

# Solar Decathlon Rules and Regulations

## September 16, 2002

*The Engineer's aesthetic, and Architecture, are two things that march together and follow one from the other.... The Engineer, inspired by the law of economy and governed by mathematical calculation, puts us in accord with universal law. He achieves harmony. The Architect, by his arrangement of forms, realizes an order, which is a pure creation of his spirit...it is then that we experience the sense of beauty.*

—Le Corbusier

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## 1. INTRODUCTION

The Solar Decathlon is a new intercollegiate and interdisciplinary design and construction competition that takes up a persistent and age-old question: How do we integrate architecture and technology with a dwelling? In other words, what makes a good house?

More than 2,000 years ago, the Roman architect Vitruvius claimed that all buildings should possess the qualities of “firmness, commodity, and delight.” Centuries later, architects and engineers of the Industrial Revolution were inspired and challenged by the new technologies and building tasks their age presented. In the early twentieth century, the influential Swiss Modernist architect, Le Corbusier, wrote in *Towards a New Architecture*, “Let us state the problem. Let us shut our eyes to what exists. A house: a shelter against heat, cold, rain, thieves, and the inquisitive. A receptacle for light and sun. A certain number of cells appropriate to cooking, work, and personal life.”

The sources of energy that powered the Industrial Age have revealed their limitations and their consequences, even as contemporary living demands more and more energy for “commodity and delight” as well as “cooking, work, and personal life.” Architecture and engineering students of today, then, face both an old and a new problem: to satisfy an age-old curiosity about dwelling while solving the relatively new problem of post-industrial energy and its consequences. The Solar Decathlon will challenge engineering and architecture students to design and construct a fully self-sufficient solar-powered house. Or, to paraphrase and gather inspiration from Le Corbusier’s words: a sun-machine for living in.

Like the athletic decathlon, the Solar Decathlon will test proficiency in a wide range of skills. Unlike its athletic counterpart, however, the Solar Decathlon is a team event, in which the diversity of abilities comes from the composition of the team rather than a single individual. Architecture and engineering students will work with students from other disciplines such as marketing, communications, graphic arts, analysis, and computer science to do the troubleshooting, communicating, dreaming, and building this challenging event will require.

The first Solar Decathlon competition will take place on the National Mall in Washington, D.C., in the fall of 2002. Teams will compete against each other during a week of 10 decathlon contests to which the public and media will be invited. The team with the highest point total at the end of the week will be the winner. Additional awards will be presented in several other categories.

The 10 contests are based on three guiding principles for the competition:

- Supplying the energy requirements necessary to live and work using only the global solar radiation incident on the building during the contests,
- Exemplifying design principles that will increase the public’s awareness of the aesthetic and energy benefits of solar technologies, which in turn increases the use of these design principles and technologies, and
- Stimulating accelerated research and development of renewable energy, particularly in the area of building applications.

The following set of priorities has been used to determine what the 10 contests should encompass.

*Design*—Since the time of Vitruvius, design has been an essential part of deciding what makes “a good house.” Good design is both robust and aesthetically pleasing. It improves structural

integrity (“firmness”), function and comfort (“commodity”), and consumer appeal (“delight”). A house must be visually pleasing and compelling, especially when new technology is being introduced. Design will be a critical part of the competition, emphasizing dwelling livability, aesthetics of structural and system components, and the integration of the dwelling with its energy systems.

*Energy Production*—The house must be able to supply all of the energy needed for its occupants to survive and prosper in today’s society for cooking, work, and personal life. The contests will test the supply of domestic energy and energy required for a home-based business. The contests will quantify energy production and productive output.

*Energy Efficiency*—Efficiency reduces consumption and enables more work to be accomplished with a given amount of energy. Because the amount of sunlight that strikes the surface of a house is limited, end-use efficiency will be a key strategy to success.

*Heating and Air Conditioning*—As Le Corbusier stated, a house must be a comfortable space in which to live protected from wind and rain, from winter snow and summer heat. For good health, the conditioned space must also minimize indoor pollutants.

*Refrigeration*—Food preservation is a necessity.

*Water*—Hot running water is considered a necessity.

*Lighting*—Lights improve our safety, productivity, and quality of life. Beyond its purely practical application, lighting also has the power to please the inhabitants of the “receptacle for light” that Le Corbusier described.

*Graphics and Communication*—Print, electronic, and video communications save time and improve our safety and quality of life by supplying the important information we use to make critical decisions. Variety, content, and design of communications products are essential to drawing an audience to a message. Getting a pleasing message about delightful design, energy efficiency, and solar energy to the public audience will be an important consideration in this event.

*Transportation*—Mechanized transportation gives us greater freedom, saves time, and improves productivity. The contests will reward teams that can use their house to provide the energy to supply modern transportation needs and that plan their transportation use the most efficiently.

*Daily Tasks*—Household appliances have improved our quality of life since the dawning of the industrial age. They use energy to save the time and physical work of a household’s inhabitants. The demand for appliances grows greater every day, even as the consequences of supplying the energy they require becomes ever more apparent. The Solar Decathlon will challenge students to meet the energy demands for cooking, work, and personal life while competing to solve the problem of energy and its consequences in the post-industrial age.

## **2. ADMINISTRATION**

### **2.1 Definitions**

*Chief Inspector*—The individual selected by the Organizers to be ultimately responsible for all inspections. The Chief Inspector must be present at all instances when the teams use non-solar energy sources for continued participation in the contests. The Chief Inspector is ultimately responsible for determining if a Rules and Regulations violation has occurred.

*Chief Judge*—The individual selected by the Organizers to be responsible for final scoring of the contests and applicable penalties as well as the assignment of those penalties.

*Competition*—The Competition is the series of events that take place on the site; this includes check in, construction, inspection, contests, public access times, and disassembly.

