becoming very engineering-focused which is tending to diminish the contributions of the architects.
Communication between DOE and the decathletes	• Sometimes we got conflicting or last-minute changes. Communication should be improved. • Provide more feedback from subjective juries on point distribution. • The month chosen (October) for the Solar Decathlon is not congruent with school schedules. Mid-terms are held in October at many collegiate teams and students have to juggle the Solar Decathlon and their exams. • Have better outreach to students by DOE to help explain and give an overview of the program to the collegiate teams. Two-hundred students worked on our house, but only a select few (5-10) were involved in pre-planning and meetings with DOE. Causes lack of morale and motivation for teams and lack of communication.
Geographic location	• Do a regional competition in different localities. This would lower costs for some collegiate teams to transport the houses to the competition site.

6. Impact on Solar-related Research

EERE asked that the evaluation inquire whether DOE staff who visited the Solar Decathlons or other Solar Decathlon-related sources have identified any new research ideas for possible pursuit by the DOE Building Technologies Program (Buildings Program) or Solar Energy Technologies Program (Solar Program). This is not one of the Solar Decathlon's stated objectives but is listed as an intermediate outcome on the Solar Decathlon's program logic (Appendix B).

Five members of the DOE Buildings and Solar Programs' staff were interviewed by telephone for this outcome. The staff recognized the impressive creativity of the students as demonstrated in their houses. One noted, however, that no formal mechanism exists to recommend DOE solar research based on innovations observed at the Solar Decathlons. The staff did not report any specific ideas that resulted in funded research, although several were considered for additional research.

The staff offered the following observations on how to apply the entries' creativity to productive use:

- Some of the Solar Decathlon entries appear to use state-of-the-art products and systems. These may have been prototypes that a sponsor is testing. DOE has communicated some of these to renewable-energy contractors working with the Department. They are believed to be commercially available now.
- The entries appear to respond to specific competition criteria in innovative ways that might lead to non-proprietary suggestions that DOE can pass along to renewable-energy contractors with which it is working. The competition criteria might be used to stimulate innovations.

Table 38, on the following page, summarizes the staff observations of advanced residential clean-energy technologies and concepts demonstrated at the Solar Decathlons. It also offers their suggestions for how to increase visitors' awareness of these technologies and concepts.

Table 38: Staff Observations on Advanced Residential End-use Technologies and Concepts Demonstrated at the Solar Decathlons and Suggestions for Increasing Awareness of Them

Topic Area	Observations
Home energy automation	• Some of the entries use state-of-the-art automation systems. The automation products are now commercially available. • One manufacturer may have tested a home energy automation system in a Solar Decathlon entry. This system not only fed-back energy-usage information to the homeowner but also offered suggestions on how to optimize usage. This was a unique piece of energy-management equipment for home use. • Software being developed by the National Renewable Energy Laboratory to model net-zero-energy homes to assist builders to design and offer such homes may have been suggested by builders visiting the Solar Decathlons.
Sustainability	• One year (2009) when sustainability was believed to be a competition criterion, the entries demonstrated novel ways to contribute to sustainability (e.g., growing algae to consume CO_2, bamboo floors)
Residential new construction	• One of the 2005 Solar Decathlon entries demonstrated an interesting desiccant system for solar thermal panels that could potentially reduce construction costs. Most have used higher-cost evacuated tube systems. DOE was unable to get funding for additional research on this topic. • One of the entries demonstrated a photovoltaic/solar-thermal hybrid design. Another demonstrated a new absorption chiller prototype (HW drum). These were considered for research. • Suggestion: Demonstrate through handouts at the Solar Decathlon how solar energy systems may be able to reduce heating and cooling loads. Such load reduction can, in turn, permit a reduced duct size. • Suggestion: Point out to visitors how Photo Voltaic panels can be aesthetically integrated with wall and roof products. Integrates aesthetics with performance. • Suggestion: Some entries demonstrated how to use solar energy systems with the climate characteristics of the school's geographic location. This suggests the Solar Decathlon may be able to use competition criteria to demonstrate to public organizations in the school's region how to create regional policies to promote residential construction incorporating net-zero-energy technologies.

7. Recommendations for Future Solar Decathlons

The findings developed for this evaluation and the interviews conducted produced a number of recommendations for future Solar Decathlons. This section summarizes them in five topic areas:

- Additional information for visitors;
- Geographic location for future Solar Decathlons;
- Competition criteria;
- Promotion of the benefits of net-zero-energy houses; and
- Decathlete services.

7.1 Additional Information for Visitors

The evaluation asked Visitor Homeowners about additional information that would enhance the value of their visit. They were asked whether the following three types of information would be: very important to them, somewhat important to them, not important to them, or don't know if it would be important to them. They were also given an option stating that they already had the information.

1. *Information on how I could find contractors near where I live who install solar panels.*
2. *Websites on the Internet where I could learn more about solar energy and energy efficiency*.
3. *Information on how I could find a store that sells efficient lighting and appliances near where I live*.

Figures 12, 13, and 14 show that two-thirds or more of the visitors (29%+38%; 42%+40%; and 41%+40%) believed that these types of information would be important or somewhat important to them.

Figure 12: How important is information on how I could find contractors near where I live who install solar panels?*

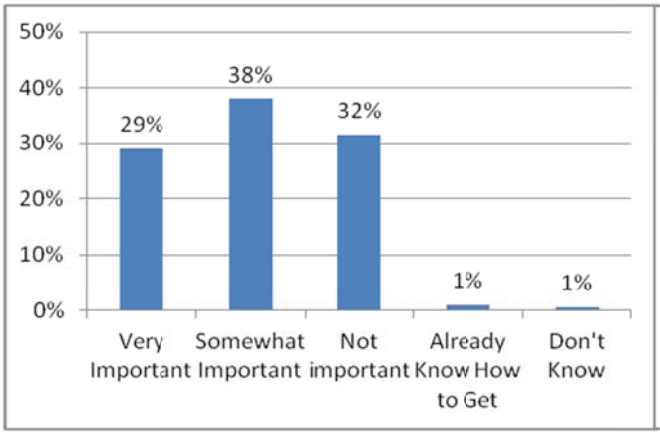
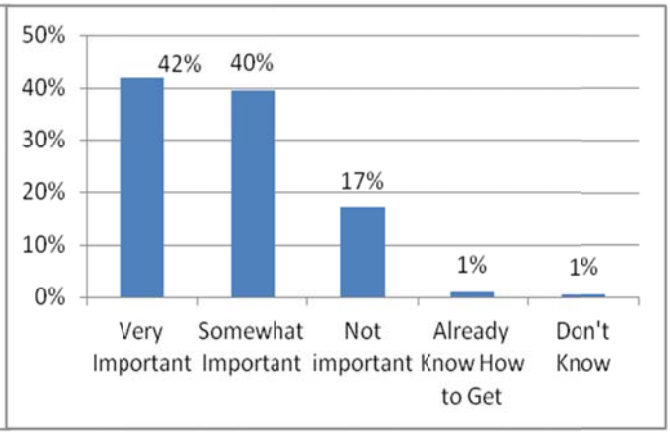
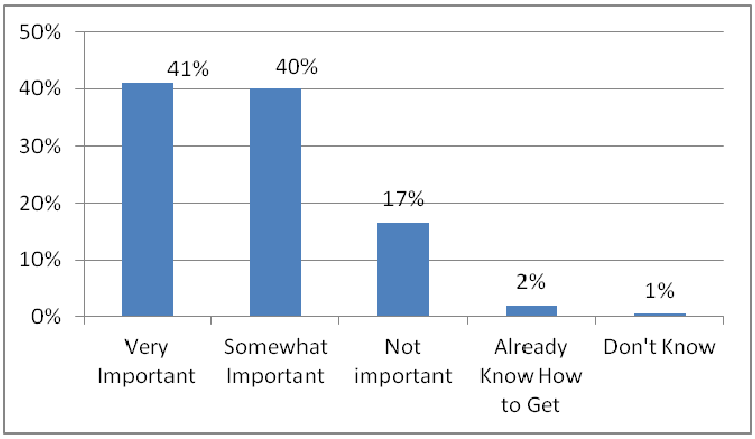


Figure 13: How important are websites where I can learn more about solar energy and energy-efficiency?*





*Note: n for these charts is 200.

7.2 Geographic Location of Future Solar Decathlons

A number of comments were offered suggesting that future Solar Decathlons could benefit from varying the geographic locations at which the Solar Decathlons were held. These suggestions offered the following rationales for rotating the venue:

1. The Solar Decathlon would reach a broader audience. This would enhance the outcomes of its objectives of educating the public about the many cost-saving opportunities presented by clean-energy savings technologies and of demonstrating these opportunities.
2. Varied geographic locations would reduce the transportation costs for some collegiate teams and might bring entry proposals from collegiate teams that currently are reluctant to risk

raising the funds needed for a successful entry. Such entries would serve the Solar Decathlon's objective of providing more student participants with unique training that prepares them to enter the clean-energy workforce.

3. If the competition criteria required demonstration of houses that were cost-effective in the region of the Solar Decathlon, they might attract the attention of more builders, architects, financiers, and homeowners in that region.

7.3 Competition Criteria

The recommendation topic heard most often involved adding a competition criterion for demonstrating cost-effective housing. The competition has a criterion for affordability, but the comments appeared to ask that "affordability" be changed to a cost-effectiveness metric, and that it be applied for the region in which the Solar Decathlon was being held. In view of the variety of these comments, implementing these suggestions might require tradeoffs. The following recommendations are based on these comments:

- Some decathletes commented that no matter where the Solar Decathlon was held, their school would design its house to satisfy cost-effectiveness criteria in its home location. Several pointed out that region-specific criteria (for regions other than that from which the team originates) put these collegiate teams at a disadvantage.
- On the other hand, some decathletes thought a regionally cost-effective home would draw more local attention from both the public and the building trades and financiers. It might result in more net-zero-energy homes being built in the region.
- Based on DOE staff's positive comments about the ingenuity of the students, a focus on cost-effectiveness might discourage innovative thinking about a broader array of engineering and design issues. Some novel ideas will be more expensive at first, and a focus on cost-effectiveness might discourage them.
- Some decathletes wanted more credit given to innovativeness. This may require more highly-qualified jurors.

7.4 Promotion of the Benefits of Net-zero-energy Houses at Solar Decathlons

Several recommendations for future Solar Decathlons imply more proactive promotion of the cost-effectiveness of houses powered by solar energy and equipped with energy-efficient products and systems. The following suggestions are developed from comments appearing in this report:

- Add a criterion on the potential cost-effectiveness of the house. As part of the judged factors for this criterion, require the teams to prepare a short paper describing how their house can be scaled up to a "normal"-sized house for the region in which the house will

be demonstrated. This could be either the location of the Solar Decathlon, or if the house will be permanently displayed in a different location, the latter region.

- Provide handouts illustrating solar-powered houses that have been demonstrated to be cost-effective, with information on the features that produced cost-effectiveness.
- Encourage all school entries to provide handouts describing the benefits of the solar and energy-efficiency features of their houses (e.g., describe the potential cost-savings of the house in the demonstration location).
- Provide handouts on how to choose upgraded residential heating and cooling systems.
- Advertise the visitor workshop tent at more locations throughout the village.
- Sell Solar Decathlon merchandise such as T-shirts, coffee mugs, and caps. These will "travel" farther than handouts. They will promote both the Solar Decathlon and the concepts it demonstrates.
- Maintain a list of the innovative ideas developed by the students and demonstrated at each of the Solar Decathlons. Communicate these ideas to architects, builders, and designers.
- Provide visitors with links to websites where they can (1) learn more about solar energy and energy efficiency, and (2) find contractors near where they live who install solar panels and stores that sell energy-efficient products.

7.5 Decathlete Services

The following recommendations are based on comments by the Former Decathletes:

- Have food services available for decathletes near their building sites, or provide scheduled 24-hour bus transportation to a location where food services are available. This is particularly important during the construction phase of the Solar Decathlon when decathletes may work late.
- Do not include the lighting required to erect the houses in the energy budget of the houses.

8. References

Bickman, L. (ed). 1987. "The Functions of Program Theory." *Using Program Theory in Evaluation, New directions for Program Evaluation*, no. 33. San Francisco: Jossey-Bass. http://onlinelibrary.wiley.com/doi/10.1002/ev.1443/abstract.

Campbell, D. T., and J. C. Stanley. 1963. *Experimental and Quasi-Experimental Designs for Research*. Chicago: Rand McNally.

Cook, T. D., and D. T. Campbell. 1979. *Quasi-Experimentation: Design & Analysis for Field Settings*. Boston: Houghton Mifflin.

Dillman, D.A. 2000. *Mail and Internet Surveys*, 2nd edition. New York: John Wiley & Sons.

Fishbein, M., and I. Ajzen. 1975. *Beliefs, Attitudes and Behavior*. Reading, MA: Addison Wesley.

Greene, J., and C. McClintock. 1985. "Triangulation in Evaluation: Design and Analysis Issues. *Evaluation Review*, v9, no. 5. (October): 523-45.

Janda, K. 2006. "The Eleventh Event: Public Perceptions of the Solar Decathlon." Paper presented at the American Solar Energy Society Annual Conference, (July 12). *Proceedings of the 35th American Solar Energy Society Annual Conference*.

Opinion Dynamics. 2011. "Reconsidering What We Measure: A White Paper." Prepared for Southern California Edison and Pacific Gas and Electric, 2011. http://www.calmac.org.

Rogers, E. M. 2003. *Diffusion of Innovations*, 5th edition. New York: Free Press.

TecMarket Works Team. 2006. "California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals." Prepared for the State of California Public Utilities Commission. (April).
These protocols are the result of an extensive investigation of the issues associated with evaluating energy-related programs. They have been widely accepted within the state and utility evaluation industry.

TecMarket Works Framework Team. 2004. "The California Evaluation Framework." Prepared for Southern California Edison Company (June 2004): 103-104 and 135-144. http://www.calmac.org/publications/California_Evaluation_Framework_June_2004.pdf.

West Hill Energy & Computing. 2003. "Vermont Residential New Construction 2002: Baseline Construction Practices, Cole Compliance, and Energy Efficiency." Prepared for the Vermont Department of Public Service (January 2). http://www.cee1.org/eval/db_pdf/368.pdf.

Appendices
to the
Impact Evaluation of the
U.S. Department of Energy's
Solar Decathlon Program

December 2012

Appendix A: Methodology

Evaluation Research Design

Program Circumstances

The following program circumstances governed the selection of an evaluation research design for the Solar Decathlon impact evaluation:

- The Department of Energy (DOE) has conducted five Solar Decathlons. The first took place in 2002; after that in 2005. After 2005, DOE conducted subsequent Solar Decathlons biennially. The most recent Solar Decathlon was conducted in 2011.
- The Solar Decathlons included in this evaluation have started during the last week of September or first week of October and have run for two to three weeks.
- All of the Solar Decathlons included in this evaluation have been conducted in Washington, D.C. The first four were conducted on the National Mall. The 2011 Solar Decathlon was held at the National Mall's West Potomac Park. All Solar Decathlons have been open to the public.
- DOE has not collected information on the number of visitors to the Solar Decathlons or their names. The Program's rough estimates indicate there were approximately 500,000 attendees through 2009.
- DOE has not collected lists of names of the decathletes. It estimates that through 2011 approximately 15,000 students have participated in some part of their college team's Solar Decathlon activities. Some of the teams have posted a list of their decathletes on their school Solar Decathlon websites, from which names can be drawn.
- DOE has collected contact information on many of the schools' team leaders and has posted contact information for the 2011 and 2013 team leaders on its Solar Decathlon website.
- DOE conducts workshops for the public and building tradespersons at the Solar Decathlon site. No records are kept of attendees.
- DOE announces the school teams that will send entries to the next Solar Decathlon approximately two years before the entries are due at Solar Decathlon. Schools often begin to develop their entries immediately.
- The National Mall draws visitors from across the nation and world; however, it is likely that a higher proportion of the visitors are local.
- The Solar Decathlon receives national media and print coverage. The local television stations cover the opening. The Solar Decathlon has received national awards for its national public relations efforts.

The Evaluation Research Design

DOE desired that a version of quasi-experimental evaluation design be used for the Solar Decathlon impact evaluation. Such designs typically call for comparing before-and-after measurements of a group that receives the program treatment (in this case, the program treatment is the Solar Decathlon) and one or more comparison groups that do not receive the program treatment. The evaluator selects a set of outcomes that represent the effects that the treatment wants to achieve and measures the treatment and comparison group(s) for those outcomes. The measurements on the comparison group(s) represent the level of the selected outcome(s) that could be expected to have occurred in the absence of the treatment, and the measurements on the treatment group represent the level of the selected outcome(s) that occurred because of the treatment. The difference in the two sets of outcome measurements constitutes the estimated impact of the treatment—or the outcome(s) levels that can be attributed to it.

After consideration of the program circumstances and discussions with DOE the evaluation team designed the following research plan for the evaluation:

- Audiences covered by the evaluation would be the:
  - End-user Audience, represented by homeowners; and
  - University/schools Audience, represented by students who had participated in a Solar Decathlon.

The selection of the end-user audience would be further governed by the ability to install a solar energy system. Renters were excluded because they usually do not have the legal right to install a solar energy system on their residential building.

Further information on the audiences covered by the evaluation is included below.

- End-user Audience (Homeowners):
  - Two types of treatments would be considered for the homeowner evaluation:
    1. Visitor treatment - a homeowner visit to a Solar Decathlon and
    2. Media/Word-of-mouth (WOM) treatment - homeowner knowledge of the Solar Decathlon gained through the media or WOM without the experience of a visit.
  - Any of the Solar Decathlons of 2002, 2005, 2007, and 2009 constitute a visitor treatment.
  - Homeowners with the physical possibility of installing a solar energy system constituted the unit of analysis for the end-user audience evaluation. Homeowners that have the physical possibility of installing a solar energy system, but who are unaware of the Solar Decathlon, constituted the principal unit of analysis for the comparison group. This further restricted the end-use audience to homeowners living in single-family attached and detached houses.
  - Three homeowner groups constituted the levels of analysis for the end-user evaluation:
    1. *Visitor Homeowners* (visit treatment group) - Homeowners who have visited a Solar Decathlon;

2. *Aware Homeowners* (media/WOM treatment group and comparison group for Visitor Homeowners) - Homeowners who are aware of the Solar Decathlon but have not visited one; and
3. *Unaware Homeowners* (comparison group for Visitor and Aware Homeowners and principal representative of the outcomes that would have occurred had the Solar Decathlon not existed) - Homeowners who have never heard of the Solar Decathlon.

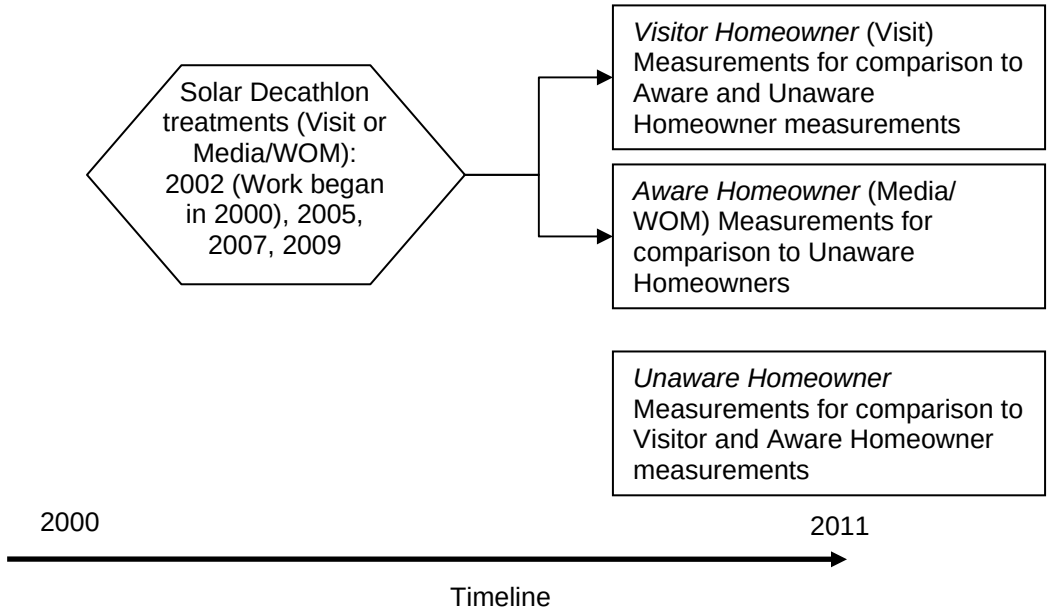
- The period from 2000 to 2011 constituted the period for measurement for the Aware and Unaware Homeowner groups.
- The outcome measurements were made two years after the 2009 Solar Decathlon to give 2009 visitors an opportunity to take action on what they observed and learned.
- The geographic area of analysis for the homeowner audience was the Baltimore and Washington, D.C., metropolitan statistical areas (MSAs). These MSAs were chosen because of the probable higher density of Visitor and Aware Homeowners compared to other regions of the country.
- Random-digit-dialed (RDD) telephone surveys were used to measure outcomes for the homeowner audience.