*Contest*—One of the ten categories in which teams will be evaluated comparatively against each other in order to determine a winner of the Event.

*Director*—The Director is the individual responsible for conducting the Event and determining disqualification.

*Event*—All activities involved in the Solar Decathlon from the initial meetings through the conclusion of the Competition.

*Headquarters*—During the Competition, a Headquarters, established at the site, will assume the management functions for the Competition.

*Inspectors*—The individuals selected by the Organizers to visit teams for pre-competition on-site inspections, and the individuals responsible for inspections and instrumentation installation during the Competition. The Inspectors shall monitor activities and are responsible for identifying any infractions of these Rules and Regulations infractions that occur during the Event.

*Judges*—Individuals selected by the Organizers to judge and score all Contest components of a subjective nature.

*Jury*—To resolve team disputes, a Jury will be formed to evaluate protests concerning conformity with these Rules and Regulations. In addition, the Jury is empowered to decide cases not specifically covered by these Rules and Regulations. The Jury will be available to teams until contests and the assessment of penalties are completed.

*Observer*—A person assigned to each team by the Organizers who will observe team activity and progress during the contests. The Observer will also report to the Chief Inspector any observed violation of the Rules and Regulations but will not provide official interpretation of the Rules and Regulations. The Observer will also verify task completion. Teams should expect that the Observer will spend a significant portion of the Contest hours as an occupant in the house and should be accommodated.

*Organizers*—The body of individuals responsible for organizing the Event. The Organizers will select Officials, Observers, Jury Members, Judges, and Inspectors.

*Official Point Total*—Final point summation after the contests have been concluded and all penalties have been taken into account.

*Official Point Total Sheets*—A sheet containing the sum of each team's final point totals and penalties generated after the conclusion of the contests and assessment of penalties.

*Officials*—A team of Officials to conduct the Competition, including registration, inspection, monitoring, and judging, will be selected by the Organizers. Officials having specific duties will be announced to the teams through the Solar Decathlon Web site, newsletters, and briefings.

*Solar Decathlon Rules and Regulations Committee*—The body of individuals responsible for writing and revising this Rules and Regulations document and its amendments.

## **2.2 Timeline**

*Registration and Formal Proposals: February 20, 2001*  
*Team Selections Announced: March 30, 2001*  
*Solar Decathlon Workshop: April 22, 2001*  
*Student Team Web Site: October 1, 2001*  
*Qualification: December 4, 2001*  
*Approval Rating: June 1, 2002*  
*Final Design Report: June 12–August 14, 2002*  
*On-Site Inspections: July–August 2002*  
*Competition Schedule: September 19–October 10, 2002*

*Registration and Formal Proposals: February 20, 2001*—Each team must submit a written proposal that describes its organization, timeline, and commitment to complete the project on schedule. For detailed proposal criteria, see the Request for Proposals posted October 19, 2000, at <http://www.nrel.gov/contracts/rfps/>.

*Team Selections Announced: March 30, 2001*

*Solar Decathlon Workshop: April 22, 2001*—The U.S. Department of Energy hosts a one-day Solar Decathlon “kickoff” workshop in Washington, D.C., on Sunday, April 22, 2001, for the teams selected to participate. The purpose of the workshop is to provide technical tutorials on solar buildings, answer questions about the Event, and present the monetary awards to each successful team. Additionally, each team selects its National Mall “building site” at the workshop, through a lottery system.

*Student Team Web Site: October 1, 2001*—See Contest 3: Graphics and Communication.

*Qualification: December 4, 2001*—Teams selected for participation will be required to submit team and technical information describing their building’s design no later than December 4, 2001 (see Administration, Regulations and Documents, Qualification Documents). This is a qualifying step, and approval of this report is mandatory for participation in the Event. The Organizers will provide feedback to teams identifying deficiencies and requirements for final approval as early as possible. This feedback process may continue until June 1, 2002, when the teams must have an approval rating for this report.

*Approval Rating: June 1, 2002*—Teams must have achieved an approval rating on the December 4, 2001, qualification document by June 1, 2002, 5:00 P.M. MDT. For this approval, the teams must have provided documentation and/or drawings to address all items identified in the qualification review by the Rules and Regulations Committee as “unable to determine compliance” or “noncompliant.”

**Note:** This does not mean that teams must submit required documents and/or drawings on June 1, but that the process to achieve approval has been completed. By June 1, 2002, the Solar Decathlon Rules and Regulations Committee must have approved all outstanding items on your review. If a team fails to achieve an approval rating, it may be asked to withdraw from the Competition.

*Final Design Report: June 12–August 14, 2002*—Student Teams must submit a final design and performance report to reflect the final version of design plans and energy analysis (see Administration, Regulations and Documents, Final Design Report).

*May 22, 2002*—If teams plan to submit construction drawings in electronic format, they must notify the Solar Decathlon Organizers by May 22, 2002, which electronic format they will use.

*June 12, 2002*—The building plans for the final design report must be received by June 12, 2002 at 5:00 P.M. MDT. This is a critical deadline. The National Park Service (NPS) must review and approve the plans from all the teams. If a team fails to submit these plans, it may be asked to withdraw from the Competition.

*July 31, 2002*—If teams plan to submit electronic files of simulation input files, they must indicate by July 31, 2002, which version of the permitted simulation tools they are using, and if custom libraries or program modules were developed.

*August 14, 2002*—The results from the building energy analysis (simulation) and the transportation (Getting Around) analysis, both critical pieces of the final design report, are due by August 14, 2002, at 5:00 P.M. MDT.

*On-Site Inspections: July–August 2002*—See Inspection, Pre-Competition, On-Site Inspections.

*Competition Schedule: September 19–October 10, 2002*

- Day 1–5: Arrival, assembly, and construction
- Day 6–8: Inspection
- Day 9–10: Tours and solar operation of houses begin
- Day 11–15: Contests
- Day 16–18: Tours and awards
- Day 19–21: Disassembly and cleanup

## **2.3 Regulations and Documents**

*Applications of Rules and Regulations*—These Rules and Regulations apply to the Event and include the selection, registration, and Qualification of teams; the inspection of houses and cars; and the Competition.

*Supplemental Documents*—Additional documents may be distributed to all teams entered in the Event to supplement these Rules and Regulations. These documents will clearly state that they are a supplement to the Rules and Regulations, and they will have the same force and effect as these Rules and Regulations. If there is a conflict between a supplemental document and these Rules and Regulations, the document having the later date shall take precedence. Supplemental documents specifically referenced in these Rules and Regulations include Solar Decathlon newsletters, official interpretations, and instructions for inspection.

*Acceptances of Rules and Regulations*—All persons or groups selected to participate in the Event are assumed to know these Rules and Regulations. Their participation in the Event will constitute acceptance of these Rules and Regulations.

*Interpretation of Rules and Regulations*—All interpretations must be published in Solar Decathlon newsletters or posted on the Solar Decathlon Web site under “Official Interpretations” in order to be considered official. During and after the Competition, all official interpretations will be announced at briefings and posted at Headquarters and on the Internet. The only group authorized to interpret the Rules and Regulations is the Solar Decathlon Rules and Regulations Committee.

*Advertising, Promotion, and Publicity*—All advertising, sales promotion, and publicity material produced by the teams or their sponsors concerning or referring to the Event will refer prominently to the Event as the Solar Decathlon. All teams, by entering the Event, specifically agree to abide by this regulation. By entering the Event, all teams and team members agree to the use of their names and their likenesses in any publicity materials (brochures, magazines, videos, photographs, etc.) that may be issued by the Event’s sponsors or Organizers.

*Data Sheets*—The data sheets must include house dimensions, construction type, solar-design features, estimated peak solar-array power (overhead sun, clear sky), and glazing areas by orientation. All specifications must be provided in English units. The team leader, team members, decathletes, and faculty advisor(s) must be listed. A data summary of the components of the solar house must include manufacturers’ specifications or acquired data, areas or amounts used, and capacities or performance measures for the following items:

- Insulation
- Photovoltaic collectors
- Solar hot-water system
- Batteries
- Additional balance of system components
- Glazing surfaces
- Appliances and office equipment
- Space-conditioning equipment
- Water-pumping equipment
- Thermal storage devices and tanks



- Material Safety Data Sheets (MSDS) for all heat transfer fluids and batteries for approval
- Total cost estimate for the solar house (excluding labor).

*Technical Documents*—Technical documents describing the building design will be evaluated as part of Qualification and as a final report. Early submissions will receive prompt review by Headquarters. The Organizers will provide feedback to teams identifying deficiencies and requirements for final approval. The technical information provided in these documents will not be made public without team approval. The final submission must match the building structure, batteries, and solar cells presented at the Competition. For the December 4, 2001, Qualification report, the entire collection of documents, including appendices, shall not exceed 30 pages in length.

For the final design report (June 12–August 14, 2002), the entire collection of documents, including appendices, shall not exceed 60 single-sided pages (8.5 in. x 11 in.) in length. This page limit applies only to the building plans, narrative design description, the building energy analysis and the transportation (Getting Around) analysis sections as described in the Rules and Regulations as well as the final design report requirements documents. Construction drawings and schematics, MSDS sheets, and solar cell and battery approval data are not subject to the size limitation (8.5 in. x 11 in.) or the single-sided 60-page-length limitation.

Teams are not required to resubmit in their final design reports any solar cell, battery data, and MSDS sheets already approved in the qualification document reviews. In the event of a change to the solar cells, batteries, or heat transfer fluids, documentation reflecting these changes must be submitted for approval as described in Regulations and Documents, Structural Report, Solar Cell Approval, Battery Approval.

*Structural Report*—Safety should be the primary concern for the structural development, fabrication, construction, and operation of the solar house. The structural report must present and address the design issues involved in the fabrication and construction phase, transporting the house to Washington, D.C., and operating it on site. Safety should be documented with calculations, testing, or both. Photos, drawings, and anecdotal references are also acceptable.

*Solar Cell Approval*—All solar cells and modules must be approved by Solar Decathlon Headquarters (see Regulations, Electrical, Solar Cell Technology Limitation). Each team must provide a copy of the manufacturer's solar cell and module specification sheet, and the following information:

Manufacturer's name and contact information  
 Stock number, type, or description  
 Manufacturer's quote for cell or module area  
 Manufacturer's quote for performance  
 Cost (US\$) per watt for each cell or module.

*Battery Approval*—All storage batteries used in the house must be approved by Solar Decathlon Headquarters (see Regulations, Energy Collection and Storage, Storage Batteries). Each team must provide a copy of the manufacturer's battery specification sheet, the MSDS obtained from the battery manufacturer, and the following battery information:

- Manufacturer's name and contact information
- Stock number, type, or description

- Module voltage (e.g., 6 V, 12 V, or 24 V)
- Bus voltage
- Number of modules to be used in the house
- Manufacturer's specifications, including capacity (kWh), weight (lb), and cost (US\$)
- Spill and damage protocols and procedures (If these are not provided in the MSDS, the team must obtain this information from the manufacturer and submit it to Headquarters with the MSDS.)

*Qualification Documents*—Information due at qualification (December 4, 2001) will include all aspects of technical documents, solar cell and battery approval data, building and assembly plans from Contest 2, Design Presentation and Simulation. This submission will also include results from simulations as described in Contest 2, Design Presentation and Simulation.