- The University/schools Audience (Participating Students)
  - One type of treatment is used for the participating student evaluation–participation in a school's Solar Decathlon entry.
  - Participation in at least one of the Solar Decathlons of 2002, 2005, 2007, and 2009 constituted a treatment. Participating students from the 2011 Solar Decathlon were not included in the participating student audience because they would not have had enough time to establish the post-Solar Decathlon outcomes of interest.
  - Participating students, or decathletes (the terms "participating student" and "decathlete" are used interchangeably throughout the evaluation report), constituted the unit of analysis for the university/school audience evaluation. Non-decathlete Students, former college students who attended college during the period 2000 to 2011 and who majored in one of the disciplines in which most decathletes major, constituted the unit of analysis for the comparison group.
  - The period from 2000 to 2011 constituted the period for measurement for the Non-decathlete former-student comparison group.
  - The outcome measurements were made two years after the 2009 Solar Decathlon to give 2009 decathletes an opportunity to take action on what they observed and learned.
  - The geographic area of analysis for the participating-student evaluation is the 48 contiguous United States.
  - Random-digit-dialed (RDD) telephone surveys were used to measure outcomes for the comparison group of Non-decathlete former college students.

- The outcomes for participating students were measured using an online survey of Former Decathletes.

The figure below depicts the research design for the homeowner audience. The same research design was used for the participating-student audience with the exception that there was only one treatment group and one comparison group.

Research Design for the Solar Decathlon Impact Evaluation Using the Public End-user Audience as Illustration



Typically a quasi-experimental research design requires a determination that the treatment and comparison groups were similar on characteristics related to the evaluated outcomes before the treatment. Random assignment by the evaluator to treatment and comparison groups usually satisfies this requirement. The fact that the visitors and student participants volunteered for the treatment made evaluator control of pre-treatment assignment impossible. Similarly, the fact that no data were collected before the Solar Decathlons rendered any kind of direct measurement of the treatment and comparison groups before the beginning of their respective comparison periods impossible. The evaluation addressed this issue in three ways, as described below:

First, the telephone interviews screened homeowner respondents by the following criteria prior to asking any questions that determined which homeowner group the respondent would go into:

- Lived in either a single-family attached or single-family detached house
- 18 years of age or older
- Owned the house they lived in.

A similar screening ensured that Non-decathlete Students were similar to Former Decathletes on the following variables:

- Time period of college attendance
- Major field of study

Second, one of the principal rival hypotheses for explaining the results from such a design consists of the predispositions of the visitor homeowners and participating decathletes.[43] To mitigate the effect of predispositions on the observed impacts, all of the comparative analyses (the impact analyses) were conducted on two datasets. One consisted of the full set of collected data. This analysis investigated whether there might be a positive impact. The second consisted of a subset of these data consisting of treatment and comparison respondents that were similar on variables that represented their *predispositions* toward renewable energy, energy efficiency, and the environment. This subset restricted the impact analyses to homeowners, decathletes, and comparison units of analysis that were similar in predispositions toward clean energy. This grouping into a subset of individuals who had similar predispositions partially accounted for (removed) the effect of predispositions in the observed impact. The observed impact after accounting for predispositions is more likely to represent the impact of the Solar Decathlon. This supplementary impact analysis adjusted for predispositions gives the reader another perspective that will help make a judgment about the success of the Solar Decathlon in meeting its objectives. The section entitled, "Use of Cluster Analysis for Matching," that appears later in this Appendix discusses and describes this matching process in more detail.

Third, Visitor Homeowners and Former Decathletes were asked to rate the Solar Decathlon's influence on selected actions and knowledge outcomes that were related to the Solar Decathlon's objectives. These reports provided additional evidence on which to judge the impact of the Solar Decathlon on its objectives.

These three sources of information provided quantitative evidence on which to base a qualitative judgment about the success that the Solar Decathlon has had in satisfying its objectives.

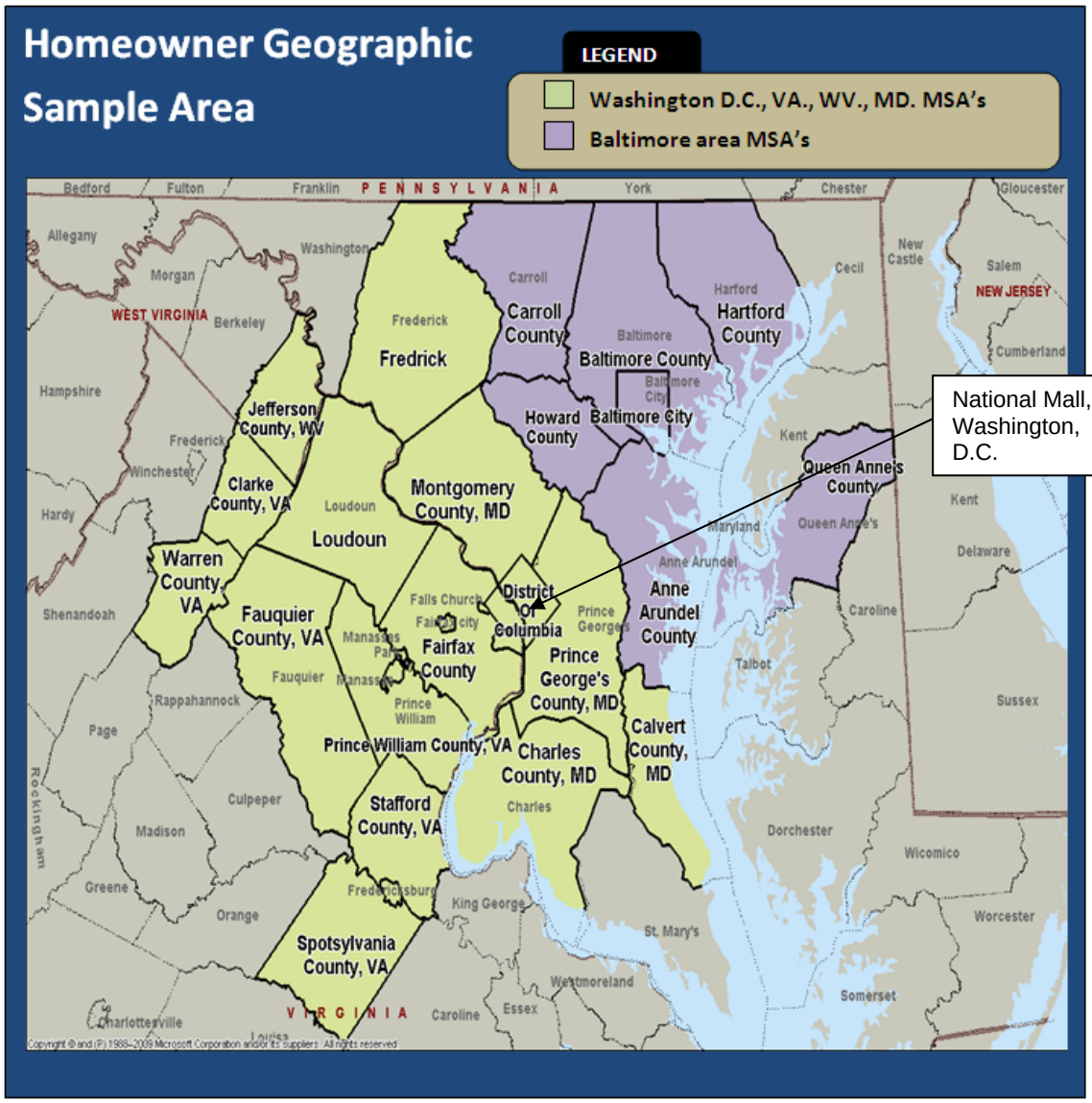
The Geographic Scopes of the Evaluation

The Homeowner Audience

The figure, on the following page, depicts the geographic region for the homeowner audience research design.

[43] Cook and Campbell 1979, 98-99.

Geographic Area Covered by the Research Design for the Solar Decathlon Homeowner Audience Impact Evaluation



The Participating Student Audience

The geographic scope of the participating student evaluation consisted of the 48 contiguous states.[44]

Samples and Data Collection

The following table summarizes sample design. The sample sizes were developed from considerations of cost and the desired power (0.8 or greater) of the tests of differences between homeowner groups, consistent with a 90% confidence level.

Sample Design for the Solar Decathlon Impact Evaluation

Audience	Group	Interviews	Sample Design
Pubic End-users (Homeowners)	Visitor to a Solar Decathlon	200	RDD for landline phones in the Baltimore and Washington, D.C., MSAs.
	Homeowners who had heard of the Solar Decathlon	280	RDD for landline phones in the Baltimore and Washington, D.C., MSAs.
	Homeowners who were unaware of the Solar Decathlon	400	RDD for landline phones in the Baltimore and Washington, D.C., MSAs.
Participating Students	Former Decathletes from the 2002, 2005, 2007, and 2009 Solar Decathlons	100 sought (received 174 useable)	The Solar Decathlon Alumni Association (SDAA), with assistance from DOE, developed a sample frame consisting of all Former Decathletes for whom it could obtain contact information. SDAA invited all in the frame by e-mail or phone to take an on-line survey and provided the link. DOE also published a general invitation on the Solar Decathlon website, which provided the link and invited Former Decathletes to take the survey.
Non-decathlete Students	Individuals with some college coursework since 2000 in majors similar to those of decathletes	110	RDD for landline phones in the 48 contiguous U.S. states.

In accordance with the U.S. Paperwork Reduction Act, the U.S. Office of Management and Budget approved the data collection instruments. Marketing Systems Group provided the residential RDD samples. Eastern Research Services conducted the telephone surveys between September 14, 2011 and October 5 2011.

SDAA programmed the online survey using Survey Money® software and made the survey available between January 25, 2012 and April 19, 2012 to all Former Decathletes.

[44] No effort was made to identify and screen out decathletes from Puerto Rico or other countries who took the online survey. The online survey was in English.

The project team used computer Internet Protocol (IP) addresses to screen online survey responses for multiple responses from the same computer. Where multiple responses from the same computer were found, the most complete survey was retained and other(s) were deleted.

Analysis

SAS® and Microsoft Excel were used to complete all of the Solar Decathlon analyses. The homeowner data were analyzed in SAS. SAS has the capability to perform the following procedures that were necessary to complete the homeowner data analysis:

- Frequency distributions
- Means
- Proportions
- Difference of means with statistical significance tests
- Difference of proportions with statistical significance tests
- Multiple-way crosstabs
- Chi-square statistical significance tests
- Cluster analysis.

With the exception of the cluster analysis which was completed in SAS, the decathlete and Non-decathlete former college student data were analyzed entirely in Microsoft Excel. The comparisons of the decathlete and non-decathlete former-student data were not statistically tested because the decathlete survey was not a random survey of decathletes. Therefore, all of the decathlete and non-decathlete analysis did not require statistical software and Microsoft Excel was used to calculate frequencies, means, proportions, and crosstabs.

Hypothesis Testing

Due to the nature of the measurement questions, two different hypothesis tests were used to statistically test the differences found in the group comparisons. The table below lists the hypothesis-testing techniques utilized during the analyses and the circumstances under which each was used.

Hypothesis Tests	Circumstances
T-test	Used to test the means and proportions of variables between treatment and comparison groups to determine if the differences in the two groups were significant. This test is used when the sample size is greater than or equal to 30.
Chi-Square Test	Used to test the relationships between discrete variables describing treatment and comparison groups to determine if the two groups were significantly different. This test was used to compare the predisposition variables and demographic variables between the groups.

Hypothesis Tests	Circumstances
Phi	Used to test the relationships between various discrete variables and discrete and interval variables used in assumptions. These tests were used to determine if the relationships were statistically significant and if so, the strength of association. They were used when contingency table cell populations were </=5.
Craver's V	
Point biserial	
Spearmans' correlation	

Use of Cluster Analysis for Matching

Introduction

In a typical quasi-experimental evaluation design, the treatment and comparison groups are both selected at random from the same population prior to the treatment. Therefore, they are assumed to be similar on characteristics that are related to the expected treatment outcomes. The treatments for this study are a visit to or knowledge of the Solar Decathlon and student participation in a Solar Decathlon. However, the evaluation design is based only on measurements made after the Solar Decathlon treatments. Further, since the recipients of the visitor and decathlete treatments are self-selected, i.e., volunteers, this creates the possibility that those who receive the visitor/decathlete treatments are somehow different from non-visitors. Energy-program evaluators usually expect that volunteers are more interested in energy conservation and the environment than randomly selected participants, and that these potential differences, if they exist, can bias the results in favor of the desired treatment outcomes.[45]

The evaluation gives the reader a basis for judging the effects of any potential bias resulting from voluntary visiting/participating by comparing those receiving the Solar Decathlon treatment to comparison groups of Aware and Unaware Homeowners and Non-decathlete Students who were similar to the visitors/decathletes on certain outcome-relevant variables. These groupings of similar respondents constituted purposively-selected subsets of their respective groups. They were analyzed for outcome impacts using the same methods as were used for the full datasets. The report presents the results from this analysis of similar groups immediately after the results from the analyses of the full sets of treatment and comparison groups; the purpose is to help the reader judge any potential bias in the latter results due to self-selection.

Three approaches were considered for creating the subsets of similar respondents. The following discussion of the approaches considered uses homeowners to illustrate the choices; they apply as well to decathletes and non-decathlete Students.

[45] For example, see the discussions of selectivity in energy-efficiency programs in TecMarket Works Framework Team, "The California Evaluation Framework," prepared for Southern California Edison Company, June 2004. pp. 103-104 and 135-144. http://www.calmac.org/publications/California_Evaluation_Framework_June_2004.pdf. Last accessed June 28, 2012.

1. Approach 1: Select variables related to the Solar Decathlon outcomes under evaluation. Define a "typical" visitor on the most common, or modal, combination of values on these variables. Match all visitors characterized by this combination of variable values to comparison individuals having the same combination of characteristics and re-perform the impact analyses on these subsets of matched treatment and comparison individuals. This amounts to using a single combination of characteristics to define similar treatment and comparison groups.
2. Approach 2: Select variables related to the Solar Decathlon outcomes under evaluation. Divide the visitors into segments with each segment characterized by one of the possible combinations of the selected matching variable values. Determine the proportions of each of these combinations in the visitor population. Randomly select comparison group members with matching combinations in the same proportions (to the extent of their availability). Re-perform the impact comparisons on this subset of matched treatment and comparison individuals. This approach amounts to identifying every possible combination of outcome-related characteristics in the visitor population and finding the matching combinations in the comparison group populations.
3. Approach 3: Select variables with relevance to the Solar Decathlon outcomes under evaluation. Use cluster analysis to create groupings (clusters) of visitors and comparison individuals on the basis of their similarity on the variable values and re-perform the impact analyses using just the subsets of similar treatment and comparison individuals. This approach did not require the evaluator to identify all of the possible combinations of outcome-related variable values.

The variables considered for homeowner matching or clustering in these three approaches were variables with a theoretical relationship to the outcomes being measured. The variables were chosen to indicate a predisposition, preferably a predisposition before visiting a Solar Decathlon or before the non-visitor measurement period began, to be interested in solar-energy and energy efficiency and to represent aspiration to certain levels of education.

The following variables were considered for use in the homeowner matching process: Some of these variables are not strictly *pre*dispositions variables. They were added for technical reasons to aid in the separation of clusters.

1. Have you attended an event that discussed solar energy or energy efficiency for a home before visiting a Solar Decathlon/prior to 2000?
2. Do you work in an occupation that sells, markets, or builds solar-energy equipment for homes or commercial buildings?
3. Have you installed any solar panels on your home to generate electricity or heat rooms or hot water prior to visiting a Solar Decathlon/2000?
4. Have you ever visited any Internet sites that described the availability of utility or state incentives for solar-energy systems to generate electricity or heat for your home?
5. Have you ever written about energy conservation or the environment in a school paper, a blob, or an e-mail, tweet, or letter to the editor?
6. Highest level of education attained by the homeowner.

Chi-square hypothesis tests were performed to determine if there was a statistical difference in the survey responses for each predisposition variable between the homeowner groups. The table below displays the results of the hypothesis tests.

Results of the Homeowner Predisposition Comparison Tests

	Homeowner Comparison Question		
Predisposition Question/Variable	Is there a difference between Visitor and Aware responses?	Is there a difference between Visitor and Unaware responses?	Is there a difference between Aware and Unaware responses?
1. Attended an event that discussed solar energy or energy efficiency for a home before visiting a SD/prior to 2000?	Yes	Yes	Yes
2. Work in an occupation that sells, markets, or builds solar-energy equipment for homes or commercial buildings?	No	No	No
3. Installed solar panels on own house before visiting a SD/prior to 2000?	Yes	No	No
4. Ever visited any Internet site that described the availability of utility or state incentives for solar-energy systems to generate electricity or heat home?	Yes	Yes	No
5. Ever written about energy conservation or the environment in a school paper, a blog, or an e-mail, tweet or letter to the editor?	No	No	No
6. Highest level of education attained?	Yes	Yes	No

It is interesting to note that the Aware and Unaware Homeowner groups, neither of which "volunteered" for the Solar Decathlon treatment, are most alike on the predisposition variables, whereas the Visitor Homeowners display more differences with either group.[46,47]

After the predisposition variables were identified, the three matching options listed above were assessed. The assessment described here is for the homeowner analyses; however, it also applies to decathletes and Non-decathlete Students. The first matching option uses a single "typical" Visitor Homeowner to represent all visitors for the purpose of selecting comparable non-visitor

[46] It might be argued that the Aware Homeowners "volunteered" to watch the news or read an article and that this might make them different than the Unaware Homeowners. Although this is true, there is a major difference between watching television or reading an article that one selects from an index and making the effort to go to the National Mall and visit a Solar Decathlon.

[47] This lends support to the expectation that volunteers differ from randomly selected non-volunteers and underlies the interpretation of the calculated appliance-installation impacts in the report of homeowner impacts (see Chapter 3).

households. This leaves many Visitor Homeowners—probably most of them—out of the subset of similar homeowners.

An alternative methodology was desired that would use all values of the predisposition variables to group similar participant and non-participant households. The second matching option would accomplish this, but at the cost of a large amount of programming effort to identify all of the possible combinations of variable values in the visitor dataset, and then to select a random set of matching households.[48]

The third option uses a statistical method called cluster analysis that was available in SAS®. Cluster analysis is a statistical analysis technique that divides a set of objects into groups (clusters) having comparable characteristics (variable values). It is widely used as a segmentation procedure in market research. In order to determine the clusters, the clustering algorithm determines the difference between each pair of objects on selected variable values and groups the objects into clusters based on the similarity of their variable values. Cluster analysis takes advantage of all of the available information at the least cost; it was chosen as the optimal method to group together similar treatment/comparison households and similar decathletes/non-decathlete Students.

A cluster analysis involves selecting the following;

1. The variables to use in the cluster analysis
2. A clustering algorithm
3. The number of clusters at which to stop clustering
4. Which clusters to choose to represent the subset of similar treatment and comparison individuals.

Variable Selection

Homeowner Clustering

The variables ultimately used for the homeowner cluster analysis are listed below. The process of selecting the variables from the list presented in the preceding section involved consideration of the differences between the groups on the variables and the number of values for each variable. Three out of four of the selected variables were considered predisposition variables in the homeowner surveys. The education variable was included in the cluster analysis based on the assumption that the respondents' education aspirations pre-dated a visit to the Solar Decathlon or the year 2000 and, therefore, their current education level could be used as a predisposition variable.

1. Did you attend an event that discussed solar energy or energy efficiency for a home before visiting a Solar Decathlon (or prior to 2000 for non-visitors)?

[48] The six variables considered have 5,005 potential combinations of variable values that would have to be identified and compared.

2. Did you install solar panels on your own house before visiting a Solar Decathlon (or prior to 2000 for non-visitors)?
3. Have you visited any Internet site that described the availability of utility or state incentives for solar energy systems to generate electricity or heat in the home?
4. What is the highest level of education you have attained?

If the variables included in the cluster analysis do not have equal variance, they have to be scaled or transformed. Since the education variable was the only variable that was not dichotomous, it was standardized in order to perform the cluster analysis with the remaining variables.

Decathletes and Non-decathlete Students

Cluster analysis was also performed in order to group together similar decathlete and Non-decathlete survey respondents for comparison. The following variables were considered for use in the decathlete and Non-decathlete cluster analysis. Some of these variables are not strictly *pre*disposition variables. They were added for technical reasons to aid in the separation of clusters.

1. College major
2. Highest level of education attained
3. Before you participated in a Solar Decathlon/prior to college, did you participate in any activity that encouraged people to conserve energy or help the environment?
4. Before you participated in a Solar Decathlon/prior to college, did you ever write about energy conservation or the environment in a school paper, a blog, a tweet, or a letter to the editor?
5. Has anyone living in your household ever had any formal technical training or engineering education?

The education variable was again standardized in order to perform the cluster analysis on the decathletes and Non-decathlete Students.

Algorithm Selection Protocols

After the predisposition variables were selected, a clustering algorithm had to be selected. Numerous clustering algorithms exist; therefore, it is necessary to develop protocols to guide the selection of an algorithm that is best suited to achieve the goal of the clustering. The goal of clustering was to develop the best subset of similar treatment and comparison group individuals. The approach used to accomplish this goal comprised a set of protocols that guided the clustering choices. These protocols were established after review of the clustering literature, including the SAS 9.3 User's Guide.

The protocols are described generally as follows. Their specific applications to the homeowner and participating-student audiences are described following the general descriptions.

1. *Determine the nature of the actual clusters as criteria for selecting the clustering algorithm*

   Since most of the predisposition variables used for the clustering analyses for both audiences are dichotomous, meaning the variable is a categorical variable with two levels of response, it was assumed that the actual clusters will be:

   - Not compact
   - Of equal size
   - Poorly separated
   - Non-overlapping

   Three clustering methods available in SAS—two-stage density, centroid, and expected maximum likelihood (EML) approaches—perform best on clusters of unequal size and poorly separated compact clusters. Therefore, cluster analysis was performed first for both the homeowner data and the decathlete/non-decathlete Student data using these three methods.

2. *Review the algorithm performance metrics on the number of clusters at which to stop clustering and select an optimal number*

   Three diagnostics from the clustering analysis output—cubic clustering criterion (CCC), pseudo F statistic, and pseudo t-squared—were reviewed for each clustering method in order to determine the appropriate number of clusters. In SAS output, the number of clusters is listed from large to small along with the diagnostic information in a table format. According to the SAS 9.3 User's Guide, a local maximum value for the cubic clustering criterion and the pseudo F statistic indicate an optimal number of clusters (i.e., the number of clusters after which further clustering produces instability in the diagnostic statistics). As a supplementary indicator, an optimal number of clusters can be identified by the pseudo t-squared value by observing the first value found that is markedly larger than the previous value.

3. *Determine which clustering algorithm to use.*

   This protocol involved identifying stable algorithms when run with different clustering variables and examining the percentages of treatment and comparison group members in the clusters produced. It is therefore interdependent with the next protocol and is best described with the next protocol.

4. *Determine which cluster(s) to use as the source(s) of similar predisposition treatment and comparison households*

   This protocol involves selecting the cluster(s) to use as the source(s) of similar treatment and comparison homeowners and treatment and comparison former students. Cluster analysis separates all members of the populations into clusters, but cluster analysis used to identify groups of similar objects for evaluation purposes must discard some of the clusters; otherwise, its purpose is defeated. This protocol specifies the guidance for performing this selectivity. This is, perhaps, the step at which the evaluator's goals exert the most influence.

In order to perform meaningful and useful analysis, clusters were chosen that had relatively large proportions of both treatment and comparison groups. The criteria used to choose the cluster(s) consisted of selecting the cluster(s) that, together, include about 30-50% of the comparison group and 50% or more of the treatment group. Also, the cluster(s) chosen needed to have close to an even percentage split between comparison and treatment groups overall. The comparison samples were larger than the treatment samples; therefore the application of this criterion results in more treatment members, and a higher percentage of all treatment members, than of comparison members in the chosen clusters. The within-cluster variance, in addition to helping to determine the clustering algorithm, also helps to determine which cluster(s) to choose to satisfy this protocol. Small within-cluster variances indicate good matches between objects within a cluster.

Using these criteria, cluster(s) were chosen for the analysis of similar comparison and treatment group members. The following sections describe the application of these protocols to the homeowner and decathlete/non-decathlete audiences.

Homeowner Clustering

For the predisposition-matched analysis of treatment and comparison households, the EML algorithm was chosen to develop the subset of similar homeowners. This section describes the selection process.

The three algorithms were run first using four variables from the homeowner survey questions to determine the clusters. These variables were:

1. Attended an event that discussed solar energy or energy efficiency for a home?
2. Installed solar panels on own house before visiting a Solar Decathlon?
3. Ever visited any Internet site that described the availability of utility or state incentives for solar-energy systems to generate electricity or heat home?
4. Highest level of education?

The two-stage density method did not converge when using all four of these variables, meaning that the individuals were never placed into well-defined clusters but rather continued to shift from one cluster to another, thus eliminating the possibility for reliable analysis. Therefore, the algorithms were run again excluding the Education variable. Using three variables, the centroid method did not converge well, so was also excluded from the analysis. Four methods remained and were further evaluated:

1. Two Stage Density method with three variables
2. EML method with three variables
3. Centroid method with four variables
4. EML method with four variables

After reviewing the cluster history diagnostics in SAS for each algorithm, the optimal number of clusters for each algorithm was determined. The table, on the next page, displays the selected number of clusters for each algorithm.

Selected Number of Clusters for Each Homeowner Clustering Algorithm

Groups	Two Stage Density (3 variables)	EML (3 variables)	Centroid with Education (4 variables)	EML with Education (4 variables)
Visitor & Aware	4	3	3	5
Visitor & Unaware	4	3	3	4
Aware & Unaware	4	4	3	5

The table below is an illustration of the clustering output using the centroid-with-education method to cluster Visitor Homeowners and Aware Homeowners. (This algorithm was not the one ultimately chosen for homeowners.) The top row shows the three clusters in which the centroid algorithm grouped the individual homeowners. The first two rows under each group show the total count and percent of the total number of homeowners (Aware plus Visitor) being clustered. The next row, Row Percentage, shows, for Aware Homeowners, the percent of Aware Homeowners within each cluster compared to the total number of Aware Homeowners, and for Visitor Homeowners, the percent of Visitor Homeowners within each cluster compared to the total number of Visitor Homeowners. Finally, the Column Percentage row shows the percent of homeowners within each homeowner group (Aware or Visitor) compared to the total number of homeowners in the cluster.

Clustering Output of the Centroid-with-Education Algorithm to Illustrate the Row and Column Percentages Used in the Algorithm-selection Protocol

	Cluster 1	Cluster 2	Cluster 3	Total
Aware				
Frequency	84	4	190	278
Percent	17.68	0.84	40.00	58.53
Row Percentage	30.22	1.44	68.35	100.01
Column Percentage	76.36	36.4	53.67	
Visitor				
Frequency	26	7	164	197
Percent	5.47	1.47	34.53	41.47
Row Percentage	13.2	3.55	83.25	100.00
Column Percentage	23.64	63.60	46.33	
Frequency	110	11	354	475
Total Column Percent	100.00	100.00	100.00	

For each method, the cluster(s) used for further analysis were determined by evaluating the row and column percentages of the cluster(s) compared to the respective total number of homeowners. As noted earlier, the goal is to find clusters containing 30-50% of the comparison households and 50% or more of the treatment households (row percentages) to be in the chosen cluster(s) with more treatment households than comparison households. Also, the column percentages would be split fairly evenly (close to 50-50) to make the best comparisons among the homeowner groups. Recall that the chosen cluster(s) should not constitute all of the clusters accepted for the algorithm. Some of the clusters should comprise mostly comparison group members having the dominant comparison group characteristics; these clusters should not be chosen. The following three tables display the number of clusters chosen for each clustering method for further analysis along with their row and column percentages.

Clustering Output of the Tested Algorithms Showing the Row and Column Percentages of the Homeowner Clusters Selected by Protocol for Further Examination and Algorithm Selection

Visitor versus Aware				
	Two Stage Density	**EML**	**Centroid with Education**	**EML with Education**
Number of Chosen Clusters	3 of 4	2 of 3	1 of 3	3 of 5
Visitor Row Percentage	56.5%	56.5%	83.3%	78.5%
Visitor Column Percentage	47.9%	47.9%	46.3%	47.5%
Aware Row Percentage	43.9%	43.9%	68.4%	60.4%
Aware Column Percentage	52.1%	52.1%	53.7%	52.5%

Visitor versus Unaware				
	Two Stage Density	**EML**	**Centroid with Education**	**EML with Education**
Number of Chosen Clusters	3 of 4	2 of 3	1 of 3	2 of 5
Visitor Row Percentage	56.5%	56.5%	83.3%	86.3%
Visitor Column Percentage	45.7%	46.3%	41.1%	41.2%
Unaware Row Percentage	33.4%	32.7%	59.3%	59.4%
Unaware Column Percentage	54.3%	53.7%	58.9%	58.8%

Aware versus Unaware				
	Two Stage Density	**EML**	**Centroid with Education**	**EML with Education**
Number of Chosen Clusters	3 of 4	3 of 3	1 of 3	3 of 5
Aware Row Percentage	43.9%	43.8%	69.5%	68.4%
Aware Column Percentage	47.9%	48.8%	45.3%	44.7%
Unaware Row Percentage	33.4%	32.7%	59.0%	63.8%
Unaware Column Percentage	52.1%	51.2%	54.7%	55.3%

In all three homeowner group comparisons, the row and column percentage criteria are met for each clustering method. The centroid and EML approaches that include education as a variable have higher column percentages for both the treatment and comparison groups, providing the inclusion of a high percentage of treatment households.

After determining the clusters, chi-square hypothesis testing was performed to compare the homeowner groups within the chosen cluster(s). The hypothesis tests compared each predisposition variable by homeowner group within the chosen cluster(s). To use the chosen cluster(s) as a group of similar survey respondents on the predisposition questions, it is desirable that hypotheses of equal predisposition responses across the homeowner groups (null hypotheses) not be rejected. The results of the hypothesis tests using an alpha value of .01 are displayed in the table below.

Chi-square Tests of the Variables within the Chosen Clusters for Each Algorithm—Used to Assess the Similarity Homeowner Members within Each Cluster

Groups	**Two-Stage Density**	**EML**	**Centroid with Education**	**EML with Education**
Visitor & Aware	Fail to reject one hypothesis (rejected first and second variable)	Fail to reject one hypothesis (rejected first and second variable)	Fail to reject one hypothesis (rejected first and second variable)	Fail to reject two of the three hypotheses (rejected second variable)
Visitor & Unaware	Fail to reject two of the three hypotheses (rejected first variable)	Fail to reject two of the three hypotheses (rejected first variable)	Fail to reject one hypothesis (rejected first and second variable)	Fail to reject two of the three hypotheses (rejected first variable)
Aware & Unaware	Fail to reject all hypotheses	Fail to reject all hypotheses	Fail to reject all hypotheses	Fail to reject all hypotheses

Based on the row percentages, column percentages, and hypothesis test results, the EML algorithm that includes the Education variable was chosen as the best algorithm. The EML algorithm including the Education variable fit the row and column percentage criteria well and failed to reject the largest number of null hypotheses. Thus, the clusters based on the predisposition variables will be the most similar when comparing treatment to comparison households for further analysis using the EML clustering method including the Education variable.

Therefore, the chosen clusters generated by the EML algorithm best satisfy the cluster and algorithm selection protocols using the following four variables:

1. Had you attended an event that discussed solar energy or energy efficiency for a home prior to participating in a Solar Decathlon (for Non-decathlete Students, prior to college)?
2. Had you installed solar panels on your own house before visiting a Solar Decathlon (for Non-decathlete Students, prior to 2000)?
3. Had you ever written about energy conservation or the environment in a school paper, a blog, or an e-mail, tweet, or letter to the editor prior to participating in a Solar Decathlon (for Non-decathlete Students, prior to college)?
4. Highest level of education?

These clusters constituted the data subset for the supplementary analyses of similar comparison and treatment homeowners.

Decathlete and Non-Decathlete Student Clustering

For the analysis of similar treatment decathletes and comparison Non-decathlete Students, a centroid algorithm was optimal for developing the subset of matched respondents to use for analysis. The algorithms examined consisted of the two-stage density, centroid, and EML algorithms. After examination of the three algorithms using the protocols described above, the centroid approach offered the best fit.

The algorithms were first run using six variables from the survey questions to determine the clusters. These variables were:

1. College major?
2. Highest level of education attained?
3. Prior to college, or while you were in college, did you participate in any activity that encouraged other people to conserve energy or help the environment?
4. Prior to college, or while you were in college, did you ever write about energy conservation or the environment in a school paper, a blog, or an e-mail, tweet, or letter to the editor?
5. Are you aware of an Internet site called the Database of State Incentives for Renewables and Efficiency or DSIRE where the availability of state and utility incentives for installing solar energy and energy efficient equipment is listed?
6. Has anyone living in the household ever had any formal technical training or engineering education?

Prior to performing the cluster analysis, the percentage of responses for each predisposition variable was determined for all decathlete and non-decathlete survey respondents, except decathletes who participated only in the 2011 Solar Decathlon. Since the set of decathlete survey respondents was not drawn from a random sample, hypothesis testing was not applied to compare the predisposition variables between Former Decathletes and Non-decathlete Students. However, the percent of respondents for each predisposition variable, except college major, are displayed in the following five tables to permit subjective comparison between Former Decathletes and Non-decathlete Students. College major is not shown because of the large variety of different academic majors studied by both Former Decathletes and Non-decathlete Students.

Comparison of Former Decathletes and Non-decathlete Students on Prospective Clustering Variables

Education of Former Decathletes versus Non-decathlete Students at Time of Survey		
Education Group	**Former Decathletes**	**Non-decathlete Students**
Currently in undergraduate college studies	3.4%	
Completed some college or associate's degree and no longer in college	1.1%	26.4%
Completed college or university degree	27.0%	40.0%
Currently taking graduate courses	11.5%	6.4%
Completed some post graduate work or a graduate degree	55.2%	27.3%
Did Not Respond	1.7%	0.0%
Total	**100% (n=174)**	**100% (n=110)**

Prior to participating, prior to college, or while you were in college, did you participate in any activity that encouraged other people to conserve energy or help the environment?		
Response	**Former Decathlete**	**Non-Decathlete Students**
Yes	43.7%	35.5%
No	39.7%	62.7%
Do Not Recall	8.1%	1.8%
Did Not Respond	8.6%	0.0%
Total	**100% (n=174)**	**100% (n=110)**

Prior to participating, or prior to college or while you were in college, did you ever write about energy conservation or the environment in a school paper, a blog, or an e-mail, tweet, or letter to the editor?		
Response	**Former Decathlete**	**Non-Decathlete Students**
Yes	35.1%	24.6%
No	50.0%	75.5%

Do Not Recall	6.3%	0.0%
Did Not Respond	8.6%	0.0%
Total	**100% (n=174)**	**100% (n=110)**

Are you aware of an Internet site called the Database of State Incentives for Renewables and Efficiency (DSIRE) where the availability of state and utility incentives for installing solar energy and energy efficient equipment is listed?		
Response	**Former Decathlete**	**Non-Decathlete Students**
Yes	42.5%	17.3%
No	48.9%	80.0%
Do Not Recall	0.0%	2.7%
Did Not Respond	8.6%	0.0%
Total	**100% (n=174)**	**100% (n=110)**

Has anyone living the household ever had any formal technical training or engineering education?		
Response	**Former Decathlete**	**Non-Decathlete Students**
Yes	47.7%	60.0%
No	40.8%	35.4%
Not applicable	2.9%	0.0%
Did Not Respond	8.6%	4.5%
Total	**100% (n=174)**	**100% (n=110)**

To perform the cluster analysis, decathletes who failed to answer at least one of the predisposition questions were eliminated from the dataset. After performing the cluster analysis and review of the clustering diagnostics, the number of clusters chosen for each method was determined and is displayed in the table below.

Selected Number of Clusters for Each Decathlete and Non-decathlete Clustering Algorithm

	Two Stage Density	**EML**	**Centroid**
Number of Clusters	3	3	4

Although three clusters were chosen as the best number of clusters for the two stage density method, the cubic clustering criterion had a fairly poor result. A local maximum for the CCC criteria helps to determine the optimal number of clusters. Using the two stage density method, a local maximum did not exist for any of the clusters. Therefore, the two stage density option was eliminated as a potential clustering method, and the EML and centroid methods were examined further.

For the EML and centroid methods, the clusters used for further analysis were determined by evaluating the row and column percentages of the cluster compared to the total number of Former Decathlete and Non-decathlete Students as described in the protocol. The table below displays the number of clusters chosen for further analysis along with their within-cluster variance, row percentages, and column percentages for each clustering method. There are missing values due to outliers in the centroid cluster results, but they are included in the row and column percentage calculations since the respondents missing from the cluster analysis are a subset of the decathlete and non-decathlete data sets.

Clustering Output of the Tested Algorithms Showing the Within-Cluster Variance and Row and Column Percentages of the Decathlete and Non-decathlete Clusters Selected by Protocol for Further Examination and Algorithm Selection

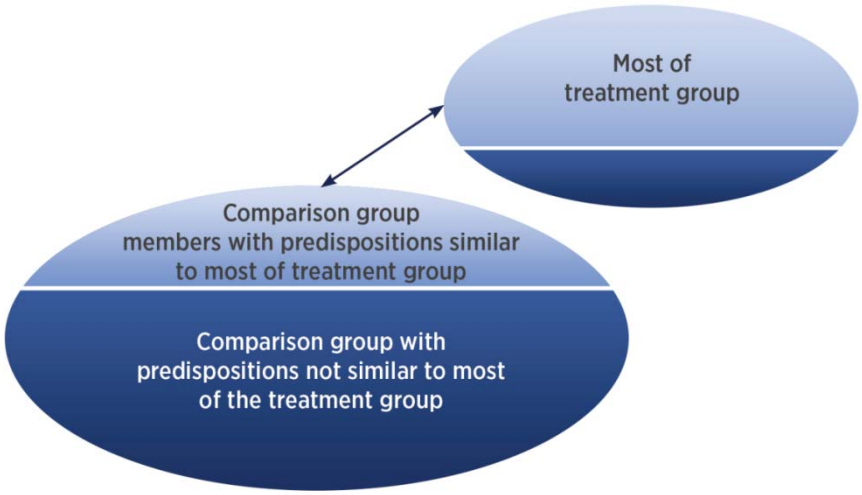
	EML	Centroid
Number of Chosen Clusters	1	1
Within-Cluster Variance	0.54	0.03
Decathlete Row Percentage	67%	53%
Decathlete Column Percentage	60%	58%
Non-Decathlete Row Percentage	57%	49%
Non-Decathlete Column Percentage	40%	42%

Comparing these two methods, the centroid method has the lower within-cluster variance. Although the row percentages for both methods meet the criteria, the column percentage criterion is slightly better for the centroid method. Therefore, the centroid method was chosen as the clustering method to use for further analysis between clustered decathlete and non-decathlete data.

Interpretation of the Cluster Analysis Results

The following Venn diagrams provide a perspective on the subset developed from the cluster analysis. The diagram helps to understand the function of the cluster analysis and its limitations. The lighter colored segments of the Venn diagrams indicate the portions of the treatment and control groups that will be included in the similar-group dataset. The white lines in the two Venn diagrams illustrate the desirable proportions of the treatment and comparison groups that will be included in the similar-group dataset.

Illustration of Cluster Analysis's Selection of Similar-group Members



By selecting members of the treatment and comparison groups with similar predisposition variable values, the cluster analysis process selects a subset of group members with similar predispositions to take actions or gather knowledge that reflects favorably on the Solar Decathlon. Thus, the influence of predispositions is already captured in the outcome measurements for both treatment and comparison individuals. The remaining differences between the two groups should contain less of the influence of predispositions. The remaining difference is more reflective of the influence of the Solar Decathlon than it was before the predispositions were accounted for. The remaining difference also reflects the influence of other rival hypotheses not accounted for in the cluster analysis. Therefore, the impact results from analysis of the similar treatment and comparison group subset improve the credibility of the effects of the Solar Decathlon.

This is not equivalent to the random selection of treatment and control groups required by true experimental designs. As seen in the Venn diagrams, some of the members of each group are omitted from the similar-group analysis. To the degree that their predispositions were not included in the similar groups by the cluster analysis, their influence would be captured in a true experimental design, but is ignored in the similar-group analysis.

Non-response

The research for this study targeted the following separate audiences: Visitor, Aware, and Unaware Homeowners; Former Decathletes; and Non-decathlete Students who majored in specific academic disciplines. The evaluators were not able to find data on the population sizes for these audiences. As a result, the data could not be weighted to adjust for unit non-response.

The survey vendor attempted each phone number called six times or until the respondent verbally refused the interview.

Records with item non-response on one of the clustering variables were excluded from the cluster analysis.

As an alternative to comparing the respondent proportions to their corresponding population proportions, the group respondent demographics may be compared subjectively.

Are Visitor Homeowners Different than Non-visitor Homeowners Demographically?

Comparison of Visitor and Non-visitor Homeowners

Demographic information was collected in the homeowner surveys for both visitors and non-visitors of the Solar Decathlon. The three demographics collected were age, education, and income of visitors and non-visitors. The following tables compare the three groups on these demographics. An attempt was made to add a column to these tables for the homeowner population at large living in single-family detached and attached houses. However, detailed data from the 2010 Census were not yet available at the time of the analysis, and the American Community Survey data did not have data available by Metropolitan Statistical Area (MSA). Therefore, comparison was not possible for the population at large.

Age of Visitor versus Non-visitor Groups			
Age Variable	**Visitor**	**Aware**	**Unaware**
18 – 19 years	0.5%	0.4%	0.5%
20 – 29 years	1.0%	1.1%	2.2%
30 – 39 years	8.5%	6.8%	12.5%
40 – 49 years	28.0%	20.4%	21.7%
50 – 59 years	30.5%	28.2%	23.7%
60 – 69 years	21.5%	25.0%	17.2%
70+ years	8.5%	17.5%	21.5%
Refused	1.5%	0.7%	0.8%
Total	**100% (n=200)**	**100% (n=280)**	**100% (n=401)**

Education of Visitor versus Non-visitor Groups			
Education Variable	**Visitor**	**Aware**	**Unaware**
Some elementary school but did not graduate	0.0%	0.4%	0.5%
Graduated from elementary school and some high school	1.0%	0.7%	3.0%
High school graduate or GED equivalency certificate	2.5%	10.4%	15.2%
Some college or associate's degree	13.0%	20.0%	21.7%
College bachelor's degree of higher	82.0%	67.9%	58.4%
Refused	1.5%	0.7%	1.3%
Total	**100% (n=200)**	**100% (n=280)**	**100% (n=401)**

Income of Visitor versus Non-visitor			
Income Variable	**Visitor**	**Aware**	**Unaware**
Less than $10,000	0.5%	0.7%	1.5%
$10,000 but less than $35,000	2.5%	5.4%	5.5%
$35,000 but less than $50,000	3.5%	4.6%	5.5%
$50,000 but less than $75,000	8.5%	6.1%	11.5%
$75,000 but less than $100,000	9.5%	13.2%	10.5%
$100,000 but less than $150,000	22.0%	17.9%	15.5%
$150,000+	30.0%	25.0%	23.7%
Do not know	2.0%	2.5%	2.2%
Refused	21.5%	24.6%	24.2%
Total	**100% (n=200)**	**100% (n=280)**	**100% (n=401)**

Chi-square hypothesis tests were completed to determine if there was a difference in the survey responses for each demographic variable among the homeowner groups. The table below displays the results of the hypothesis tests.