*Final Design Report*—Information due for final design reports (June 12–August 14, 2002) will include all aspects of team data, data sheets, technical documents, solar cell and battery approval data, structural report, building and assembly plans as described in Contest 2, Design Presentation and Simulation. This submission will also include results from simulations as described in Contest 2, Design Presentation and Simulation. Teams should also provide a discussion of the cost-effectiveness of the design and construction of their solar house.

## **2.4 Entries**

*Entry*—The Event is open to colleges, universities, and other post-secondary educational institutions. Entry is selected through a proposal process. All proposals will be reviewed, scored, and ranked. Subject to the quantity and quality of submissions, a limited number of teams will be selected for entry.

*Faculty Advisor*—Teams must have at least one faculty advisor who will provide guidance on an as-needed basis throughout the Event. The advisor will be responsible for obtaining appropriate signatures on documents that represent the school.

*Team Data*—Each team must submit team photos and team data to the Solar Decathlon Headquarters no later than June 1, 2002. The photo and data will be publicly released and used in Event brochures. Late submissions will be omitted. Submissions will not be made public before the Event without permission of the team representative.

*Team Photo*—The team photo shall be submitted as a four-color print in a horizontal or landscape orientation measuring approximately 8 in. x 11 in., or as a high-resolution (recommended 300 dpi at 8 in. x 11 in.) electronic image. Team members in the photo must be identified by name and institution affiliation when there is more than one institution. The photos will be used in Event programs and other publications.

*Registration*—All people taking part in the Competition must be registered with Headquarters. This includes team members, sponsors, Officials, guests, and the media. Badges will be issued and used to obtain access to restricted areas. These badges must be visible at all times.

*Team Requirements*—All team members involved in the Competition must present themselves at registration to complete all required forms. Team members will be required to complete and sign liability waivers and emergency medical information forms.

**Decathlete Requirements**—Only registered decathletes will be allowed to compete in the 10 contests. A team shall have a maximum of six decathletes operating the house at one time. The same six individuals do not have to remain decathletes for the entire Competition. Decathlete status is transferable to other student team members. Teams will be allotted six decathlete badges for tracking purposes. In addition to meeting the decathlete requirements, car drivers must be 18 years old or older and present a valid driver's license.

**Vehicular and General Liability Insurance**—The school, at the school's expense, shall maintain for the duration of the Event, vehicular liability insurance with limits of liability for bodily injury of not less than US \$200,000.00 for each person and US \$500,000.00 for each occurrence; and limits of liability for property damage of not less than US \$40,000.00 for each accident and US \$500,000.00 for each occurrence.

The school, at the school's expense, shall maintain for the duration of the Event, general liability insurance with limits of liability for bodily injury of not less than US \$500,000.00 for each person and US \$500,000.00 for each occurrence; and limits of liability for property damage of not less than US \$100,000.00.

The school, at the school's expense, shall maintain for the duration of the Event, workers compensation insurance with limits of liability as required by applicable law; and employer's liability insurance for liability for bodily injury of not less than US \$100,000.00 for each person and US \$100,000.00 for each occurrence.

The school agrees to furnish the National Renewable Energy Laboratory (NREL) or the U.S. Department of Energy (DOE), upon request, evidence satisfactory to NREL or DOE of such vehicular liability, general liability, workers compensation liability, or employer's liability insurance coverage.

### **3. DECATHLON CONTESTS**

The 2002 Solar Decathlon Competition consists of 10 separately scored contests. Each team will be required to participate in all 10 contests. The team with the highest total points at the end of the 10 contests will win. The total possible points within each category are listed after the Contest descriptions that follow.

#### **3.1. Tasks, Contests and Tests**

During the week of contests, teams will be subject to periodic tasks, periodic contests, and periodic system tests at any time during the scheduled contests. These include but are not limited to the following:

**Periodic Tasks:**

- Cooking items
- Delivering and picking up items with the electric car.

**Periodic Contests:**

- Additional laundry and dishwashing
- Additional domestic hot-water tests and evaluations.

**Periodic System Tests:**

- Space-conditioning tests, which may include public tours
- Refrigeration tests.

Teams will be notified via e-mail from Officials as to when additional tasks, contests, and tests will commence outside of the scheduled contests. Teams will be expected to perform typical tasks each day that use common household appliances and mechanized travel.

Teams will be expected to cook on three occasions during the contests. The solar house will need to be outfitted with appropriate appliances or devices to cook several items during the week. Food to be cooked may include items such as frozen dinners, frozen pizza, desserts, biscuits, soup, popcorn, bread, or toast. No food will be provided to the visiting public at any time. Teams will be asked to pick up items to be cooked from a grocery store during the week of the contests.

### **3.2. Contest 1: Design and Livability**

*Goal*—Integration and synthesis of design and technology into a livable and delightful domestic environment.

*Criteria*—An important objective in this Event is the public acceptance of new, innovative technologies for domestic environments. Therefore, the design must not only satisfy human needs for comfort, it must also be well organized and visually pleasing both inside and out. Although the technologies are innovative, the classic architectural standards of “firmness, commodity, and delight” remain the criteria for a successful building. A panel of architects and design professionals will judge each entry on the overall aesthetics and the successful design integration of the technical features of the house. Judging will take place early in the week and will not be based on the objectively measured technical performance of the house.

Judges will consider the following criteria in their evaluations.

#### ***Firmness:***

- Strength, suitability, and appropriateness of materials for the building
- Balance between the need for solidity and strength and the challenge of portability and ease of construction
- Integration of structure and enclosure.

#### ***Commodity:***

- Was the design team able to create a sense of easy entry into the house and circulation among the public and private zones of the house as well as the served and service spaces?
- Architectural strategy used to accommodate the technologies required to run the house
- Generosity and sufficiency of space to allow all of the activities required during the contests to take place.

#### ***Delight:***

- Surprises, unusual use of ordinary materials, or use of extraordinary materials
- Sufficiency of architectural attention given to the experiential relationship between inside and outside
- Lasting Impression: Is the house memorable in any way? In the interior? From the exterior?
- Balance of attention paid to all sides of the house.

| Scoring by Panel of Five Judges | Points Available |
|---------------------------------|------------------|
| Design and Livability           | 200              |

### 3.3 Contest 2: Design Presentation and Simulation

**Goal**—Before a project is built, the designers imagine the project through drawings, models, and computer models. This Contest evaluates the production of an imaginative and thorough set of documents illustrating the construction of the building and the simulation of its energy performance.

**Criteria**—Teams will be required to submit a complete set of “as built” construction documents at the Competition. Teams will also submit a building energy analysis, which contains an analysis of the energy requirements for Contest 10, Getting Around, and an annual, hourly energy simulation of the proposed building. These items will be evaluated as part of qualification and final design plans.

During the Competition, teams will be scored on the following criteria:

**Construction Documents:** Plans are to include architectural, mechanical, electrical, and structural considerations as well as a plan of assembly. Teams should bring one hardcopy of “as-built” construction documents in large format (requested: 24 in. x 36 in. or greater plot size) that reflect design changes that occurred during construction.

The construction documents will be judged on the basis of the following criteria:

**Completeness:** An architectural jury and an engineering design panel will rank the drawing sets based on a subjective evaluation of construction document accuracy.

**Quality**—An architectural jury and an engineering design panel will rank the drawing sets based on a subjective evaluation of construction document quality.

**Creativity**—An architectural jury and an engineering design panel will rank the drawing sets based on a subjective evaluation of the creativity used in describing the house through a set of construction documents.

**Building Energy Analysis:** Each team shall simulate annual performance characteristics of its solar house in the initial design phase using EnergyPlus (available at [http://www.eren.doe.gov/buildings/energy\\_tools/energyplus/](http://www.eren.doe.gov/buildings/energy_tools/energyplus/)), DOE2.1E-107 (or newer), DOE2.2 (for example, Equest or PowerDOE), ENERGY-10, or TRNSYS. Additional simulation tools may be used for modeling of systems, components, or features that are in the design. If possible, teams are encouraged to incorporate the data obtained from other simulation tools into the EnergyPlus, ENERGY-10, and any version of DOE2 or TRNSYS simulation.

The building energy analysis will be judged on the basis of the following criteria:

**Accuracy:** How well the simulation approaches the final building that arrives for the Competition (exception, see Regulations, Energy Collection and Storage, Thermal and Electrical Storage System Sizing).

**Assumptions:** Teams must document all assumptions made regarding their simulation.

**Simplifications:** Teams must make their simulation as simple as possible without compromising accuracy; all simplifications must be documented and justified.

**Transportation Analysis:** An analysis of the energy required to complete all tasks associated with the electric car during the week of contests.

**Improvisation:** It is recognized that currently available software may not contain routines for all situations. Teams must document and justify any improvisation necessary to simulate a specific component or system.

**Annotation:** Teams must present an input file that is fully annotated if possible.

**Annual Energy Performance—**Teams must include a discussion of design steps taken to minimize annual energy requirements of their proposed design.

Teams will submit an annual building simulation using typical meteorological year (TMY or TMY2) weather data for Washington, D.C. (WBAN #'s 93734 or 93738) available at [http://www.eren.doe.gov/solar\\_decathlon/resources.html](http://www.eren.doe.gov/solar_decathlon/resources.html). All simulations will use prescribed heating, cooling, illumination, and internal-gains schedules specified by the Rules and Regulations Committee (see Appendix A).

| Scoring by Panel of Five Judges | Points Available |
|---------------------------------|------------------|
| Construction documents          | 50               |
| Building energy analysis        | 50               |

### 3.4 Contest 3: Graphics and Communication

**Goal—**To produce outreach materials that explain each team's Solar Decathlon house, as well as the solar energy and energy efficiency technologies the house uses, to the public, public officials, the media, and any special guests visiting from schools and trade or professional organizations. This Contest has three components: (1) Web site, (2) newsletters, and (3) house tours.

**(1) Web site—**By October 1, 2001, a site consisting of a minimum of three pages should be live and linked to the Solar Decathlon Web site. The students' sites should explain the design of their houses and the technologies used in them. Sites do not have to contain information that would compromise a team's competitive edge. This portion of the Contest is pass/fail.

By September 23, 2002, the team Web sites (except for the contest diaries) should be finalized and ready for judging. We expect that the information available on your site during the Competition to be of significantly greater detail than that available on your site on October 1, 2001.

Contest updates in the form of "contest diaries" will be required each day during the weeklong contests (September 30–October 4, 2002): In these diaries, teams will discuss their progress in and experience with the Competition. The Solar Decathlon Officials will provide the teams with specific content requirements, format standards, and daily topics, as well as production schedules. Contest diary and newsletter subject matter will be the same; the challenge will be to take the same material and adapt it to two very different formats with differing user/reader expectations and preferences.

Teams should provide their own workstation (a computer, monitor, printer, and any other hardware they choose, which must be approved by Headquarters). Each workstation will be a node on a local area network provided by the Solar Decathlon Organizers. Teams will have access to the Internet and e-mail during the Competition via the Solar Decathlon local area

network. Teams should update, as needed, their off-site Web server using the workstation in their house. Each workstation will be required to run from 9 A.M. through 5 P.M. during the weeklong contests.