Chi-square Tests of the Demographic Differences of the Homeowner Groups

	7. Homeowner Comparison Question		
Demographic Variable	Is there a difference between Visitor and Aware responses?	Is there a difference between Visitor and Unaware responses?	Is there a difference between Aware and Unaware responses?
Age	No	Yes	No
Education	Yes	Yes	No
Income	No	No	No

Are Decathletes Different than Non-decathlete Students?

Comparison of Decathletes and Non-decathlete Students

Demographic information on age, education, and income was also collected in the Former Decathlete and Non-decathlete Student surveys. The following tables compare the two groups on these demographics. An attempt was made to add a column to these tables for the population at large, but detailed data from the 2010 Census were not yet available at the time of the analysis, and the American Community Survey data did not have data that could match college major and education to the homeowner for the population at large.

Age of Former Decathletes versus Non-decathlete Students at Time of Survey		
Age Variable	**Former Decathletes**	**Non-decathlete Students**
18 – 19 years		0.9%
20 – 29 years	47.4%	8.2%
30 – 39 years	26.8%	26.4%
40 – 49 years	4.7%	19.1%
50 – 59 years	2.1%	22.7%
60 – 69 years	1.1%	9.1%
70+ years	0.1%	12.7%
Did Not Respond	17.4%	0.9%
Total	**100% (n=190)**	**100% (n=110)**

Education of Former Decathletes versus Non-decathlete Students at Time of Survey		
Education Variable	**Former Decathletes**	**Non-decathlete Students**
Currently in undergraduate college studies	3.2%	
Completed some college or associate's degree and no longer in college	1.1%	26.4%
Completed college or university degree	24.7%	40.0%
Currently taking graduate courses	10.5%	6.4%
Completed some post graduate work or a graduate degree	50.0%	27.3%
Did Not Respond	10.5%	0.0%
Total	**100% (n=190)**	**100% (n=110)**

Income of Former Decathletes versus Non-decathlete Students at Time of Survey		
Income Variable	**Former Decathletes**	**Non-decathlete Students**
Less than $10,000	2.6%	0.9%
$10,000 but less than $35,000	5.8%	8.2%
$35,000 but less than $50,000	7.9%	10.0%
$50,000 but less than $75,000	20.5%	14.5%
$75,000 but less than $100,000	15.3%	20.9%
$100,000 but less than $150,000	11.1%	20.0%
$150,000+	10.5%	1.8%
Do not know	2.1%	1.8%
Declined/Did Not Respond	24.2%	21.8%
Total	**100% (n=190)**	**100% (n=110)**

The decathlete survey respondents were not selected by random sampling; therefore, hypothesis tests to determine if there was a difference in the survey responses for each demographic variable between Former Decathletes and Non-decathlete Students were not applicable.

Appendix B:
Logic Model for Solar Decathlon Report

The three-page 2008 program logic model beginning on the next page is the Department of Energy's logic model used for this evaluation study. The grey shading identifies the audiences and outcomes included in the evaluation.

The logic model diagram is a process-flow chart. The vertical arrows indicate the order in which activities occur and outputs are created for each audience. The horizontal arrows indicate interactions and interrelationships within and between activities and outputs.

SOLAR DECATHLON LOGIC MODEL (2008)

RESOURCES

Budget, Knowledge of efficiency & renewable markets, Market-ready efficient appliances, products and solar PV

ACTIVITIES

Planning & Information Development	*Collaborative Development*	*Marketing*	*Host Decathlon Event*	*Post Decathlon Activities*	*Monitoring & Evaluation*
• Team planning • Rules & regulations • Communications development • Media planning • Sponsor planning • Future Decathlon planning	• Solicitation of Teams • Recruit corporate sponsors	• Media outreach & management	• Selection of judges • Review home designs • Instrumentation • Recruit volunteers • Stagecraft procurement • Assembly of village • Safety code compliance • Onsite workshops	• Continued education (e.g., products website) • Permanent siting of Solar Homes	• Media analysis • Website stats analysis

- Establish solar BIPV research networks
- Building research

- Solar benchmarking activities

- Energy monitoring

OUTPUTS

Planning & Information Development	*Collaborative Development*	*Marketing*	*Host Decathlon Event*	*Post Decathlon Activities*	*Monitoring & Evaluation*
• Websites • Media kits	• Selected Teams • Sponsoring packages (letters, MOUs) • Secured corporate sponsors	• Secured media coverage in print, TV, online, radio & magazine	• Procured stagecraft • Safely run event • Completed workshops	• Products website created • Events Review Reports	• Media analysis report • Web stats report

- Media Plan Report
- Media list

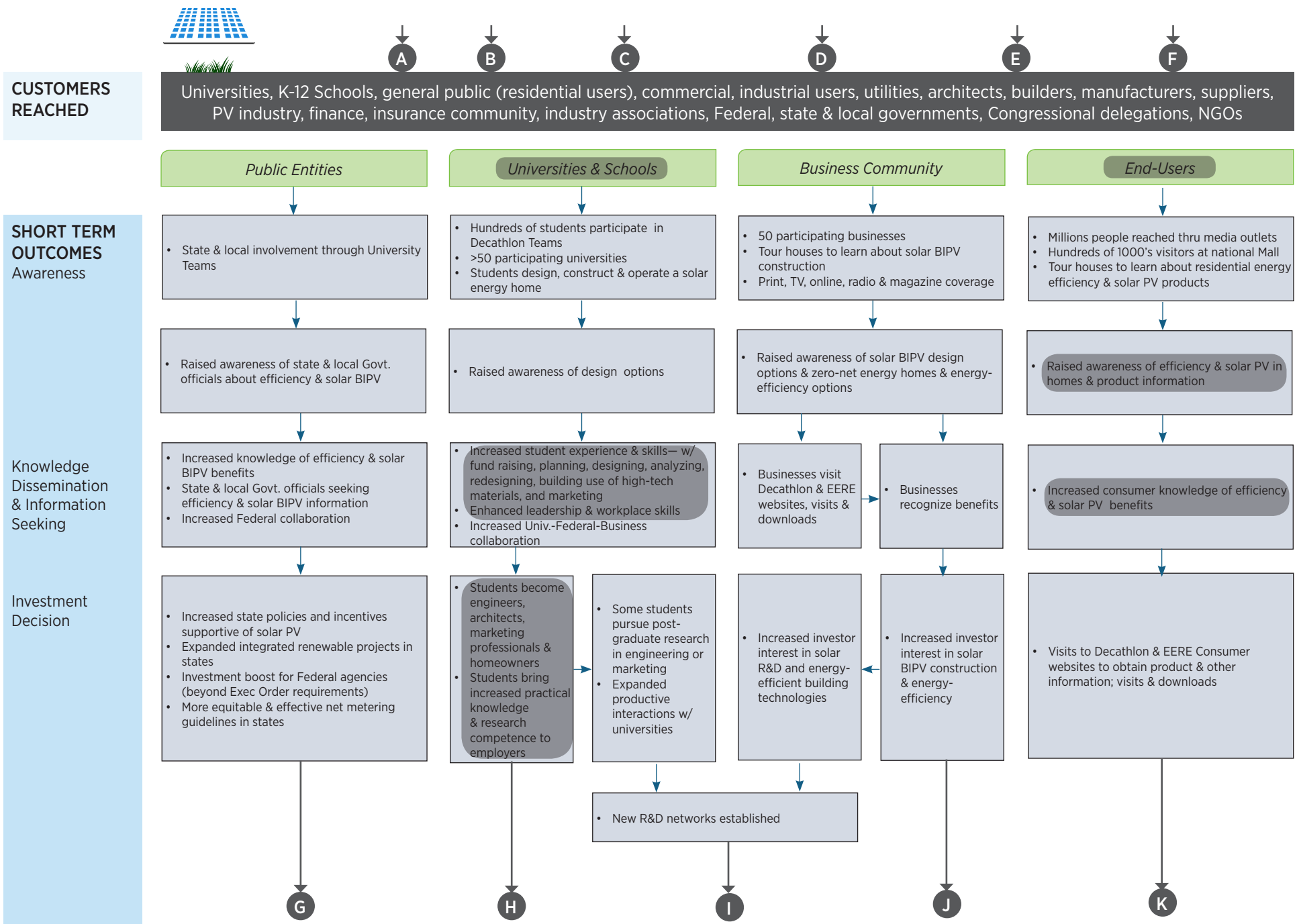
- Solar BIPV R&D networks created
- Building R&D outputs

- Installation of building energy monitoring systems at selected permanent sites

- Real time performance data for houses at permanent sites

- R&D feedback to DOE for use in solar BIPV R&D planning
- Calibration of detailed computer models using information from monitored houses to improve future Decathlons

A B C D E F


CUSTOMERS REACHED
A
B
C
D
E
F
Universities, K-12 Schools, general public (residential users), commercial, industrial users, utilities, architects, builders, manufacturers, suppliers, PV industry, finance, insurance community, industry associations, Federal, state & local governments, Congressional delegations, NGOs
Public Entities
Universities & Schools
Business Community
End-Users
SHORT TERM OUTCOMES
Awareness
• State & local involvement through University Teams
• Hundreds of students participate in Decathlon Teams
• >50 participating universities
• Students design, construct & operate a solar energy home
• 50 participating businesses
• Tour houses to learn about solar BIPV construction
• Print, TV, online, radio & magazine coverage
• Millions people reached thru media outlets
• Hundreds of 1000's visitors at national Mall
• Tour houses to learn about residential energy efficiency & solar PV products
• Raised awareness of state & local Govt. officials about efficiency & solar BIPV
• Raised awareness of design options
• Raised awareness of solar BIPV design options & zero-net energy homes & energy-efficiency options
• Raised awareness of efficiency & solar PV in homes & product information
Knowledge Dissemination & Information Seeking
• Increased knowledge of efficiency & solar BIPV benefits
• State & local Govt. officials seeking efficiency & solar BIPV information
• Increased Federal collaboration
• Increased student experience & skills— w/ fund raising, planning, designing, analyzing, redesigning, building use of high-tech materials, and marketing
• Enhanced leadership & workplace skills
• Increased Univ.-Federal-Business collaboration
• Businesses visit Decathlon & EERE websites, visits & downloads
• Businesses recognize benefits
• Increased consumer knowledge of efficiency & solar PV benefits
Investment Decision
• Increased state policies and incentives supportive of solar PV
• Expanded integrated renewable projects in states
• Investment boost for Federal agencies (beyond Exec Order requirements)
• More equitable & effective net metering guidelines in states
• Students become engineers, architects, marketing professionals & homeowners
• Students bring increased practical knowledge & research competence to employers
• Some students pursue post-graduate research in engineering or marketing
• Expanded productive interactions w/ universities
• Increased investor interest in solar R&D and energy-efficient building technologies
• Increased investor interest in solar BIPV construction & energy-efficiency
• Visits to Decathlon & EERE Consumer websites to obtain product & other information; visits & downloads
• New R&D networks established
G
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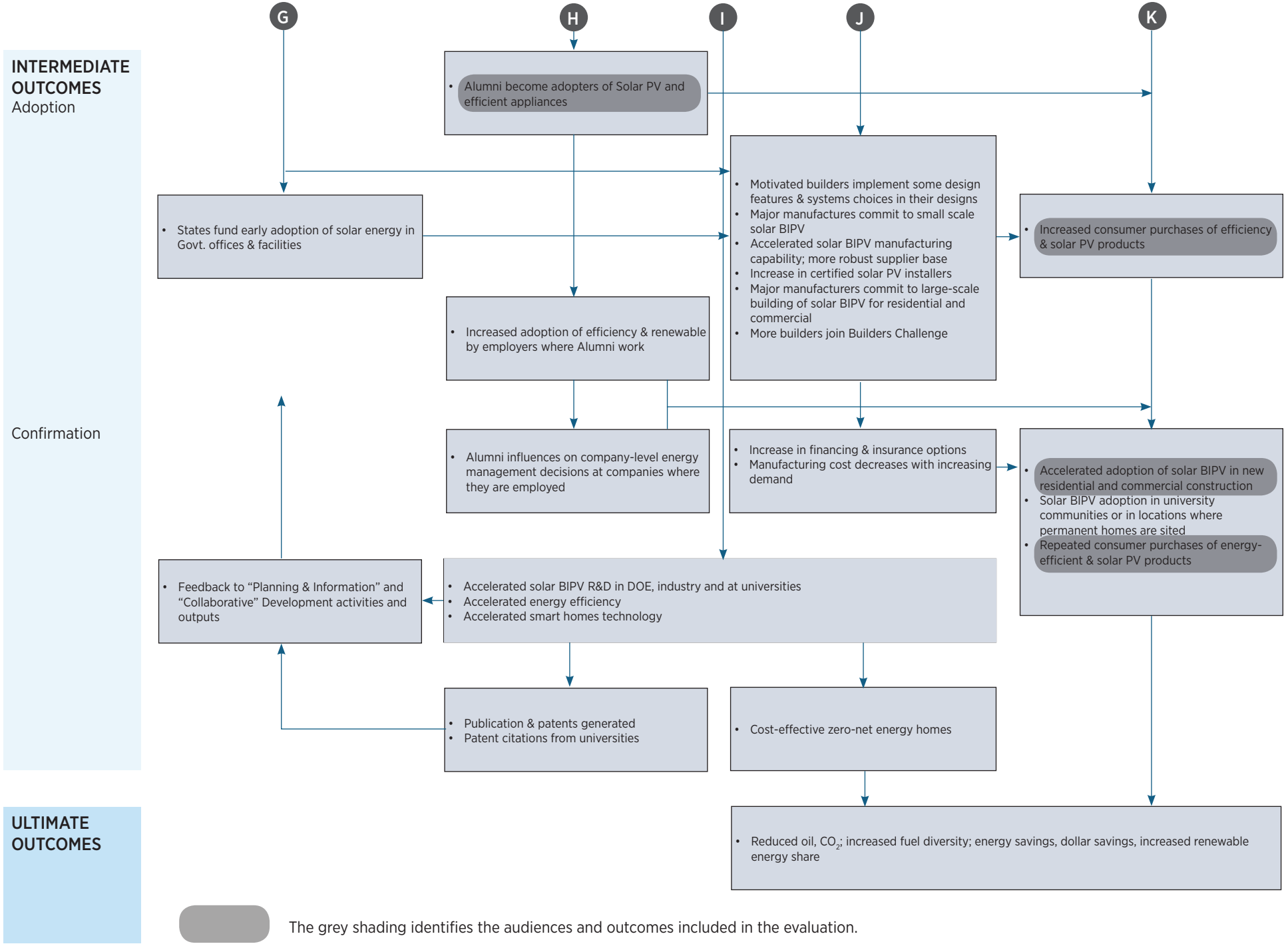
K
The grey shading identifies the audiences and outcomes included in the evaluation.


G
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INTERMEDIATE OUTCOMES
Adoption
Confirmation
ULTIMATE OUTCOMES
• Alumni become adopters of Solar PV and efficient appliances
• States fund early adoption of solar energy in Govt. offices & facilities
• Motivated builders implement some design features & systems choices in their designs
• Major manufactures commit to small scale solar BIPV
• Accelerated solar BIPV manufacturing capability; more robust supplier base
• Increase in certified solar PV installers
• Major manufacturers commit to large-scale building of solar BIPV for residential and commercial
• More builders join Builders Challenge
• Increased consumer purchases of efficiency & solar PV products
• Increased adoption of efficiency & renewable by employers where Alumni work
• Alumni influences on company-level energy management decisions at companies where they are employed
• Increase in financing & insurance options
• Manufacturing cost decreases with increasing demand
• Accelerated adoption of solar BIPV in new residential and commercial construction
• Solar BIPV adoption in university communities or in locations where permanent homes are sited
• Repeated consumer purchases of energy-efficient & solar PV products
• Feedback to "Planning & Information" and "Collaborative" Development activities and outputs
• Accelerated solar BIPV R&D in DOE, industry and at universities
• Accelerated energy efficiency
• Accelerated smart homes technology
• Publication & patents generated
• Patent citations from universities
• Cost-effective zero-net energy homes
• Reduced oil, CO_2; increased fuel diversity; energy savings, dollar savings, increased renewable energy share
The grey shading identifies the audiences and outcomes included in the evaluation.

Appendix C: Decathlete's Open-ended Comments about Their Solar Decathlon Experience

Appendix C lists the Former Decathletes' open-ended comments on the Solar Decathlon. The comments have been edited only to remove information that might identify which school or individual made the comment and to correct obvious misspellings.

Former Decathlete Comments

1. From the standpoint of architectural education, the Solar Decathlon is a fantastic educational opportunity for architecture university students. Students have the opportunity to interact with other different disciplines, work as a team, learn about design strategies and measures that reduce building energy use and get hands-on construction experience (if involved in later project design phase). I hope that universities will choose to take part in the Solar Decathlon and encourage students to do so. While it's a big commitment on part of the university, the rewards are just as great.
2. Classroom education is great but the actual participation in designing, building, and testing a real house is an education that cannot be replicated in the classroom and, in my opinion, is much needed real life experience!
3. Great experience
4. Rock on, but keep it in D.C.!
5. The Solar Decathlon was the most amazing, life-consuming, life-changing experience, ever, and I hope many more students, faculty, and visitors have the chance to learn through it!
6. The Solar Decathlon was the formative experience that I had in college (undergrad + grad)- an incredible journey with fantastic people and experiences that just isn't possible in a typical curriculum or extra-curricular activity. It changed my life and caused me to pursue my current career in solar energy.
7. This was an EXCELLENT program. I hope it will remain, as it was an incredible learning experience.
8. The Solar Decathlon was a formative experience for nearly everyone at my school! Not only did multiple studios aid in the successful design, but many of us helped build it as well. In fact, the studio inspired further eco-studios at the school which continue to operate.
9. It was invaluable in my education as an architect, invaluable in my understanding of proper building and efficient design.
10. The SD was a life changing experience for me. From the months prior to arriving in D.C. to the competition to the months following the competition, the intensity of the experience allowed me to gain an unparalleled amount of knowledge about building energy performance and construction of energy efficient residential buildings. I have capitalized on that experience and will continue to do so throughout the rest of my life as an architect. So far I

have helped a regional economic development organization, a modular startup enter the energy performance market. This is only the beginning. A great, great experience!!

11. It was a great experience, but we did experience governmental censorship regarding current Energy Policy as we attempted to discuss it at events in D.C. I feel the event should be moved back to Washington, D.C.
12. This survey was a bit too long and poorly written.
13. Solar Decathlon is a phenomenal program that has heavily influenced my education. During the competition, I had a B.S. and M.S. in mechanical engineering with an emphasis on energy conversion and energy efficiency. I am now completing a Ph.D. in solar energy storage. Solar energy combined with energy efficiency is cost competitive with "conventional technology" for hundreds of millions of people, including millions within the U.S. The central objective of the Solar Decathlon moving forward should be to highlight this fact for students, Americans, and policy makers so that the U.S. can join the revolution presently occurring throughout the rest of the world.
14. I think the advisor(s) of the project make a very big difference in the experience for the Decathlete. You may want to consider putting more emphasis on evaluating the leadership and project management capabilities of the team advisors.
15. Solar Decathlon needs to be about more than just solar energy and solar panels. It needs to be about sustainable design and living and about all forms of renewable energy. Wind, solar, solar thermal, etc. The scoring system for the competition should reflect affordability and other factors with as much or more importance than how much solar energy the house can produce. The competition (and therefore the educational) focus should be more about energy reduction, improving lifestyle choices, and therefore needing less energy, NOT about creating more energy. The years I was involved directly (or indirectly) with the Solar Decathlon, the team that created the most energy won the competition. A million dollar 800 square foot house is not sustainable. Cheers!
16. In addition to all the criteria in the Decathlon - affordability or price should be one of the key criteria that were not considered.
17. The Solar Decathlon was the most influential experience of my college career. It nicely rounded out my textbook education with a hands-on project. With the Decathlon it was make it work or fail; I have since discovered that is true in the corporate world as well. Every team that participates in the Decathlon is a startup company that has to operate within the limits of a budget, a set of school rules and bureaucracy, has an R&D team, operations team, marketing and sales department and is ultimately responsible for getting a product to market. I learned more than engineering during my time in the Decathlon; I learned how to be a professional.
18. Solar Decathlon has been the launching pad for years of involvement in sustainable planning and development at my institution. I enjoyed may experiences with Decathlon the most out any involvement I had as undergraduate and found it to be the most rewarding socially, educational, and as a means of developing my human capital. The lack of interaction between the DOE and the institutions in the development and structure of the teams seems, in retrospect, has caused extreme differences between teams; I would imagine those differences have effected team performance and experience at least to the same extent as differences in

faculty/institutional resources, teams' particular designs and strategies, and changes made to the competition's structure.