Teams should not provide a Web server or host Web pages in their house using the Solar Decathlon's Internet connection. Teams should retain their Web sites on the servers on which they were first housed in October 2001—typically at their university or college. There should be no Web site hits or other public access to the teams' workstations on the National Mall through the Solar Decathlon's Internet connection.

**(2) Newsletters**—Students will produce daily newsletters both electronically and in print. The Solar Decathlon Officials will provide the teams with specific content requirements, format standards, a design template, and daily topics, as well as production and delivery schedules. The teams' progress in and experience with the Competition will drive the content. Newsletters will be two pages (front and back). Contest diary and newsletter subject matter will be the same; the challenge will be to take the same material and adapt it to two very different formats with differing user/reader expectations and preferences.

**Print distribution:** Copies of the newsletter must be printed on site. Teams will be given a quantity of official Solar Decathlon watermarked paper. Thirty copies will be required per day and all of these copies will be in color. Officials will provide delivery instructions of print newsletters.

**Electronic distribution:** Officials will supply a distribution list via e-mail. Students will also create their own distribution lists. Newsletter deliveries and team distribution lists will be subject to verification.

**(3) House Tours**—Teams must provide guided tours of their house to explain the house, and the technologies and products used in the house, to visitors. Operation of the TV/video player is mandatory during house tours. The content of any video/audio/electronic presentation must complement the information provided in the house tour and/or support the goal of Contest 3.

**Criteria**—Individual elements of the Contest will be judged on the following criteria.

**Web site:**

**Timeliness**—Teams must adhere to production and delivery schedules. Deadlines will be provided. If your team does not meet a deadline, that portion of the Web site and/or contest diary will not be judged, thereby affecting the overall score.

**Content**—Inclusion of specified content, use of audience-appropriate language, consistent tone, originality, and correct spelling and grammar

**Format and design**—Integration of text and graphics, consistency of design

**Creativity and interest**—Engaging content and innovative design

**Advertising**—Limited use and tasteful integration of team sponsor logos and other marketing materials. Sponsors should be recognized only according to the document "Guidelines for Sponsor Recognition" (*Solar Decathlon Bulletin*, May 21, 2002).

**Estimated download times**—The site will be tested with Bobby (a testing software)

**Navigation**—Consistency and ease of usability

**Value of any multimedia or JavaScript elements**

**Adherence to guidelines posted on the Solar Decathlon Sub site at**

**[http://www.eren.doe.gov/solar\\_decathlon/web.html](http://www.eren.doe.gov/solar_decathlon/web.html)**

**Newsletters:**

**Timeliness**—Teams must adhere to production and delivery schedules. Deadlines will be provided. If your team does not meet a deadline, that issue of your newsletter will not be judged, thereby affecting the overall score.

**Content**—Inclusion of specified content, use of audience-appropriate language, consistent tone, originality, and correct spelling and grammar

**Format and design**—Integration of text and graphics, consistency of design

**Creativity and interest**—Engaging content and innovative design

**Advertising**—Limited use and tasteful integration of team sponsor logos and other marketing materials. Sponsors should be recognized only according to the document “Guidelines for Sponsor Recognition” (*Solar Decathlon Bulletin*, May 21, 2002).

Adherence to guidelines posted on the Solar Decathlon Sub site at [http://www.eren.doe.gov/solar\\_decathlon/print.html](http://www.eren.doe.gov/solar_decathlon/print.html)

**House tours:**

**Content**—Description and explanation of house design strategies and technological features

**Creativity and interest**—Engaging audience interest and innovative approach

**Advertising**—Recognition will be subject to NPS rules. The role of sponsors of special events or activities may be recognized, but the method of recognition must comply with NPS policy.

Sponsors should be recognized only according to the document “Guidelines for Sponsor Recognition” (*Solar Decathlon Bulletin*, May 21, 2002).

**Presentation**—Design and presentation of tour materials as they relate to the house’s features, demeanor of tour guides toward the public

**Environmental Impact**—Use of recyclable products, minimization of throwaway materials.

| Scoring by Panel of Judges | Points Available |
|----------------------------|------------------|
| Web site                   | 40               |
| Newsletters                | 30               |
| House tours                | 30               |

**3.5. Contest 4: The Comfort Zone**

**Goal**—This Contest serves to demonstrate that the house is designed to provide interior comfort through ventilation, heating, cooling, and humidity controls with minimal energy usage.

**Criteria**—This is a two-part Contest: (1) a 24-hour evaluation, and (2) a weeklong evaluation.

**(1) A 24-hour evaluation** of the building’s ability to maintain a narrow temperature range: During the 24-hour evaluation, the house will need to maintain a minimum of 30% relative humidity and a maximum of 60% relative humidity as well as a temperature between 70°F and 74°F.

**(2) A weeklong evaluation** of the building’s ability to maintain comfort: Outside the 24-hour evaluation period, the house must maintain a minimum of 30% relative humidity and a maximum of 60% relative humidity as well as a temperature between 69°F and 78°F.

| Scoring by Panel of Five Judges       | Points Available |
|---------------------------------------|------------------|
| Innovation of system                  | 15               |
| Consumer appeal/integration of system | 15               |



| Scoring by Measure of Performance                                                                                                                                                                                                                       | Points Available |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| 24-hour evaluation:<br>If temperature >74°F, $E = (\text{temperature} - 74)$<br>If temperature <70°F, $E = (70 - \text{temperature})$<br>If RH >60%, $E = (\text{RH} - 60)$<br>If RH <30%, $E = (30 - \text{RH})$<br>$PI = \sum E$                      | 20               |
| Week-long temperature and humidity test:<br>If temperature >78°F, $E = (\text{temperature} - 78)$<br>If temperature <69°F, $E = (69 - \text{temperature})$<br>If RH >60%, $E = (\text{RH} - 60)$<br>If RH <30%, $E = (30 - \text{RH})$<br>$PI = \sum E$ | 20               |
| Electrical energy consumed to provide the space conditioning                                                                                                                                                                                            | 30               |

Teams will be ranked according to the lowest performance index (lowest  $PI = 1\text{st}$ ) for temperature and humidity setpoints.  $E$  represents the error or deviation from temperature setpoints. The electrical energy consumed to provide space conditioning will be measured and teams will be ranked on the basis of minimizing electrical energy use (lowest electrical energy consumed = 1st).

### 3.6. Contest 5: Refrigeration

**Goal**—Demonstrate that low-energy cold storage is possible.

**Criteria**—The challenge of this Contest is to maintain certain temperatures in a freezer and a refrigerator for a week while minimizing energy use. Each team must provide a refrigerator and freezer with a minimum of 15-ft<sup>3</sup> combined interior capacity. Any attached freezer compartment shall have a separate door from the refrigerator compartment and will have a minimum of 3-ft<sup>3</sup> interior capacity. Teams must submit manufacturers' specifications on refrigerator interior volume based on the Association of Home Appliance Manufacturers (AHAM) standard, AHAM MRF-1-2001 (see <http://www.aham.org/>). For custom refrigerators, teams must submit volume calculations based on the same standard. Points will be awarded based on how consistently the refrigerator maintains interior temperatures throughout the test week. Refrigerators will be subject to periodic inspections for items other than food and beverage items necessary for other contests.

| Scoring by Panel of Five Judges       | Points Available |
|---------------------------------------|------------------|
| Innovation of system                  | 15               |
| Consumer appeal/integration of system | 15               |

| Scoring by Measure of Performance                                                                                                                                                              | Points Available |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Maintain refrigeration system temperature of 32°F to 40°F and freezer system temperature of 0°F to -40°F.                                                                                      |                  |
| Refrigeration system performance index:<br>If temperature >40°F, $E = (\text{temperature} - 40)$<br>If temperature <32°F, $E = (32 - \text{temperature})$<br>Freezer system performance index: |                  |

|                                                                                                          |    |
|----------------------------------------------------------------------------------------------------------|----|
| If temperature >0°F, E = (temperature)<br>If temperature <-40°F, E = (temperature + 40)<br>$PI = \sum E$ | 35 |
| Electrical energy consumed to provide refrigeration                                                      | 35 |

Teams will be ranked according to the lowest performance index (lowest  $PI = 1st$ ) for temperature setpoints.  $E$  represents the error or deviation from temperature setpoints. The electrical energy consumed to provide refrigeration will be measured and teams will be ranked on the basis of minimizing electrical energy use (lowest electrical energy consumed = 1st).

### 3.7. Contest 6: Hot Water

**Goal**—This Contest demonstrates that a house can provide all of the energy necessary to heat water for common uses.

**Criteria**—All tasks using water of any kind will be restricted because the water circulation system is of a closed-loop nature (see Regulations, Water Supply and Distribution, Water Supply and Wastewater). This Contest has three components: (1) the shower test, (2) laundry, and (3) dishwashing.

#### (1) The Shower Test:

- Teams must complete two shower tests every day of contests.
- The shower must provide at least 15 gallons of water at a minimum temperature of 110°F, in at most 10 minutes. Water temperature will be measured in a bucket after the required 15 gallons have been delivered.
- The shower tests must occur once in the morning and once in the evening every day.
- An actual shower need not be present; a tap to draw the required hot water will suffice.
- Teams that do not complete a shower test will be assessed a penalty for 15 gallons of additional water (see Penalties, Energy Penalties, Receiving Additional Water).

#### (2) Laundry

- On two occasions during the contests, teams will be asked to do laundry using an automatic washer.
- The laundry will be considered dry and finished when the weight of the load returns to the weight of the load previous to the washing cycle.
- Teams will have six hours to wash and dry the laundry.
- The laundry for each occasion will be 12 large cotton bath towels weighing approximately 1 lb each.
- All water ports on the washing machine must be connected directly to the hot-water system outlet so that the machine only draws hot water when running.
- Washing machines must be automatic in operation and must have a wash and rinse cycle.
- Teams that do not complete a laundry cycle (a complete cycle includes a wash and rinse) will be assessed a penalty (see Penalties, Energy Penalties, Failure to Wash Laundry or Failure to Dry Laundry).

#### (3) Dishwashing

- Teams will be asked to run one dishwashing cycle using an automatic dishwasher within the 8:00 A.M. to 9:45 P.M. contest time frame per day.

- The dishwasher will be required to have a minimum capacity of six place settings according to manufacturer specifications. A single place setting is defined as a dinner plate, a salad plate, a bowl, a cup and saucer, two forks, a knife, and a spoon.
- All water ports on the dishwasher must be connected directly to the hot water system outlet so that the machine draws hot water only when running.
- Dishwashers must be automatic in operation and must have a wash and rinse cycle.
- Teams that do not complete a dishwashing cycle (a complete cycle includes a wash and rinse) will be assessed a penalty (see Penalties, Energy Penalties, Failure to Wash Dishes).

| Scoring by Panel of Five Judges       | Points Available |
|---------------------------------------|------------------|
| Innovation of system                  | 15               |
| Consumer appeal/integration of system | 15               |

| Scoring by Measure of Performance                                                                                                  | Points Available |
|------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Hot-water system output temperature performance index:<br>If temperature <120°F, $E = (120 - \text{temperature})$<br>$PI = \sum E$ | 35               |
| Electrical energy consumed to heat the water and run associated appliances (washer and dishwasher)                                 | 35               |

Teams will be ranked according to the lowest performance index (lowest  $PI = 1st$ ) for temperature setpoints.  $E$  represents the error or deviation from temperature setpoints. The electrical energy consumed to heat water will be measured and teams will be ranked on the basis of minimizing electrical energy use (lowest electrical energy consumed = 1st).