19. As Safety Officer of my team, I would like you to take a look at your onsite safety procedures when working at night. The rules made it necessary to shut off the boom lights, as once our generators were to be turned off, the power required to power them would penalize our team. This led to situations where workers were performing rather dangerous work by flashlight, which I found less than ideal. In future competitions, please address this issue.
20. Amazing experience. One of the first questions this survey asked was whether SD inspired me to change my major. I haven't changed my major yet, but I'm giving it significant thought, especially regarding my graduate degree.
21. The Decathlon was an invaluable experience that helped prepare me to enter the workforce in the field of renewable energy and energy efficiency.
22. Needs to be a more open-minded competition. Ingenuity comes from thinking outside the box, but is not rewarded in the competition. Additionally, rules are confusing to understand/interpret. It seems success lies in partaking in the competition twice.
23. My experience participating in the 2007 Solar Decathlon was meaningful, educational, and very valuable to me.
24. Yea, the competition should be urban focused, nobody lives in villages any longer!
25. The team work, planning and implementation of the product led me to my Grad Studies with System Management. I became very aware that the technology exists, in many cases off shelf, the political will and infrastructure is what is lacking. The U.S. is far behind with government backing of green energy. It will take time to weed out bought and paid for congressman tied to corporate's immediate profits. This has always been the case, safety features in automobiles comes to mind in the '50s
26. One complaint about how the juried contests are run. The judges had no formal point system to go off of. They did not seem to give points out equally, or at the same rate as other juried contests. For example, Architecture judges scores ranged from 90s to 80s, while engineering, scores ranged from 90s to 50s. This inconsistency in scoring ranges makes the competition unfair and unbalanced. By doing this, you are putting more emphasis on some categories than others. To fix this inconsistency, the DOE needs to organize a point-based system where the judges grade the houses based on a fair and equal system. The juried contests need objectives and a point system that each house is graded by. Each jury will subtract the same amount of points based on how that house met the criteria.
27. I was completely unaware of the solar industry prior to working on the Solar Decathlon. My intention was to become a professor because I was struggling to find a meaningful occupation in the business world. After my amazing experience with the Solar Decathlon I only applied to work for solar companies. I've been in the industry for over three years and I love what I do. Thank you for everything,
28. This was a wonderful opportunity for all participants and all schools. I am also glad to see the Decathlon has grown to encompass more countries and technologies. While it was an often painful experience, especially in those early years, it helped me personally to

understand my life/career path, form lasting bonds with persons around the globe and I know it helped my college to take a more serious look at the need for sustainable and energy efficient education. Thank you!

29. It is an amazing hands-on opportunity for engineers, architects, and anyone interested in EE or RE.
30. Positive, life changing experience. Thank you.
31. It was a really grateful experience. Belonging to a team which worked so hard during a whole year, and especially during the competition, taught me a lot about the importance of belonging to a team, and that the effort is the path to obtain the best things. I also learned how to build a non-emissions home, and I will apply this knowledge in the future in my own home as well as in my professional career. Thanks a lot for the opportunity to participate in the competition.
32. In fact the Solar Decathlon was the start for many projects we generated in this field. It gave us the possibility to combine theoretical work with practical work.
33. Fantastic experience for all involved! The experience has certainly changed my life for the better and has given me opportunities that I otherwise might have ignored. These include a teaching position, and a dual Master's degree in Sustainability in the Urban Environment & Environmental Systems Management.
34. I think: we need better food services at the construction site, ESPECIALLY during construction. Analyze the locale of the Great Park at Irvine, and make sure it is easy for all decathletes to have access to FOOD.
35. I participated in the first competition and had a wonderful experience. My only complaint was that the point structure changed during the two-year period leading up to the competition, which impacted my team.
36. I thought that doing Solar Decathlon was one of the very best decisions that I have ever made. It was an incredible experience. I wish that there were a sustainability category of the competition where teams are also judged on factors like the embodied energy of their home. It is important to make environmentally-sound decisions in all aspects of the project beyond just buying solar panels. Teams that make environmentally sound decisions should be rewarded.
37. Thanks! But please, for future reference, follow the announcement dates posted on the DOE website...
38. Literally the greatest and most difficult and most hated experience of my college career. Never have I seen people pushed to the limit combine talents to produce so much.
39. The Solar Decathlon has improved my life and I will carry its experience with me for the rest of my life. I anticipate it being the most outstanding item on my resume when I begin applying for jobs and it already has presented opportunities to me in my graduate program (M.S. in Sustainable Engineering). Thank you and I hope it continues to change lives.
40. The judging was often not done by open-minded professionals. In the 'architecture' category, the judges were largely home-builders as opposed to architects and they seemed to develop their own specific criteria for judging (greatest result with the least resources), rather than

judging based on architectural merit and inventiveness. In the engineering categories the judges seemed unwilling to understand new ideas, if they didn't understand components of our system that were not yet in wide-spread use, they didn't endeavor to learn how they worked and instead seemed to ignore what they had no interest in trying to understand. In both cases inventiveness was not rewarded. The Solar Decathlon was however one of the greatest experiences of my life.

41. The Solar Decathlon was an invaluable educational experience. Not only did it teach me much about renewable energy and engineering, but it taught me more about project management and leadership than anything else I can imagine having done.
42. To be succinct; Solar Decathlon was an extremely worthwhile and life changing experience. It was the highlight of my academic career.
43. It wasn't so much the first place win that affected me, but the interdisciplinary work, team building, leadership, community outreach, and the final product that shaped my future goals. The whole experience made me realize that integration within the design process was important from the environmental design aspect, and I needed to continue this philosophy for future sustainability.
44. Ironically, I design simple cycle gas cycle power plants now for utilities that need spinning reserve to account for the wind they are building.
45. Overall, a fantastic experience. Confident all my fellow decathletes feel the same.
46. The Solar Decathlon was the most valuable learning experience I could possibly have hoped for in my 3 years of University education. It deserves to go from strength to strength in putting the message of lower-energy living out in the public domain.
47. Running my school's Solar Decathlon team was one of the keystone experiences in my college education. I learned more about leadership, hard work, collaboration, and working in a team than anywhere else. I went on to work in something unrelated. But I never would have gotten a great first job without the experience.
48. Best college educational experience.
49. It was great!
50. It is without hesitation that I can state that the Solar Decathlon was my most influential learning experience while I was at my university. Beyond the hands-on technical experience I received, I had the opportunity to develop leadership competencies that have served me well in my career. I can think of no college course that better prepared me for the working world and consider the experience instrumental to my quick ascent into engineering management at my current company. As a hiring manager, I have recruited alumni of this competition as I believe it helps fully prepare students in a way that typical college courses do not offer. If there is anything else I can do to help support the advancement of the Solar Decathlon, I would welcome the opportunity. Regards.
51. The West Potomac location was not a good location. The shuttle bus did not have good hours, especially during construction days, which forced a lot of decathletes to walk to the nearest station after long work shifts. I am sure Irvine will be much better. D.C. had great symbolic importance, but with kicking us from the National Mall comes an understanding that we must go where the leaders are more appreciative. The 30s and 40s might be the best

time where CA created the American Dreams and standards, the 60s and 70s where CA was still the Golden destination to settle and prosper, but today I bet Irvine will pose a "welcome home" feeling to all competitors and prove we don't need to build in front of distracted and lumbering politicians to get their full attention.

52. My experience during the Solar Decathlon is something I will always consider a highlight of my life. The experience is one that I have encouraged students from my alma mater to pursue as it is a great learning experience for students to build a house and measure how it works. I believe events like this are engaging to future leaders and will put us on the path to leadership in the future of energy technology.
53. It was a great experience, though I had three years earlier built a house with solar electricity, solar water heating, green products and a rainwater catchment system. I had also started a nonprofit to promote sustainability and energy efficiency. The Solar Decathlon gave me additional credentials.
54. The Decathlon had a profound impact on my life. I cherish the experience.
55. Leading our Solar Decathlon team and building our house was the defining accomplishment of my undergraduate education.
56. The Solar Decathlon was the most powerful experience of my intensive graduate program. Besides becoming a focal point for the University and community's sustainability efforts, it also cultivated talents and skills in all of the est. 60 major participants. It directly resulted in various graduate research projects, public outreach and education, local renewable installations, and many "green" jobs for the team. Everyone can agree that this was one of the most influential and memorable experiences of their life.
57. You should sell Solar D merchandise during the event...umbrellas, water bottles, solar powered toys, t-shirts for the teams
58. The U.S. Energy Policy needs to change. FAR too much tax payer money is wastefully spent on subsidizing Big Oil companies. Those companies already own the most profitable money making machines in history with record profits every year. So why then would we ever give them money from our Treasury?! We need the Solar Decathlon to train young students in the energy industry. And we need to start subsidizing green companies so that they have jobs when they graduate.
59. The Solar Decathlon changed my life. I have the confidence to go out and change the world for the better because of the project.
60. A truly pivotal experience...knowledge of residential renewable energy strategies and solutions is wholly due to the Solar Decathlon event.
61. Your survey seems to assume that I participated in the Solar Decathlon as an undergraduate. For me, it was part of grad school when I was pursuing my M. Arch as a first professional degree.
62. Fantastic experience that MUST be available to all students across the country.
63. I think it's too bad that you changed up the regulations that made it so hard for a community college to take part on their own instead needing to partner up with another school. It was a major disservice.

64. Even though I had already made an educational and professional commitment to energy-efficient design, the Solar Decathlon was a game changing experience. It was an ideal bridge between my academic and professional work and was the first collaboration with my current business partners. We launched an architecture and mechanical design firm soon after the 2005 competition. Now, six years later, we have weathered the economic downturn, which I believe is largely a result of our niche in high performance homes. Our most recent hire was a Former Decathlete; the experience he gained from participating in the competition was a primary factor in our decision to hire him.
65. Put the Solar Decathlon back on the main part of the National Mall next time.
66. Awesome Ride! Thanks for the experience.
67. Opportunity of a lifetime. Focus on sustainability in the future: promoting spray foam is not going to help us deal with global climate change or landfill waste
68. Amazing experience. I hope the Solar Decathlon continues for many years to come.
69. Being on the Solar Decathlon team was an amazing experience. I still read environmental blogs and went to last year's decathlon. Without the marketing experience I gained working on the project I may not have been able to find a job out of college.
70. The Decathlon offers a unique experience for students to work on a multidisciplinary team of students, faculty, and professionals (industry experts). Everyone that gets involved with this project learns something along the way. Students especially learn things that classroom or semester-long projects cannot teach. The Decathlon should work more closely with universities to give more support to the faculty that are involved with the project. Depending on the school, the faculty advisers may have to act as a university professor and researcher, AND the project adviser which can be a full time job in itself. They may not receive recognition for the hard work that they put in, from the university. So, it may be hard for students to recruit dedicated and fully engaged faculty advisers.
71. The Solar Decathlon was a phenomenal experience. The biggest hindrance/obstacle to participation from a team's perspective is the cost of such an endeavor. Our team accumulated so much debt that more than 2 years after the fact, the house we created remains in pieces and has not been re-erected. This is a tragedy - The houses should be made to be part of a community with a final build site perhaps, rather than just an exhibition piece like a circus - a real living lab that can track development of the technology over time and show what works and does not work in terms of long-term durability. There is so much to be learned from these structures, that 15 days of public exhibition only really scratches the surface of their potential.
72. It should be moved back to the center of the National Mall; the new site decreases viewing and impact of the event.
73. The Solar Decathlon was the capstone of my education at my school of architecture. It was a great experience.
74. Even though I couldn't stay on my Decathlon team till the end due to school work, it was an eye-opening experience to learn about how solar energy can be a promising alternative to fossil fuels. I do hope my school can be selected again for future Solar Decathlons.

75. Unbelievable experience. I learned essentially EVERYTHING I know about green design, detailing, and gained construction experience. I also met a client while giving tours in D.C., and subsequently designed her a net-zero energy house. I wonder, however, if the whole thing couldn't be localized. Such effort and cost went into shipping the project, and requiring that we ship the house across the country limited the design's market relevance. I think a consortium of local academic design-build projects might be just as effective, and would certainly be more affordable for the universities.
76. The Solar Decathlon was the single most significant event in my career in energy efficiency and renewable energy. This DOE-funded program is crucial to igniting the next generation of the EERE workforce and couldn't be more in line with what the President called for in his 2012 State of the Union address. Bring the Solar Decathlon back to front and center on the National Mall where it belongs and fund it for the next decade.
77. The experience was really fabulous but I felt like the audience was rather limited, especially with houses that were sold to private buyers rather than being able to be accessible to the public afterward.

Faculty Advisor Comments

78. The Solar Decathlon provided a great training ground for students and the opportunity to demonstrate the power of renewable energy to fully power our daily living needs. As a result of the SD experience, I designed a new home that is a true net-zero solar powered home at a cost competitive with neighboring homes. The primary difficulties to encourage others are: 1) Education and awareness of cost and performance of solar energy 2) Improved appraisal process that recognizes value of house efficiency and solar collection system for increase bank mortgage to cover up front cost 3) Improved marketing to turn renewable energy from a "like" to a "want"
79. Q? 19: failed to specify the amount of shading at south facing and east facing sites, so no answer is possible. Q? 31: I have a D.C. chest refrigerator made by an engineer that beats any Energy Star refrigerator in efficiency, but his business is too small & poor to afford an Energy Star label. Please stop using "solar panel" for both PVs and solar thermal technologies (some of which aren't panels) - it confuses the layperson. Don't give the Solar Decathlon too much credit for my accomplishments or those of my students - I was doing and teaching EE & RE for decades before SD2007, and will continue afterwards for decades to come. Training as a Certified Passive House Consultants in the USA educated me better and had more influence on my activities than SD ever did.
80. It's a great program; please keep up the good work! Even better, put it back on the Mall where it is more easily accessible and/or move it around the country to reach out to as much of the American public as possible (I know this was being discussed to some degree).
81. It was an excellent experience. I was a professor of architecture in 2001 when we learned of the competition. We had only half the time of most of the other participant institutions and ran into funding problems. Yet we did get to the competition and the students had a unique experience. Overall, this is a wonderful opportunity for the students and is helpful for the general population to reflect upon what can be done today.

Appendix D:
Impact Evaluation Plan for Future Solar Decathlon Evaluations

The following table provides high-level recommendations for a future evaluation of the Solar Decathlon. Inasmuch as this evaluation has targeted homeowners and Former Decathletes, it is recommended that a future evaluation target one of the Solar Decathlon's other audiences described in its logic model (see Appendix B).

Impact Evaluation Plan for a Future Solar Decathlon Evaluation

Design Element	Considerations and Options
Audiences and objectives	Future evaluations should evaluate the effectiveness of the Solar Decathlon on its objectives as they apply to audiences not addressed by the current evaluation. These include: • Public governments with zoning and regulation-approval authorities. • Trade allies such as design-build firms, contractors, equipment manufacturers. • Trade associations supporting manufacturers and installers of clean-energy equipment. • Universities' and colleges' engineering and architecture department faculties and curricula • Local elementary and high school curricula and faculties • Financiers • Clean-energy equipment manufacturers • Households of students who visited a Solar Decathlon on a field trip.
Treatment	From an experimental design viewpoint, the Solar Decathlon is considered to be a "treatment" for those who either visit it or learn about it through the media or word-of-mouth. This outline for a future evaluation uses the term "treatment" to mean exposure to the Solar Decathlon.
Outcomes to evaluate	Use the logic model to select outcomes appropriate to the selected audiences. Limit the outcomes to between three and six; this will ultimately improve data-collection response rates by shortening the interviews.
Unit of analysis	Will depend on the audience (e.g., a department chairman in an engineering department or president of a solar installation company).
Level of analysis	Will depend on the audience (e.g., mortgage banks, credit unions, energy-efficient appliance dealer).
Scheduling	The elapsed time required to obtain approval of the questionnaires must be considered. It can take up to a year to obtain OMB's approval of an Information Collection Request. A minimum of two years should be allotted for design, review, data collection, analysis, and reporting.

(Continued)

Design Element	Considerations and Options
Research questions	The research questions will be determined by the Solar Decathlon audience selected as the target for the evaluation and the outcomes chosen for evaluation. See the Research Design and Data Collection topics for other considerations affecting the selection of research questions. Ask more questions about use of efficient appliances and lighting products. Evaluate any assumptions used in designing the questions and prepare for the possibility that an assumption might be incorrect for one or more audiences. Consider whether to include questions that address higher-level policy issues such as the following: • Is the program still relevant to the needs of the U.S.? • Is it necessary for the federal government to operate this program, or could it be transferred to other levels of government or to the private or voluntary sector? • The following questions, recommended in peer review, amount to adding a process evaluation to the impact evaluation: - Are the program's resources being used in the most efficient and effective way to deliver appropriate results? - Are there more effective program structures and service delivery arrangements? - Are program management practices appropriate and of sufficient quality?
Research Design	Carefully assess whether a quasi-experimental design is feasible at reasonable cost for application to any of the audiences addressed by the evaluation. For the focal audiences listed above, it may be that a non-experimental approach using self-report as the source of impact information, is the optimal design. If a pre-/post-treatment quasi-experimental design is preferred, the evaluation should use the 2015 (or later) Solar Decathlon as treatment and collect pre-treatment data on the target audience as soon as DOE establishes a location. It should then collect demographic and predisposition data on a random sample of 500 visitors as they enter the Solar Decathlon village and attempt to obtain contact information for a follow-up interview two years after the Solar Decathlon. The time typically required for approval by the U.S. Office of Management and Budget (OMB) for a data collection (up to a year) precludes using the 2013 Solar Decathlon as the treatment. See the Data Collection topic for more information on potential OMB requirements. If pre-treatment data can be collected, and tests of statistical significance are not required, explore the use of a matched-pair design with matching accomplished after the Solar Decathlon being evaluated. This research design might be applicable to audiences other than homeowners and Former Decathletes[49] If pre-treatment data collection is not feasible, the evaluation may be based on all Solar Decathlons, a subset of them, or a single the Solar Decathlon as the treatment and use the post-treatment-only design used for this evaluation with mixed methods, retrospective pre-treatment data collection on variables that are associated with multiple rival hypotheses, and cluster analysis to create a similar subset of treatment units. However, if multiple Solar Decathlons are used, see "Geographic level of analysis" on the following page.

(Continued)

[49] Cook and Campbell 1979, 175-182.

Design Element	Considerations and Options
Geographic area of analysis	Select a large market area around the location of the chosen Solar Decathlon. If the audience will be businesses, area(s) compatible with geographic regions delineated by the most recent available Bureau of the Census Survey of Business Owners (SBO) are recommended for population estimates, sample design, and possible non-response assessment. The area should also have an established media market and roadway system that facilitates travel to and from the Solar Decathlon. If the audience will be residential end users, Metropolitan Statistical Areas should be appropriate. If the treatment is to include historical Solar Decathlons, then the geographic level of analysis must also include a similar region surrounding the historical Solar Decathlons.
Sample design	Random sampling is preferred because it enables the variety of statistical tests, confidence intervals on point estimates, and relationship estimations; however, it may not be feasible for business and university audiences because of the expense of creating a credible sample frame and the difficulty in getting access to a qualified and authoritative spokesperson. Business lists are available commercially through Dun & Bradstreet, Selectory, and InfoUSA and can serve as a working sample frame if they have good NAICS codes. The Census Bureau's SBO will not identify specific businesses. Trade associations for the audiences included in the evaluation may provide guidance to lists of members. It will probably be more practical to conduct interviews with a representative sample that is not random. Non-random sampling will shorten the paperwork required for the OMB process by eliminating the requirement for Part B of the Information Collection Request (ICR) (required for statistical collections).
Sample Size	If the data collection will be random, use statistical power analysis and expected quantitative results on the research questions to determine the sample sizes needed. If most of the findings will be proportions (a likely consideration), a confidence level of 90% and one-sided tests for equality of proportions will be appropriate.
Data Collection	Multimodal methods are preferable. Potential respondents should be contacted, usually by mail or e-mail, inviting them to take the survey. This approach should be repeated at least twice before abandoning the contact. The survey should be offered as a mail, online, or telephone survey. If mail is used, delivery by Express Mail or FedEx will increase the response rate. The data collection instrument should take no longer than five minutes to complete to improve chances of acceptance. This will limit the evaluation to three to six outcomes. All data collections sponsored by the federal government must be approved by the OMB. If a self-report research design is chosen (i.e., no individuals will serve as a comparison group), it may be possible to obtain OMB approval through the faster generic approval process. This process applies to satisfaction surveys; the wording of the questionnaires would need to be predominantly satisfaction oriented. Should be random if results with statistical significance are desired. If statistical significance is not needed, collect as many sample points as possible. The number will depend on the target audience.

Appendix E:
Survey Questionnaires

Appendix E.1 Homeowner Telephone Questionnaire

The answers to questions V8 and N3 that were counted as correct for the Knowledge analysis for the homeowner education objective are listed in the Addendum to Appendix E.1 which appears at the end of the Homeowner Telephone Questionnaire.

SOLAR DECATHLON EVALUATION
HOMEOWNER TELEPHONE SURVEY
OMB Control No. 1910-5161

THIS SURVEY HAS TWO TRACKS. IT WILL NOT BE POSSIBLE TO KNOW BEFORE CALLING WHETHER THE RESPONDENT HAS VISITED A SOLAR DECATHLON OR NOT; THEREFORE, SEPARATE TRACKS ARE PROVIDED FOR VISITORS AND FOR NON-VISITORS. THE TRACK TO USE IS DETERMINED AT QUESTION A2.

ALL-CAPITALS INSTRUCTIONS IN [BRACKETS] ARE FOR THE INTERVIEWER AND WILL APPEAR ON THE CATI MONITOR. INFORMATION IN A BOX IS FOR CATI PROGRAMMER.

NUMBERING LEGEND:
S = SCREENER QUESTIONS
A = ALL RESPONDENTS, AWARENESS QUESTIONS
V = VISITOR QUESTIONS
N = NON-VISITOR QUESTIONS

SCREENER QUESTIONS, ASKED OF ALL WHO TAKE THE CALL

S1 Hello, my name is _____. I'm calling from _____ on behalf of the U.S. Department of Energy. I'm calling with a few questions that will help the Department of Energy evaluate homeowners' knowledge and use of solar energy and energy efficient products. The questions will take about 12 minutes. The survey is voluntary and any answers you provide will not be identified to you or shared with the Department of Energy. They will be combined with those of others in the reported results. This call may be monitored or recorded for quality purposes.

May I please speak to a person 18 years or older who is a member of the household?

01 YES. PERSON ANSWERING THE PHONE QUALIFIES → CONTINUE
02 YES, BUT NEEDS TO BRING TO PHONE → [CONTINUE. WHEN PERSON IS ON THE PHONE, REPEAT S1.]
03 NO, NOT AVAILABLE → [GET NAME; SCHEDULE CALLBACK:]
NAME OF QUALIFYING PERSON:
_____
DATE:_____
TIME: _____
AM: ____
PM: ____
04 REFUSED TO PARTICIPATE OR NO ONE 18 YEARS OR OLDER → [TERMINATE]

S2 Are you age 18 or older?

01 YES
02 NO → [ASK IF A PERSON AGE 18 OR OLDER IS AVAILABLE AND IF SO, ASK TO SPEAK TO THAT PERSON OR SCHEDULE A CALL BACK. OTHERWISE, READ:] That is all of our questions. Thank you for taking our call. Have a nice day. [TERMINATE]

PROVIDE CAPABILITY TO RETURN TO S1 IF PERSON AGE 18 COMES TO PHONE OR TO SCHEDULE A CALLBACK.

S3 Does your house stand alone on a lot or stand on a lot and is attached to other houses, such as a townhouse or row house?

01 YES
02 NO → That is all of our questions. Thank you for taking our call. Have a nice day. [TERMINATE]

S4 Do you own the house you live in?

01 YES
02 NO → [ASK IF A THE HOMEOWNER IS AVAILABLE AND IF SO, ASK TO SPEAK TO THAT PERSON OR SCHEDULE A CALL BACK. OTHERWISE, READ:] That is all of our questions. Thank you for taking our call. Have a nice day. [TERMINATE]

PROVIDE CAPABILITY TO RETURN TO S1 IF HOMEOWNER COMES TO PHONE OR TO SCHEDULE A CALLBACK.

QUESTION ASKED TO DETERMINE AWARENESS OF SOLAR DECATHLON.

A1 Every two years, the Department of Energy sponsors an exhibition on the National Mall in Washington, D.C. that demonstrates energy-efficient, solar-powered houses designed by college students. The houses are displayed on the Mall and are open to visitors. This exhibition is called the Solar Decathlon. Have you ever read or heard about this exhibit of solar-powered houses in Washington, D.C.?

01 YES
02 NO
03 DON'T KNOW

IF A1 = 01, CONTINUE. ALL OTHERS SKIP TO N1.

IF A1 = 02 OR 03, THE QUOTA FOR COMPLETED "N" INTERVIEWS = 400. (THE "NOT AWARE, NOT VISIT" QUOTA)

QUESTIONS ASKED TO SCREEN FOR A VISITOR TO THE SOLAR DECATHLON.

A2 Have you or anyone in your household ever personally visited one of these Solar Decathlon exhibitions on the National Mall in Washington, D.C.?

01 YES
02 NO
03 SOMEONE ELSE IN THE HOUSE HAS → [ASK IF THAT PERSON IS AT LEAST 18 YEARS OF AGE AND LIVING IN THE HOUSE, AND IF SO, ASK THAT PERSON TO COME TO THE PHONE AND RESTART AT S1 AND CONFIRM THAT A2 = 01. IF SECOND RESPONDENT CONFIRMS SELECT 01 FOR THIS QUESTION. IF VISITOR CANNOT COME TO PHONE, SELECT 03 AND SCHEDULE A CALL BACK WITH PERSON WHO HAS VISITED A SOLAR DECATHLON.]
NAME OF QUALIFYING PERSON:
_____
DATE:_____
TIME: _____
AM: ____
PM: ____
04 DON'T KNOW

PROVIDE CAPABILITY TO RETURN TO S1 IF SD VISITOR COMES TO PHONE OR TO SCHEDULE A CALLBACK.

IF A2 = 01, CONTINUE. IF A2 = 02 OR 04, SKIP TO N1.

IF A2 = 02 OR 04, THE QUOTA FOR COMPLETED "N" INTERVIEWS = 280. (THE "AWARE BUT NOT VISITED" QUOTA)

QUESTIONS ASKED ONLY OF VISITORS TO A SOLAR DECATHLON (A2 = 01)

V1 How many Solar Decathlons have you visited?

01 ONE
02 TWO
03 THREE
04 FOUR
05 MORE THAN FOUR
06 DON'T KNOW

V2 What years did you visit a Solar Decathlon on the National Mall in Washington, DC? [RECORD AS MANY YEARS AS MENTIONED.]

01 2011
02 2010
03 2009
04 2008
06 2007
07 2006
08 2005
09 2004
10 2003
11 2002
05 NO SPECIFIC YEARS RECALLED

IF V2 = 05, CONTINUE TO V3. ALL OTHERS SKIP TO V4.

IF ONLY ANSWER TO V2 = "2011," READ:
That is all of our questions. Thank you for taking our call. Have a nice day. [TERMINATE]

V3 About how many years ago was your first visit to a Solar Decathlon? [AID TO MEMORY IF V2 = 05.]

01 ONE
02 TWO
03 THREE
04 FOUR
05 FIVE
06 SIX
07 SEVEN
08 MORE THAN SEVEN
09 DON'T KNOW → [ASK FOR AN APPROXIMATE NUMBER OF YEARS AND RECORD. IF RESPONDENT CAN'T PROVIDE AN ESTIMATE, SELECT 09]

IF V3 = 09, SKIP TO N1. ASSUME NON-VISITOR AND COUNT TOWARD THE "AWARE" QUOTA. (SEE INSTRUCTION AFTER A2).

THE QUOTA IS 200 COMPLETED INTERVIEWS FOR RESPONDENTS WHO ANSWER:
A2=01 AND,
V2 = ANY YEAR EXCEPT 2011, AND
RESPONDENTS ANSWERING V2 = 2009, OR V3 = 01 OR 02 DOES NOT EXCEED 40, AND
IF V2=05 AND V3 = ANY ANSWER EXCEPT 09.
(THE VISITOR QUOTA)
IF THE V2 AND V3 CONDITIONS HAVE BEEN SATISFIED (40 VISITOR RESPODENTS), HAVE THE SURVEYOR READ TO EACH NEW REPSONDENT SATISFYING THE CONDITIONS:

That is all of our questions. Thank you for taking our call. Have a nice day. [TERMINATE]

V4 Before you visited a Solar Decathlon, had you ever participated in, or attended any other event that discussed solar energy or energy efficiency for a home?

01 YES
02 NO
03 DON'T KNOW

V5 Do you work in an occupation that sells, markets, or builds solar-energy equipment for homes or commercial buildings?

01 YES
02 NO

V6 I'm going to read three statements about your experience during your visit to the Solar Decathlon exhibition. After each, please tell me if you: agree, neither agree nor disagree, or disagree with each of the following statements.

PRESENT INTERVIEWER WITH STATEMENTS A - C. ROTATE THEM BETWEEN RESPONDENTS.

[READ EACH STATEMENT. AFTER READING EACH STATEMENT, ASK:]
Do you,

01 Agree
02 Neither agree nor disagree
03 Disagree

[DO NOT READ THE FOLLOWING TWO RESPONSES, BUT SELECT IF GIVEN AS RESPONSE.]

04 NOT APPLICABLE
05 DON'T KNOW

A. The Solar Decathlon helped me gain a better understanding of homes that use solar energy than I had before.
B. The Solar Decathlon helped me gain a better understanding of how a home can be made more energy efficient than I had before.
C. The students who described their homes were friendly and courteous.

V7 I'm going to describe three types of information about solar-powered and energy-efficient homes. After each, please tell me if the following information about solar-powered and energy-efficient homes would be very important to you, somewhat important to you, or not important to you.

PRESENT INTERVIEWER TOPICS A - C. ROTATE THEM BETWEEN RESPONDENTS.

[READ EACH TOPIC. AFTER READING EACH TOPIC, ASK:]
Is this information [READ 01, 02, AND 03 AND SELECT THE RESPONSE:]

01 very important to me,
02 somewhat important to me,
03 not important to me.

[DO NOT READ THE FOLLOWING TWO RESPONSES, BUT SELECT IF GIVEN AS RESPONSE.]

04 I ALREADY HAVE OR KNOW HOW TO GET THIS INFORMATION
05 I DON'T KNOW

A. Information on how I could find contractors near where I live who install solar panels.
B. Websites on the Internet where I could learn more about solar energy and energy-efficiency.
C. Information on how I could find a store that sells efficient lighting and appliances near where I live.

V8 Please think for a moment about what you know about houses that collect energy from the sun and use it for electricity or heating. What would you say are the ways in which houses that collect energy from the sun for electricity or heating <u>are different</u> from houses that do not collect energy from the sun for electricity or heating? [DO NOT READ ANSWERS. SELECT RESPONSE CLOSEST TO THAT MENTIONED. AFTER EACH RESPONSE, ASK THE RESPONDENT IF HE/SHE CAN THINK OF ANY OTHER DIFFERENCES. SELECT ALL MENTIONED. (ANSWERS DESCRIBE THE SOLAR HOUSE.)]

01 ARE MORE EXPENSIVE
02 CAN USE THE SUN TO GENERATE ELECTRICITY
03 CAN USE THE SUN TO HEAT ROOMS OR HOT WATER
04 FACE THE SOUTH / LET MORE SUNLIGHT IN
05 HAVE A WALL THAT ABSORBS HEAT FROM THE SUN / TROMBE WALL
06 HAVE MORE GLASS
07 HAVE MOVABLE OUTSIDE WINDOW SHADES
08 HAVE PANELS ON THE ROOF
09 HAVE SENSORS OR TIMERS TO TURN LIGHTS ON AND OFF
10 HAVE VEGETATION ON THE WALLS OR ROOF
11 LOOK DIFFERENT
12 SAVE MONEY / REDUCE UTILITY BILLS
13 THEY DON'T DIFFER/ LOOK THE SAME / DON'T LOOK DIFFERENT
14 TYPICALLY ARE SMALLER
15 USE MORE DAYLIGHT
16 USE MORE ENERGY-EFFICIENT APPLIANCES
17 OTHER → [RECORD] _____
18 OTHER → [RECORD] _____
19 DON'T KNOW → CONTINUE

V9 Had you ever installed solar panels on a house you owned <u>before you visited the Solar Decathlon</u>?

01 YES
02 NO
03 DON'T KNOW

V10 Have you installed any solar panels on your home to generate electricity or to heat rooms or hot water <u>since you visited the Solar Decathlon</u>?

01 YES
02 NO
03 DON'T KNOW

IF V10 = 01 CONTINUE TO V11. ALL OTHERS SKIP TO V13.

V11 Were the panels installed to generate electricity or heat rooms or hot water? [SELECT ALL THAT APPLY]

01 GENERATE ELECTRICITY
02 HEAT ROOMS
03 HEAT HOT WATER
04 DON'T KNOW

V12 How would you rate the influence of your visit to the Solar Decathlon on your decision to install these solar panels? Please answer on a scale of 0 to 10, where 0 means your visit to the Solar Decathlon had no influence on your decision and 10 means your visit was the main influence on your decision to install solar-electric panels.

01 [RECORD RATING; CONFIRM YOUR ENTRY:] ____
02 DON'T KNOW

SKIP TO V16.

V13 Have you ever visited any Internet site that described the availability of utility or state incentives for solar-energy systems to generate electricity or heat for your home?

01 YES
02 NO
03 DON'T RECALL

V14 Since you visited the Solar Decathlon have you given any thought to the advantages and disadvantages of installing solar panels to generate electricity or to heat water for your own house?

01 YES
02 NO
03 DON'T KNOW

IF V14 = 01 CONTINUE. ALL OTHERS SKIP TO V16.

V15 Since you visited the Solar Decathlon have you asked a contractor to offer you a price for installing solar panels to generate electricity or to heat water for your house or have you investigated a price on your own?

01 YES
02 NO
03 DON'T KNOW

V16 After your visit did you install any lighting in your home that you knew to be more energy-efficient than typical incandescent lighting?

01 YES
02 NO
03 DON'T KNOW

IF V16 = 01 CONTINUE. ALL OTHERS SKIP TO V19.

V17 What kind of energy-efficient lighting did you install after you visited the Solar Decathlon? [DO NOT READ LIST. AFTER EACH ANSWER, ASK IF THEY INSTALLED ANY MORE. SELECT ALL THAT APPLY.]

01 COMPACT FLUORESCENT LIGHT BULBS (CFLs)
02 DAYLIGHTING
03 ENERGY STAR LIGHT FIXTURES
04 FLUORESCENT LAMPS
05 LIGHT EMITTING DIODE (LED) LIGHTING
06 LIGHTING TIMER
07 MOTION SENSOR
08 PHOTOCELL CONTROL
09 OTHER → [RECORD:] _____
10 DON'T KNOW → CONTINUE

V18 How would you rate the influence of your visit to the Solar Decathlon on your decision to install this energy-efficient lighting? Please answer on a scale of 0 to 10, where 0 means your visit to the Solar Decathlon had no influence on your decision and 10 means your visit was the main influence on your decision to install efficient lighting.

01 [RECORD RATING; CONFIRM YOUR ENTRY:] ____
02 DON'T KNOW

V19 After your visit did you install any appliance in your home that you knew to be more energy-efficient than the typical appliance?

01 YES
02 NO
03 DON'T KNOW

IF V19 = 01 CONTINUE TO V20. ALL OTHERS SKIP TO V22.

V20 What kind of energy-efficient appliance did you install after you visited the Solar Decathlon? [DO NOT READ LIST. AFTER EACH ANSWER, ASK IF THEY INSTALLED ANY MORE. SELECT ALL THAT APPLY.]

01 CENTRAL AIR CONDITIONER
02 CLOTHES WASHER
03 DEHUMIDIFIER
04 DISHWASHER
05 FREEZER
06 HEAT PUMP
07 REFRIGERATOR
08 ROOM AIR CONDITIONER
09 WATER HEATER
10 OTHER → [RECORD:] _____
11 DON'T KNOW → CONTINUE

V21 How would you rate the influence of your visit to the Solar Decathlon on your decision to install this (these) energy-efficient appliance(s)? Please answer on a scale of 0 to 10 where 0 means your visit to the Solar Decathlon had no influence on your decision, and 10 means your visit was the main influence on your decision to install this (these) efficient appliance(s).

01 [RECORD RATING; CONFIRM YOUR ENTRY:] ____
02 DON'T KNOW

V22 I have just a few final important questions. Are you aware of a website called the Database of State Incentives for Renewables and Efficiency, or [SPELL] DSIRE? This is an Internet site where you can get information on incentives for installing solar energy and energy efficiency equipment for the home.

01 YES
02 NO
03 NOT SURE

V23 Have you ever written about energy conservation or the environment in a school paper, a blog, or an e-mail, tweet, or letter to the editor?

01 YES
02 NO
03 DON'T RECALL

V24 Which of the following age categories includes your age? [READ THE CATEGORIES. WHEN STOPPED, SAY:] Your age is between [READ THE LAST CATEGORY SPOKEN.] Is that correct? [SELECT CATEGORY IF CONFIRMED. IF NOT CONFIRMED, ASK FOR THE CORRECT CATEGORY AND SELECT.]

01 18 to 19 years
02 20 to 29 years
03 30 to 39 years
04 40 to 49 years
05 50 to 59 years
06 60 to 69 years
07 70 years or older
08 REFUSED

V25 Which of the following education categories includes your highest level of education? [READ THE CATEGORIES. WHEN STOPPED, SAY:] Your highest level of education is [READ THE LAST CATEGORY SPOKEN.] Is that correct? [SELECT CATEGORY IF CONFIRMED. IF NOT CONFIRMED, ASK FOR THE CORRECT CATEGORY AND SELECT.]

01 Some elementary school but did not graduate
02 Graduated from elementary school and some high school
03 High school graduate or GED equivalency certificate
04 Some college or associate's degree
05 College bachelor's degree or higher
06 REFUSED

V26 Finally, for analysis purposes only, I am going to ask about the combined income of all persons living in this household during the past 12 months. I am going to read several income categories. Please stop me when I read the category that includes the combined income in the last 12 months of everyone living in the household. [WHEN STOPPED, SAY: Your household income in the last 12 months was READ THE LAST CATEGORY SPOKEN AND CONFIRM. SELECT IT IF CONFIRMED. IF NOT CONFIRMED, ASK FOR THE CORRECT CATEGORY AND SELECT.]

01 Less than $50,000 → [CONTINUE TO V27]
02 $50,000 but less than $100,000 → [SKIP TO V28]
03 $100,000 or more → [SKIP TO V29]
04 DON'T KNOW → That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]
05 REFUSED → That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]

V27 Was the household income [CONFIRM AND SELECT THE RANGE CHOSEN]

01 Less than $10,000?
02 $10,000 but less than $35,000?
03 $35,000 but less than $50,000?
04 DON'T KNOW
05 REFUSED

That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]

V28 Was the household income [CONFIRM AND SELECT THE RANGE CHOSEN]

01 $50,000 but less than $75,000?
02 $75,000 but less than $100,000?
03 DON'T KNOW
04 REFUSED

That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]

V29 Was the household income [CONFIRM AND SELECT THE RANGE CHOSEN]

01 Less than $150,000?
02 $150,000 or greater?
03 DON'T KNOW
04 REFUSED

That is all of our questions. Thank you very much for your time. Have a nice day. [TERMINATE]

END OF SURVEY FOR SOLAR DECATHLON VISITORS. QUOTA = 200.
START OF SURVEY FOR NON-VISITOR RESPONDENTS; FROM QUESTION A1, ANSWERS 02 0R 03, OR QUESTION A2, ANSWERS 02 OR 04

N1 Have you ever participated in, or attended, any event that discussed solar energy or energy efficiency for a home?

01 YES
02 NO
03 DON'T KNOW

N2 Do you work in an occupation that sells, markets, or builds solar-energy equipment for homes or commercial buildings?

01 YES
02 NO

N3 Please think for a moment about what you know about houses that collect energy from the sun and use it for electricity or heating. What would you say are the ways in which houses that collect energy from the sun for electricity or heating <u>are different</u> from houses that do not? [DO NOT READ ANSWERS, BUT AFTER EACH RESPONSE, ASK THE RESPONDENT IF HE/SHE CAN THINK OF ANY OTHER DIFFERENCES. SELECT ALL MENTIONED. ANSWERS DESCRIBE THE SOLAR HOUSE.]

01 ARE MORE EXPENSIVE
02 CAN USE THE SUN TO GENERATE ELECTRICITY
03 CAN USE THE SUN TO HEAT ROOMS OR HOT WATER
04 FACE THE SOUTH / LET MORE SUNLIGHT IN
05 HAVE A WALL THAT ABSORBS HEAT FROM THE SUN / TROMBE WALL
06 HAVE MORE GLASS
07 HAVE MOVABLE OUTSIDE WINDOW SHADES
08 HAVE PANELS ON THE ROOF
09 HAVE SENSORS OR TIMERS TO TURN LIGHTS ON AND OFF
10 HAVE VEGETATION ON THE WALLS OR ROOF
11 LOOK DIFFERENT
12 SAVE MONEY / REDUCE UTILITY BILLS
13 THEY DON'T DIFFER/ LOOK THE SAME / DON'T LOOK DIFFERENT
14 TYPICALLY ARE SMALLER
15 USE MORE DAYLIGHT
16 USE MORE ENERGY-EFFICIENT APPLIANCES
17 OTHER → [RECORD] _____
18 OTHER → [RECORD] _____
19 DON'T KNOW

N4 I'm going to describe three types of information about solar-powered and energy-efficient homes. After each, please tell me if the following information about solar-powered and energy-efficient homes would be very important to you, somewhat important to you, or not important to you.

PRESENT INTERVIEWER TOPICS A - C. ROTATE THE TOPICS.

[READ EACH TOPIC. AFTER READING EACH TOPIC, ASK:]
Would this information be [READ 01, 02, AND 03 AND SELECT THE RESPONSE:]

01 very important to me,
02 somewhat important to me,
03 not important to me.
04 I ALREADY HAVE OR KNOW HOW TO GET THIS INFORMATION
05 I DON'T KNOW

A. Information on how I could find contractors near where I live who install solar panels.
B. Websites on the Internet where I could learn more about solar energy and energy-efficiency.
C. Information on how I could find a store that sells efficient lighting and appliances near where I live.

N5 Have you installed any solar-energy panels on your home to generate electricity or heat rooms or hot water since 2000?

01 YES
02 NO
03 DON'T KNOW

N6 Had you installed any solar panels on your home to generate electricity or heat rooms or hot water prior to 2000?

01 YES
02 NO
03 DON'T KNOW

IF N5 OR N6 = 01 SKIP TO N10. ALL OTHERS CONTINUE TO N7.

N7 Since 2000 have you given any thought to the advantages and disadvantages of installing solar panels to generate electricity or to heat water for your own house?

01 YES
02 NO
03 DON'T KNOW

N8 Since 2000 have you visited any Internet sites that described the availability of utility or state incentives for solar-energy systems to generate electricity or heat for your home?

01 YES
02 NO
03 DON'T RECALL

IF N8 = 01 CONTINUE TO N9. ALL OTHERS SKIP TO N10.

N9 Since 2000 have you asked a contractor to offer you a price for installing solar panels to generate electricity or to heat water for your house or have you investigated a price on your own?

01 YES
02 NO
03 DON'T KNOW

N10 Have you installed any lighting in your home since 2000 that you knew to be more energy-efficient than typical incandescent lighting?

01 YES
02 NO
03 DON'T KNOW

IF N10 = 01, CONTINUE TO N11. ALL OTHERS SKIP TO N12.

N11 What kind of efficient lighting did you install? [AFTER EACH ANSWER, ASK IF THEY INSTALLED ANY MORE AND SELECT ALL THAT APPLY.]

01 COMPACT FLUORESCENT LIGHT BULBS (CFLs)
02 DAYLIGHTING
03 ENERGY STAR LIGHT FIXTURES
04 FLUORESCENT LAMPS
05 LIGHT EMITTING DIODE (LED) LIGHTING
06 LIGHTING TIMER
07 MOTION SENSOR
08 PHOTOCELL CONTROL
09 OTHER → [RECORD:] _____
10 DON'T KNOW

N12 Have you purchased and installed any appliance for your home since 2000 that you knew to be more energy-efficient than the typical appliance?

01 YES
02 NO
03 DON'T KNOW

IF N12 = 01, CONTINUE TO N13. ALL OTHERS SKIP TO N14.

N13 What kind of efficient appliance did you install? [AFTER EACH ANSWER, ASK IF THEY INSTALLED ANY MORE AND SELECT ALL MENTIONED.]

01 CENTRAL AIR CONDITIONER
02 CLOTHES WASHER
03 DEHUMIDIFIER
04 DISHWASHER
05 FREEZER
06 HEAT PUMP
07 REFRIGERATOR
08 ROOM AIR CONDITIONER
09 WATER HEATER
10 OTHER → [RECORD:] _____
11 DON'T KNOW

N14 I have just a few final important questions. Are you aware of a website called the Database of State Incentives for Renewables and Efficiency or [SPELL] DSIRE? This is an Internet site where you can get information on incentives for installing solar energy and energy efficiency equipment for the home.

01 YES
02 NO
03 NOT SURE

N15 Have you ever written about energy conservation or the environment in a school paper, a blog, or an e-mail, twitter, or letter to the editor?

01 YES
02 NO
03 DON'T KNOW

N16 Which of the following age categories includes your age? [READ THE CATEGORIES. WHEN STOPPED, SAY:] Your age is between [READ THE LAST CATEGORY SPOKEN.] Is that correct? [SELECT CATOEGORY IF CONFIRMED. IF NOT CONFIRMED, ASK FOR THE CORRECT CATEGORY AND SELECT.]

01 18 to 19 years
02 20 to 29 years
03 30 to 39 years
04 40 to 49 years
05 50 to 59 years
06 60 to 69 years
07 70 years or older
08 REFUSED

N17 Which of the following education categories includes your highest level of education? [READ THE CATEGORIES. WHEN STOPPED, SAY:] Your highest level of education is [READ THE LAST CATEGORY SPOKEN.] Is that correct? [SELECT CATEGORY IF CONFIRMED. IF NOT CONFIRMED, ASK FOR THE CORRECT CATEGORY AND SELECT.]

01 Some elementary school but did not graduate
02 Graduated from elementary school and some high school
03 High school graduate or equivalency certificate
04 Some college or associate's degree
05 College bachelor's degree or higher
06 REFUSED

N18 Finally, for analysis purposes only, I am going to ask about the combined income of all persons living in this household during the past 12 months. I am going to read several income categories. Please stop me when I read the category that includes the combined income in the last 12 months of everyone living in the household. [WHEN STOPPED, SAY: Your household income in the last 12 months was READ THE LAST CATEGORY SPOKEN AND SELECT IT IF CONFIRMED. IF NOT CONFIRMED, ASK FOR THE CORRECT CATEGORY AND SELECT.]

01 Less than $50,000 → [CONTINUE TO N19]
02 $50,000 but less than $100,000 → [SKIP TO N20]
03 $100,000 or more → [SKIP TO N21]
04 DON'T KNOW → That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]
05 REFUSED → That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]

N19 Was the household income [SELECT THE RANGE CHOSEN]

01 Less than $10,000?
02 $10,000 but less than $35,000?
03 $35,000 but less than $50,000?
04 DON'T KNOW
05 REFUSED

That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]

N20 Was the household income [SELECT THE RANGE CHOSEN]

01 $50,000 but less than $75,000?
02 $75,000 but less than $100,000?
03 DON'T KNOW
04 REFUSED

That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]

N21 Was the household income [SELECT THE RANGE CHOSEN]

01 Less than $150,000?
02 $150,000 or greater?
03 DON'T KNOW
04 REFUSED

That is all of our questions. Thank you very much for your time. Have a nice day.

END OF SURVEY FOR SOLAR DECATHLON NON-VISITORS

Addendum to Appendix E.1
Correct Answers to Questions V8 and N3

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01 ARE MORE EXPENSIVE
02 CAN USE THE SUN TO GENERATE ELECTRICITY
03 CAN USE THE SUN TO HEAT ROOMS OR HOT WATER
04 FACE THE SOUTH / LET MORE SUNLIGHT IN
05 HAVE A WALL THAT ABSORBS HEAT FROM THE SUN / TROMBE WALL
06 HAVE MORE GLASS
07 HAVE MOVABLE OUTSIDE WINDOW SHADES
08 HAVE PANELS ON THE ROOF
09 HAVE SENSORS OR TIMERS TO TURN LIGHTS ON AND OFF
10 HAVE VEGETATION ON THE WALLS OR ROOF
11 LOOK DIFFERENT
12 SAVE MONEY / REDUCE UTILITY BILLS
13 (Not counted as correct) THEY DON'T DIFFER/ LOOK THE SAME / DON'T LOOK DIFFERENT
14 TYPICALLY ARE SMALLER
15 USE MORE DAYLIGHT
16 USE MORE ENERGY-EFFICIENT APPLIANCES
17 OTHER → [RECORD] _____
18 OTHER → [RECORD] _____
19 (Not counted as correct) DON'T KNOW
20 ("OTHER" response recoded and counted as correct) ENVIRONMENTALLY FRIENDLY

All other "OTHER" responses were either recoded to one of the fixed responses or not counted as incorrect.

Appendix E.2 Former Decathlete Online Questionnaire

The answers to question 29 through 36 that were counted as correct for the Knowledge analysis for the homeowner-education objective are identified in the Addendum to Appendix E.2 which appears at the end of the Former Decathlete Online Questionnaire.

SOLAR DECATHLON EVALUATION
FORMER-DECATHLETE ONLINE (WEB) SURVEY
OMB Control No. 1910-5161 Expiration Date: 7/31/2014

INFORMATION IN A BOX IS FOR THE WEB PROGRAMMER.

Thank you for taking our survey. This data is being collected to help the U.S. Department of Energy evaluate the Solar Decathlon. The data you supply will be used for improving its value to future Decathletes.

Public reporting burden for this collection of information is estimated to average eleven minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Office of the Chief Information Officer, Records Management Division, IM-23, Paperwork Reduction Project (1910-5161), U.S. Department of Energy, 1000 Independence Ave SW, Washington, D.C., 20585-1290, and to the Office of management and Budget (OMB), OIRA, Paperwork Reduction Project (1910-5161), Washington, D.C. 20503.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a currently valid OMB control number.

The survey is voluntary. Your answers will be combined with the answers of others and will not be linked to your name.

Please click on CONTINUE to begin the survey.

SHOW A CONTINUE BUTTON TO BEGIN THE SURVEY.

UNLESS OTHERWISE INDICATED, AFTER EACH QUESTION, SHOW:
"PRESS 'CONTINUE' TO RECORD YOUR ANSWER AND CONTINUE TO THE NEXT QUESTION. TO RETURN TO A PREVIOUS QUESTION PRESS 'GO BACK'."

PROVIDE CONTINUE AND GO BACK BUTTONS AFTER EACH QUESTION.

1 We understand that you may have participated in your college's entry into one of the Department of Energy's Solar Decathlon competitions. These were held in Washington, D.C. in 2002, 2005, 2007, and 2009. However, your school may have begun work on its entry for up to two years before these competition dates. Did you participate at any time in your university or college's entry into one of the Department of Energy's Solar Decathlons?

Yes
No
Don't recall

IF Q1 = YES, CONTINUE. ALL OTHERS SHOW:

Thank you. This survey is for students and former students who participated in one of the U.S. Department of Energy's Solar Decathlons. Please click on EXIT to close this screen and return to your browser.

SHOW AN EXIT BUTTON TO TERMINATE THE SURVEY. DO NOT ALLOW THE RESPONDENT TO CONTINUE OR GO BACK.

2 In which of the following years' Solar Decathlons did you participate? If you participated in more than one, select as many as apply.

2002
2005
2007
2009
2011
Don't recall

IF Q2 = DON'T RECALL, CONTINUE. ALL OTHERS SKIP TO Q4

3 Did you participate in the design or construction of a solar-powered home that was eventually displayed at the Solar Decathlon on the National Mall in Washington, D.C., or did you participate in something else that might have been like that?

Solar-powered home for display in Washington, D.C.
Something else
Don't know

IF Q3 = "SOLAR HOME FOR DISPLAY IN WASHINGTON, D.C.", CONTINUE. ALL OTHERS SHOW:

Thank you. This survey is for students and former students who participated in one of the U.S. Department of Energy's Solar Decathlons. Please click on EXIT to close this screen and return to the browser.

SHOW AN EXIT BUTTON TO TERMINATE THE SURVEY. DO NOT ALLOW THE RESPONDENT TO CONTINUE OR GO BACK.

FOR OPEN-ENDED RESPONSES TO "OTHER" QUESTIONS IN THIS SURVEY. ALLOW 80 CHARACTERS. PROVIDE A COUNTER THAT SHOWS HOW MANY CHARACTERS ARE LEFT AS THE RESPONDENT ENTERS HIS/HER RESPONSE.

4 What academic major or majors were you taking when you participated in your first Solar Decathlon? Select as many as apply.

Architecture
Computer design
Ecology
Electrical engineering
Environmental engineering
Lighting design
Marketing or communications
Materials engineering
Mechanical engineering
Physics
Other → _____
Other → _____
Had not declared a major / Don't recall

5 After you participated in your first Solar Decathlon did you select a major or change your original undergraduate major to one that can be used in producing, managing, using, or marketing renewable energy or energy efficiency?

Yes
No → SKIP TO THE INSTRUCTION BEFORE Q7

6 What academic major or majors did you select or change to after you participated in the Solar Decathlon? Select as many as apply.

Architecture
Computer design
Ecology
Electrical engineering
Environmental engineering
Lighting design
Marketing or communications
Materials engineering
Mechanical engineering
Physics
Other → ☐
Other → ☐

The following are some questions about the value of your Solar Decathlon experience. Please rate the value of your Solar Decathlon experience on a scale of 0 to 10 where 0 means your Solar Decathlon experience provided no value for you at all and 10 means your Solar Decathlon experience was extremely valuable.

7 Please rate how much more you learned about using solar energy and energy efficiency for homes from your Solar Decathlon experience than you would have learned just from taking your regular college courses.

I learned nothing more than I would have learned anyway					My Solar Decathlon experience taught me about twice as much as I would have learned otherwise					The Solar Decathlon taught me everything that I learned in college about using solar energy and energy efficiency in homes
0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

8 Please rate how much your Solar Decathlon experience helped you get a job after graduation.

My experience was no help at all in getting a job					My experience was equally as helpful as other factors					My experience was the main factor in getting a job	No opinion
0	1	2	3	4	5	6	7	8	9	10	
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

9 If you were in the market now to buy a house that generated most of its electricity and heat from solar energy, how confident do you feel in your ability to judge the quality of the house's energy system?

Not confident at all					Have a moderate degree of confidence					Highly confident	No opinion
0	1	2	3	4	5	6	7	8	9	10	
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

10 Which of the following includes your highest level of education?

Currently in undergraduate college studies → SKIP TO Q16
Completed some college or associate's degree and no longer in college → SKIP TO Q13
Completed college or university degree → SKIP TO Q13
Currently taking graduate courses
Completed some post graduate work or a graduate degree

11 Did, or does, your graduate work include the study of how to use energy from the sun or wind to generate electricity or heat for a house?

Yes
No

12 Did, or does, your graduate work include the study of how to make a house more energy efficient?

Yes
No

13 Since your undergraduate college studies, have you been employed in work involving the design, manufacture, sales, installation, research, or use in buildings of renewable energy or energy-efficient products?

Yes
No → SKIP TO Q16

14 Please describe the work. Select as many as apply.

Design, Manufacture, sales, or installation of—

Solar systems
Wind power systems
Efficient appliances
Efficient lighting
Efficient cars, trucks, or rail vehicles

Education or training related to—

The environment, including ecology
Renewable energy or energy efficiency

Government policy or operations related to the—

Design, evaluation, or operation of energy efficiency programs
Use of energy efficient or renewable energy equipment
Setting or enforcing building codes or standards
Research on energy efficiency or renewable energy

Building design and construction—

Architectural design of energy-efficient buildings or buildings using renewable energy
Mechanical design of energy-efficient buildings or buildings using renewable energy
Construction of energy-efficient buildings or buildings using renewable energy

Other non-government professional—

Research on energy efficiency or renewable energy
Consulting regarding energy efficiency or renewable energy

Other → [ ]

15 Have you ever started up a business related to this work?

Yes
No

16 Since you participated in a Solar Decathlon, have you helped to convince anyone, including yourself, to install any type of renewable-energy equipment, such as solar panels, on a home or business?

Yes
No
Don't know

IF Q16 = YES, CONTINUE. ALL OTHERS SKIP TO Q21

17 What kind of renewable-energy equipment was installed? If you helped to influence the installation of multiple types of renewable-energy equipment, select "More than one kind" below.

Solar panels to generate electricity
Solar panels to heat hot water
Solar panels for space heating
Wind turbines to generate electricity
Wind turbines to pump water
More than one kind
Other → [ ]
Don't know

IF Q17 = "MORE THAN ONE KIND", CONTINUE. IF Q17 = "DON'T KNOW," SKIP TO Q21. ALL OTHERS SKIP TO Q19a.

17a Please select as many kinds of renewable-energy equipment as were installed.

Solar panels to generate electricity
Solar panels to heat hot water
Solar panels for space heating
Wind turbines to generate electricity
Wind turbines to pump water
Other → [ ]
Don't know

18 Which of these installations would you say is likely to generate the most energy for its owner?

Solar panels to generate electricity
Solar panels to heat hot water
Solar panels for space heating
Wind turbines to generate electricity
Wind turbines to pump water
Other → [ ]

19 Did you install any of the equipment you selected in the previous question on your own home or business?

Yes
No

20 Considering all of the possible things that might have led up to the decision to install INSERT RESPONSE FROM Q18, how important would you rate your Solar Decathlon experience to the influence you had on the decision? Please rate the importance of your Solar Decathlon experience to the decision on a scale of 0 to 10, where 0 means your experience was not at all important and 10 means you believe the equipment would not have been installed if you had not had the Solar Decathlon experience.

My Solar Decathlon experience had no influence					My Solar Decathlon experience counted about as much as other influences					My Solar Decathlon experience was the primary influence	No opinion
0	1	2	3	4	5	6	7	8	9	10	
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

AFTER Q20, SKIP TO Q24.

19a Did you install any of the equipment you selected in the previous question on your own home or business?

Yes
No

20a Considering all of the possible things that might have led up to the decision to install INSERT RESPONSE FROM Q17, how important would you rate your Solar Decathlon experience to the influence you had on the decision? Please rate the importance of your Solar Decathlon experience to the decision on a scale of 0 to 10, where 0 means your experience was not at all important and 10 means you believe the equipment would not have been installed if you had not had the Solar Decathlon experience.

My Solar Decathlon experience had no influence					My Solar Decathlon experience counted about as much as other influences					My Solar Decathlon experience was the primary influence	No opinion
0	1	2	3	4	5	6	7	8	9	10	
□	□	□	□	□	□	□	□	□	□	□	□

AFTER Q20a, SKIP TO Q24.

21 Since you participated in a Solar Decathlon have you visited any Internet sites that described the availability of utility or state incentives for solar-energy systems to generate electricity or heat for your home?

Yes
No
Don't recall

22 Since you participated in a Solar Decathlon, have you given any thought to the advantages and disadvantages of installing solar panels to generate electricity or heat water for your own house?

Yes
No
Live in an apartment
Don't have a permanent residence

IF Q22 = YES, CONTINUE, ALL OTHERS SKIP TO Q24.

23 Since you participated in a Solar Decathlon, have you asked a contractor to offer you a price for installing solar panels to generate electricity or to heat water for your house, or have you investigated a price on your own?

Yes
No

24 Since you participated in a Solar Decathlon, have you helped to convince anyone, including yourself, to install any type of energy-efficient equipment, such as an efficient appliance or lighting fixture, in a home or business?

Yes
No

IF Q24 = YES, CONTINUE, ALL OTHERS SKIP TO THE INSTRUCTION BEFORE Q29.

25 What kind of energy-efficient equipment was installed? If you helped to influence the installation of multiple types of energy-efficient equipment, select "More than one kind".

Compact fluorescent light bulbs
Efficient appliances for residential, commercial, or industrial buildings
Efficient industrial or commercial equipment, e.g., motors
Efficient lighting fixtures for residential, commercial, or industrial buildings
Efficient windows
Insulation
More than one kind
Other → [ ]
Don't know

IF Q25 = "MORE THAN ONE KIND", CONTINUE. IF Q25 = "DON'T KNOW," SKIP TO THE INSTRUCTION BEFORE Q29. ALL OTHERS SKIP TO Q27a.

25a Please select as many kinds of energy-efficient equipment as were installed.

Compact fluorescent light bulbs
Efficient appliances for residential, commercial, or industrial buildings
Efficient industrial or commercial equipment, e.g., motors
Efficient lighting fixtures for residential, commercial, or industrial buildings
Efficient windows
Insulation
Other → [ ]
Don't know

26 Which of these installations would you say is likely to save the most energy for its owner?

Compact fluorescent light bulbs
Efficient appliances for residential, commercial, or industrial buildings
Efficient industrial or commercial equipment, e.g., motors
Efficient lighting fixtures for residential, commercial, or industrial buildings
Efficient windows
Insulation
Other → ☐

27 Did you install any of the equipment you selected in the previous question in your own home or business?

Yes
No

28 Considering all of the possible things that might have led up to the decision to install INSERT RESPONSE FROM Q26, how important would you rate your Solar Decathlon experience to the influence you had on the decision? Please rate the importance of your Solar Decathlon experience to the decision on a scale of 0 to 10, where 0 means your experience was not at all important and 10 means you believe the equipment would not have been installed if you had not had the Solar Decathlon experience.

My Solar Decathlon experience had no influence					My Solar Decathlon experience counted about as much as other influences					My Solar Decathlon experience was the primary influence	No opinion
0	1	2	3	4	5	6	7	8	9	10	
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

AFTER Q28, SKIP TO THE INSTRUCTION BEFORE Q29.

27a Did you install any of the equipment you selected in the previous question in your own home or business?

Yes
No

28a Considering all of the possible things that might have led up to the decision to install INSERT RESPONSE FROM Q25, how important would you rate your Solar Decathlon experience to the influence you had on the decision? Please rate the importance of your Solar Decathlon experience to the decision on a scale of 0 to 10, where 0 means your experience was not at all important and 10 means you believe the equipment would not have been installed if you had not had the Solar Decathlon experience.

My Solar Decathlon experience had no influence					My Solar Decathlon experience counted about as much as other influences					My Solar Decathlon experience was the primary influence	No opinion
0	1	2	3	4	5	6	7	8	9	10	
□	□	□	□	□	□	□	□	□	□	□	□

Please indicate whether you believe the following statements are true or false. If you are not sure whether the statement is true or false, select "Not sure."

RANDOMLY CHANGE THE ORDER OF QUESTIONS 29 – 36 FOR DIFFERENT RESPONDENTS

29 Over the course of a year, a home called a "zero-energy" home will produce at least as much electricity as it uses.

True
False
Not sure

30 If you install solar-electric panels on your house you might still need to buy electricity from your local utility.

True
False
Not sure

31 A house that uses solar panels to reduce its energy costs will usually have a higher initial purchase price than the same home without solar panels.

True
False
Not sure

32 Houses that use solar panels also require batteries.

True
False
Not sure

33 Solar panels that collect energy from the sun can only be used to generate electricity.

True
False
Not sure

34 In most of the northern hemisphere, a rooftop solar panel that faces due south will collect more energy than one facing due east.

True
False
Not sure

35 A compact fluorescent light bulb uses one-quarter to one-third as much energy as an incandescent bulb that produces the same amount of light.

True
False
Not sure

36 A refrigerator that is labeled ENERGY STAR will use less electricity to cool an item of food than a similar refrigerator that is not labeled ENERGY STAR.

True
False
Not sure

The remaining questions will be used only to group answers from all of the surveys. Your answers will not be identified with you personally.

37 Do you own or rent your home?

Own
Rent
Other

38 Before you participated in a Solar Decathlon, did you ever participate in any other activity that encouraged people to conserve energy or help the environment?

Yes
No
Don't recall

39 Before you participated in a Solar Decathlon, did you ever write about energy conservation or the environment in a school paper, a blog, or an e-mail, a tweet, or letter to the editor?

Yes
No
Don't recall

40 Are you aware of an Internet site called the Database of State Incentives for Renewables and Efficiency where the availability state and utility incentives for solar energy and efficient equipment is listed?

Yes
No
Don't know

41 Has anyone living in your household ever had any formal technical training or engineering education?

Yes
No
Not applicable

42 Select the range that includes your age.

Less than 20 years
20 to 29 years
30 to 39 years
40 to 49 years
50 to 59 years
60 to 69 years
70 years or older

43 Please select the range that includes the combined income of all persons living in your household during the past 12 months.

Less than $10,000
$10,000 to $34,500
$35,000 to $49,999
$50,000 to $59,999
$60,000 to $74,999
$75,000 to $99,999
$100,000 to $149,999
$150,000 or more
Don't know
Declined

44 If you would like to provide any comments about the Solar Decathlon or your experience as a decathlete, please type them in the box below.

LIMIT THE RESPONSE TO Q44 TO 800 CHARACTERS. PUT A CHARACTER COUNTER UNDER THE BOX SHOWING THE NUMBER LEFT.

That is all of our questions. Please click on SUBMIT to record your answers.

Thank you very much for your time.

SHOW A SUBMIT BUTTON TO RECORD ANSWERS AND END THE SURVEY.

Addendum to Appendix E.2
Correct Answers to Questions 29 through 36

The answer counted as correct is underlined.

29 Over the course of a year, a home called a "zero-energy" home will produce at least as much electricity as it uses.

<u>True</u>
<u>False</u>
<u>Not sure</u>

Question 29 was created in 2008. After approval by OMB, subsequent internal testing and review disclosed a lack of agreement within the renewable energy industry on the meaning of the term, e.g., the term "*net* zero energy" appeared after designing the questionnaire; does it refer to electricity usage only or does it include natural gas? As a consequence of this review, all answers to this question were accepted as correct.

30 If you install solar-electric panels on your house you might still need to buy electricity from your local utility.

<u>True</u>
False
Not sure

31 A house that uses solar panels to reduce its energy costs will usually have a higher initial purchase price than the same home without solar panels.

<u>True</u>
False
Not sure

32 Houses that use solar panels also require batteries.

True
<u>False</u>
Not sure

33 Solar panels that collect energy from the sun can only be used to generate electricity.

True
<u>False</u>
Not sure

34 In most of the northern hemisphere, a rooftop solar panel that faces due south will collect more energy than one facing due east.

True
False
Not sure

35 A compact fluorescent light bulb uses one-quarter to one-third as much energy as an incandescent bulb that produces the same amount of light.

True
False
Not sure

36 A refrigerator that is labeled ENERGY STAR will use less electricity to cool an item of food than a similar refrigerator that is not labeled ENERGY STAR.

True
False
Not sure

Appendix E.3 Non-Decathlete Former-Student Telephone Questionnaires

The answers to questions 26A through 26H that were counted as correct for the Knowledge analysis for the homeowner education objective are listed in the Addendum to Appendix E.3 which appears at the end of the Non-Decathlete Former-Student Telephone Questionnaire.

SOLAR DECATHLON EVALUATION
NON-DECATHLETE FORMER-COLLEGE-STUDENT CATI SURVEY
OMB Control No. 1910-5161

ALL-CAPITALS INSTRUCTIONS IN [BRACKETS] ARE FOR THE INTERVIEWERS AND WILL APPEAR ON THE CATI MONITOR. INFORMATION IN A BOX IS FOR THE CATI PROGRAMMER.

Q1-Q5 ARE SCREENING QUESTIONS

1 Hello, my name is _____. I'm calling from _____ on behalf of the U.S. Department of Energy. I'm calling with a few questions that will help the Department of Energy evaluate the public's knowledge and use of solar energy and energy-efficient products. The questions will take about 12 minutes. The survey is voluntary and any answers you provide will not be identified with you. They will be combined with those of others in the results. The call may be monitored or recorded for quality purposes.

Since the year 2000, has someone in this household attended a four-year college or university for at least a year, even if they didn't graduate?

01 YES / I DID → CONTINUE TO Q2
02 YES [ASK IF IT'S THE PERSON ON THE PHONE. IF NOT THE PERSON ON THE PHONE, ASK TO SPEAK TO THE PERSON WHO ATTENDED A FOUR-YEAR COLLEGE FOR AT LEAST A YEAR. WHEN PERSON IS ON THE PHONE, REPEAT Q1. IF THAT PERSON CANNOT COME OT THE PHONE, SCHEDULE A CALL BACK.]
03 NO → That is all of our questions. Thank you for taking our call. [TERMINATE]
04 DON'T KNOW → That is all of our questions. Thank you for taking our call. [TERMINATE]

2 Are you currently enrolled in a college undergraduate degree program?

01 YES
02 NO
03 DON'T KNOW

IF Q2 = 02, CONTINUE TO Q3. ALL OTHERS, INTERVIEWER READ, That is all of our questions. Thank you for taking our call. [TERMINATE]
(THE QUOTA FOR THIS SURVEY IS 110 COMPLETED INTERVIEWS.)

3 Since 2000, students in some colleges or universities have built demonstration houses that get all of their electricity and heat from the sun and entered them into a competition in Washington, D.C. called the Solar Decathlon. The houses are displayed on the National Mall for about two weeks for the public to visit. Recently this has been in October. When you were in college, did you help build one of these solar-powered houses for a Solar Decathlon competition?

01 YES → [READ: This survey is for college students that did not participate in a Department of Energy Solar Decathlon. That is all of our questions. A link to a separate, voluntary online survey for college students who helped build a solar-powered house for the Solar Decathlon competition will be available in October on the Solar Decathlon Alumni Association Website at http://solardecathlonalumni.org. That survey is voluntary. We encourage you to go to the Website and follow the links to participate in the Decathlete survey. Thank you for taking our call.] [TERMINATE]
02 NO
03 DON'T KNOW

4 Have you ever read about or heard of this exhibit of solar-powered homes built by students on the National Mall in Washington, D.C. called the Solar Decathlon?

01 YES
02 NO
03 DON'T KNOW

5 In college, did you major in an engineering, architectural, marketing, physics, communications, or computer-aided design field of study?

01 YES
02 NO / DID NOT HAVE A MAJOR
03 DON'T KNOW

IF Q5 = 01, CONTINUE TO Q6. ALL OTHERS, INTERVIEWER READ, That is all of our questions. Thank you for taking our call. [TERMINATE]

6 Which of the following includes your highest level of education? [READ AND RECORD ANSWER]

01 Some college or associates degree
02 College or university bachelor's degree
03 Currently taking graduate courses
04 Some postgraduate work or degree
05 DECLINED

7 In what academic field or fields did you major in college? [SELECT ALL MENTIONED]

01 ARCHITECTURE
02 COMPUTER DESIGN
03 ECOLOGY
04 ELECTRICAL ENGINEERING
05 ENVIRONMENTAL ENGINEERING
06 LIGHTING DESIGN
07 MARKETING OR COMMUNICATIONS
08 MATERIALS ENGINEERING
09 MECHANICAL ENGINEERING
10 PHYSICS
11 OTHER → [RECORD:] _____
12 OTHER →]RECORD:] _____
13 DID NOT DECLARE A MAJOR / DON'T RECALL

IF Q6 = 03 OR 04, CONTINUE TO Q8. ALL OTHERS SKIP TO Q10.

8 Did (does) your graduate work include the study of how to produce, manage, market, or use energy from the sun or wind to generate electricity or heat a house?

01 YES
02 NO
03 DON'T KNOW

9 Did (does) your graduate work include the study of how to make a house more energy efficient?

01 YES
02 NO
03 DON'T KNOW

10 Since leaving your undergraduate college studies, have you been employed in work involving the design, manufacture, sales, installation, research, or use of solar- or wind-energy, or energy-efficient products?

01 YES
02 NO
03 DECLINED

IF Q10 = 01, CONTINUE TO Q11. ALL OTHERS SKIP TO Q13.

11 Please describe what the work involves? [SELECT ALL MENTIONED.]

01 BUILDING CODES—SETS OR ENFORCES
02 EDUCATION OR TRAINING—ABOUT THE ENVIRONMENT
03 EDUCATION OR TRAINING—ABOUT RENEWABLE ENERGY OR ENERGY EFFICIENCY
04 EFFICIENT APPLIANCES—DESIGN, MANUFACTURE, SALES OR INSTALLATION
05 EFFICIENT CARS, TRUCKS, OR RAIL VEHICLES—DESIGN, MANUFACTURE, OR SALES
06 EFFICIENT LIGHTING—DESIGN, MANUFACTURE, SALES OR INSTALLATION
07 ENERGY EFFICIENCY PROGRAMS—DESIGN, EVALUATE, OR OPERATE
08 GOVERNMENT—ENVIRONMENTAL PROTECTION OFFICE
09 GOVERNMENT OTHER OFFICE RELATED TO PROTECTING THE ENVIRONMENT
10 GREEN BUILDINGS—ARCHITECTURAL DESIGN OF
11 GREEN BUILDINGS—CONSTRUCTION OF
12 SOLAR SYSTEMS—DESIGN, MANUFACTURE, SALES OR INSTALLATION
13 WIND POWER SYSTEMS—DESIGN, MANUFACTURE, SALES OR INSTALLATION
14 OTHER → [RECORD:] _____
_____
15 OTHER → [RECORD:] _____
_____
16 NO ANSWER

12 Have you ever started up a business related to this work?

01 YES
02 NO

13 Since 2000, have you helped to convince anyone, including yourself, to actually install any type of solar- or wind-energy equipment, such as solar panels, on a home or business?

01 YES
02 NO
03 DON'T RECALL

IF Q13 = 01, CONTINUE TO Q14. ALL OTHERS SKIP TO Q18.

14 What type of solar- or wind-energy equipment was installed? [SELECT AS MANY AS ARE MENTIONED. IF ANY CHOICE 01-06 SELECTED, DO NOT SELECT 07.]

01 SOLAR PANELS TO GENERATE ELECTRICITY
02 SOLAR PANELS TO HEAT HOT WATER
03 SOLAR PANELS TO HEAT ROOMS
04 WIND TURBINES TO GENERATE ELECTRICITY
05 WIND TURBINES TO PUMP WATER
06 OTHER → [RECORD:] _____
_____
07 DON'T KNOW

IF MORE THAN ONE RESPONSE SELECTED FOR Q14, CONTINUE TO Q15.
IF Q14 = 07, SKIP TO Q18. ALL OTHERS SKIP TO Q16.

15 Which of these equipment types would you say is likely to generate the most energy for its owner? [IF RESPONDENT DOESN'T KNOW, ASK HIM/HER TO ESTIMATE WHICH. IF THE RESPONDENT STILL CANNOT PROVIDE A RESPONSE, ENTER "This equipment" FOR 09.]

01 SOLAR PANELS TO GENERATE ELECTRICITY
02 SOLAR PANELS TO HEAT HOT WATER
03 SOLAR PANELS TO HEAT ROOMS
04 WIND TURBINE TO GENERATE ELECTRICITY
05 WIND TURBINE TO PUMP WATER
06 OTHER → [RECORD:] _____
09 DID NOT REPOND: "This equipment"

16 Did you install this equipment on your own home or business?

01 YES
02 NO

IF Q16 = 01, SKIP TO Q21

17 Considering all of the possible things that might have influenced the decision to install the IF Q14 HAS ONE RESPONSE, INSERT RESPONSE FROM Q14; ELSE INSERT RESPONSE FROM Q15, 09, how important would you rate your personal influence on the decision? Please rate your influence on a scale of 0 to 10, where 0 means your influence was not at all important and 10 means you believe the equipment would not have been installed if you had not influenced it.

01 [RECORD RATING BETWEEN 0 AND 10; CONFIRM YOUR ENTRY:] ____
02 DON'T KNOW

18 Since 2000 have you visited any Internet sites that described the availability of utility or state incentives for solar-energy systems to generate electricity or heat for your home?

04 YES
05 NO
06 DON'T RECALL

19 Since 2000 have you given any thought to the advantages and disadvantages of installing solar panels to generate electricity or to heat water for your own house?

04 YES
05 NO
06 LIVE IN AN APARTMENT
07 NO PERMANENT RESIDENCE
08 DON'T RECALL

IF Q19 = 01 CONTINUE TO Q20. ALL OTHERS SKIP TO Q21.

20 Since 2000 have you asked a contractor to offer you a price for installing solar panels to generate electricity or to heat water for your house, or have you investigated a price on your own?

04 YES
05 NO
06 LIVE IN AN APARTMENT
07 NO PERMANENT RESIDENCE
08 DON'T RECALL

21 Since 2000 have you helped to convince anyone, including yourself, to install any type of energy-efficient equipment, such as an efficient appliance or lighting fixture, in a home or business?

01 YES
02 NO
03 DON'T RECALL

IF Q21 = 01, CONTINUE TO Q22. ALL OTHERS SKIP TO Q26.

22 What kind of energy-efficient equipment was installed? [SELECT AS MANY AS ARE MENTIONED. IF ANY CHOICE 01-07 SELECTED, DO NOT SELECT 08.]

01 COMPACT FLUORESCENT LIGHTS
02 EFFICIENT APPLIANCES FOR RESIDENTIAL, COMMERCIAL, OR INDUSTRIAL BUILDINGS
03 EFFICIENT INDUSTRIAL OR COMMERCIAL EQUIPMENT (E.G., MOTORS)
04 EFFICIENT LIGHTING FIXTURES FOR RESIDENTIAL, COMMERCIAL, OR INDUSTRIAL BUILDINGS (E.G., T-8 LAMPS)
05 EFFICIENT WINDOWS
06 INSULATION
07 OTHER → [RECORD:] _____
_____
08 DON'T KNOW

IF MORE THAN ONE RESPONSE SELECTED FOR Q22, CONTINUE TO Q23.
IF Q22 = 08, SKIP TO Q26. ALL OTHERS SKIP TO Q24.

23 Which of these pieces of equipment would you say is likely to save the most energy for its owner? [IF RESPONDENT DOESN'T KNOW, ASK HIM/HER TO ESTIMATE WHICH. IF THE RESPONDENT STILL CANNOT PROVIDE A RESPONSE, ENTER "This equipment" FOR 09.]

01 COMPACT FLUORESCENT LIGHTS
02 EFFICIENT APPLIANCES FOR RESIDENTIAL, COMMERCIAL OR INDUSTRIAL BUILDINGS
03 EFFICIENT INDUSTRIAL OR COMMERCIAL EQUIPMENT (E.G., MOTORS)
04 EFFICIENT LIGHTING FIXTURES FOR RESIDENTIAL, COMMERCIAL OR INDUSTRIAL BUILDINGS (E.G., T-8 LAMPS)
05 EFFICIENT WINDOWS
06 INSULATION
07 OTHER → [RECORD:] _____
_____
09 DID NOT RESPOND: "This equipment"

24 Did you install this equipment on your own home or business?

01 YES
02 NO

IF Q24 = 01, SKIP TO Q26.

25 Considering all of the possible things that might have influenced the decision to install the IF Q22 HAS ONE RESPONSE, INSERT RESPONSE FROM Q22; ELSE INSERT RESPONSE FROM Q23, 09, how important would you rate your personal influence? Please rate your influence on a scale of 0 to 10, where 0 means your influence was not at all important and 10 means the equipment would not have been installed if you had not influenced it.

01 [RECORD RATING BETWEEN 0 AND 10; CONFIRM YOUR ENTRY:] ____
02 DON'T KNOW

26 I'm going to read several statements about renewable energy and energy efficiency. Please tell me whether you believe the statements are true or false.

PRESENT INTERVIEWER STATEMENTS A TO H. RANDOMLY CHANGE THE ORDER OF THE STATEMENTS BETWEEN RESPONDENTS.

[READ EACH STATEMENT. AFTER READING THE STATEMENT RECORD THE RESPONDENT'S CHOICE. IF NEEDED, ASK, Would you say this statement is . . .]

01 TRUE
02 FALSE
03 NOT SURE/DON'T KNOW

A. Over the course of a year, a home called a "zero-energy home" will produce at least as much electricity as it uses.
B. If you install solar-electric panels on your house you might still need to buy electricity from your local utility.
C. A house that uses solar panels to reduce its energy costs will usually have a higher initial purchase price than the same house without solar panels.
D. Houses that use solar panels also require batteries.
E. Solar panels that collect energy from the sun can only be used to generate electricity.
F. In most of the northern hemisphere, a rooftop solar panel that faces due south will collect more solar energy than one facing due east.
G. A compact fluorescent light bulb uses one-quarter to one-third as much energy as an incandescent bulb that produces the same amount of light.
H. A refrigerator that is labeled ENERGY STAR will use less electricity to cool an item of food than a similar refrigerator that is not labeled ENERGY STAR.

AFTER THE LAST TRUE-FALSE QUESTION CONTINUE TO Q27.

27 The remaining questions will be used only to group answers from all of the surveys. Your answers will not be identified with you personally.

Do you own or rent your home?

01 OWN
02 RENT
03 OTHER

28 Prior to college, or while you were in college, did you participate in any activity that encouraged other people to conserve energy or help the environment? [IF ASKED, AN "ACTIVITY" COULD INCLUDE AN ECOLOGY CLUB, RALLY, WALKATHON, OR NEIGHBORHOOD CLEAN UP.]

01 YES
02 NO
03 DON'T RECALL

29 Prior to college, or while you were in college, did you ever write about energy conservation or the environment in a school paper, a blog, or an e-mail, twitter, or letter to the editor?

01 YES
02 NO
03 DON'T RECALL

30 Are you aware of an Internet site called the Database of State Incentives for Renewables and Efficiency or [SPELL] DSIRE where the availability of state and utility incentives for installing solar energy and energy efficient equipment is listed?

04 YES
05 NO
06 NOT SURE

31 Has anyone living in the household ever had any formal technical training or engineering education?

01 YES
02 NO
03 DON'T KNOW
04 REFUSED

32 I am going to read some age categories. Please stop me when I read the category that includes your age. [WHEN STOPPED, SAY,] Your age is [READ THE LAST CATEGORY SPOKEN.] Is that correct? [SELECT IF CONFIRMED. IF NOT CONFIRMED, ASK FOR THE CORRECT CATEGORY AND SELECT.]

01 Less than 20 years
02 20 to 29 years
03 30 to 39 years
04 40 to 49 years
05 50 to 59 years
06 60 to 69 years
07 70 years or older
08 REFUSED

33 Finally, for analysis purposes only, I am going to ask about the combined income of all persons living in this household during the past 12 months. I am going to read several income categories. Please stop me when I read the category that includes the combined income in the last 12 months of everyone living in the household. [WHEN STOPPED, SAY, Your household income in the last 12 months was [READ THE LAST CATEGORY SPOKEN AND SELECT IT IF CONFIRMED. IF NOT CONFIRMED, ASK FOR THE CORRECT CATEGORY AND SELECT.]

06 Less than $50,000 → CONTINUE TO Q34
07 $50,000 to $100,000 → SKIP TO Q35
08 More than $100,000 → SKIP TO Q36
09 DON'T KNOW → That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]
10 REFUSED → That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]

34 Was the household income [READ AND SELECT THE RANGE CHOSEN]

06 Less than $10,000?
07 $10,000 but less than $35,000?
08 $35,000 but less than $50,000?
09 DON'T KNOW
10 REFUSED

That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]

35 Was the household income [READ AND SELECT THE RANGE CHOSEN]

05 $50,000 but less than $75,000?
06 $75,000 but less than $100,000?
07 DON'T KNOW
08 REFUSED

That is all of our questions. Thank you very much for your time. Have a nice day/evening. [TERMINATE]

36 Was the household income [READ AND SELECT THE RANGE CHOSEN]
05 Less than $150,000?
06 $150,000 or more?
07 DON'T KNOW
08 REFUSED

That is all of our questions. Thank you very much for your time. Have a nice day. [TERMINATE]

END OF SURVEY FOR NON-DECATHLETE FORMER-STUDENTS. QUOTA =110.

Addendum to Appendix E.3
Correct Answers to Questions 26A through 26H

The answer counted as correct is underlined.

26A Over the course of a year, a home called a "zero-energy" home will produce at least as much electricity as it uses.

<u>True</u>
False
<u>Not sure</u>

Question 29 was created in 2008. After approval by OMB, subsequent internal testing and review disclosed a lack of agreement within the renewable energy industry on the meaning of the term, e.g., the term "*net* zero energy" appeared after designing the questionnaire; does it refer to electricity usage only or does it include natural gas? As a consequence of this review, all answers to this question were accepted as correct.

26B If you install solar-electric panels on your house you might still need to buy electricity from your local utility.

<u>True</u>
False
Not sure

26C A house that uses solar panels to reduce its energy costs will usually have a higher initial purchase price than the same home without solar panels.

<u>True</u>
False
Not sure

26D Houses that use solar panels also require batteries.

True
<u>False</u>
Not sure

26E Solar panels that collect energy from the sun can only be used to generate electricity.

True
<u>False</u>
Not sure

26F In most of the northern hemisphere, a rooftop solar panel that faces due south will collect more energy than one facing due east.

True
False
Not sure

26G A compact fluorescent light bulb uses one-quarter to one-third as much energy as an incandescent bulb that produces the same amount of light.

True
False
Not sure

26H A refrigerator that is labeled ENERGY STAR will use less electricity to cool an item of food than a similar refrigerator that is not labeled ENERGY STAR.

True
False
Not sure