### 3.8. Contest 7: Energy Balance

**Goal**—This Contest demonstrates that the sun can supply the energy necessary for all the daily energy demands of a small household and home-based business. The object is to begin and end the contests with the same amount of energy stored in the electrical storage system to demonstrate that the system will function sustainably year-round.

**Criteria**—Each team will be scored on the basis of how well its house meets energy demands using only direct and diffuse global solar radiation received by the house without artificial external augmentation after construction (see Regulations, Energy Collection and Storage, Energy). All electrical energy supplied by photovoltaics or other electrical supply to the electrical-storage system will be compared to the total electrical energy demanded from the electrical-storage system. For the duration of the contests, energy supplied to and demanded from the electrical-storage system will be monitored continuously. If, at the end of the contests, the total energy supplied has met or exceeded the total energy demanded (including applicable penalties) from the electrical-storage system, teams will receive full points for this Contest. If, at the end of the contest week, the energy demanded from the electrical-storage system is shown to have been greater than the energy supplied to the electrical-storage system; teams will be ranked based on the magnitude of the difference between the demand and supply (the smaller the difference, the higher the team will rank).

To quantify each team’s supply of electrical energy, teams will be required to provide measurement points between the photovoltaics or electrical supply and any electrical storage or direct loads. Similarly, to determine each team’s electrical demand, teams will need to provide measurement points between the electrical-storage system and all electrical loads. Two measurement points, one between the electrical supply and electrical-storage system, and one between the electrical-storage system and all electrical loads, should be sufficient to accomplish these measurements. It may be possible to meet this requirement with one point of measurement, depending on the electrical-storage system configuration.

| Scoring by Measure of Performance      | Points Available |
|----------------------------------------|------------------|
| Balancing electrical supply and demand | 100              |

### 3.9 Contest 8: Lighting

*Goal*—Sunlight, moonlight, and electric light all contribute to the livability and environment of a dwelling, inside and out. This Contest evaluates the quantity, quality, and energy efficiency of the lighting in the house during both the daytime and the nighttime. The lighting system should be designed to minimize energy use by maximizing daylighting contribution and by using controls to minimize use of electric illumination.

*Criteria*—

- Design verification—To satisfy occupant requirements, lighting levels in the house must meet the design levels listed below in Table 1.
- System capacity—Working surfaces will be monitored continuously to determine that system capacity is achieved.
- Lighting environment—The combination of electric and natural lighting should provide a pleasant and attractive environment.

**Table 1. Design Lighting Levels by Location**

| Space          | Task Design Level Averages (foot-candles) | Task Measurement Location                                                                             | Ambient Design Level Averages (foot-candles) | Ambient Measurement Location                                                                                                                                                |
|----------------|-------------------------------------------|-------------------------------------------------------------------------------------------------------|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Living space   | 30                                        | Average of readings taken at center of any desk or table and 2 ft above the seat of any reading chair | 5                                            | Average of 4 readings taken 3 ft above floor at arbitrarily chosen locations as close to the center of the room as possible but no closer than 3 ft from a task measurement |
| Office space   | 50                                        | At office working surface or desk                                                                     | 5                                            | Average of 4 readings taken 3 ft above floor at arbitrarily chosen locations as close to the center of the room as possible but no closer than 3 ft from a task measurement |
| Kitchen space  | 30                                        | Average of readings taken at center of any countertop, range top and sink                             | 10                                           | Average of 4 readings taken 3 ft above floor at arbitrarily chosen locations as close to the center of the room as possible but no closer than 3 ft from a task measurement |
| Bedroom space  | 15                                        | At pillow                                                                                             | 5                                            | Average of 4 readings taken 3 ft above floor at arbitrarily chosen locations as close to the center of the room as possible but no closer than 3 ft from a task measurement |
| Bathroom space | 30                                        | At sink                                                                                               | 10                                           | Average of 4 readings taken 3 ft above floor at arbitrarily chosen locations as close to the center of the room as possible but no closer than 3 ft from a task measurement |

**Hand-held light meter evaluations:** To determine compliance with lighting level requirements, light level readings\* will be taken in each of the locations per Table 1, once during the day and once between dusk and 10:00 P.M. Any team meeting all of the criteria listed in Table 1 will receive full credit for a daytime and nighttime lighting evaluation (30 points each evaluation, 60 points total).

Any team not meeting all of the criteria during the nighttime evaluation will be scored for the nighttime evaluation (up to 30 points available) and a second daytime evaluation will be performed and scored separately (up to 30 points available). Electric lights can be used as needed to achieve required light levels.

Readings will be taken in the horizontal plane at 30 in. above the floor (or top of counter or surface if higher). Electric lights can be used if needed to achieve required light levels. A maximum of 60 points can be achieved from the daytime and nighttime evaluations.

Points will be awarded as follows:

| Measured Light Level Reading       | Points Available per Location from Table 1 (maximum 30 points per evaluation) |
|------------------------------------|-------------------------------------------------------------------------------|
| 95% of criteria from Table 1       | 3                                                                             |
| 75%–94% of criteria from Table 1   | 2                                                                             |
| 50%–74% of criteria from Table 1   | 1                                                                             |
| Below 50% of criteria from Table 1 | 0                                                                             |

**Continuously monitored light levels:** To determine that system capacity is achieved, the working surface of the office space will be monitored continuously throughout the day from 9:00 A.M. to 5:00 P.M. One location on the Kitchen work surface will be measured continuously from 8:00 A.M. to 10:00 A.M. and from 5:00 P.M. to 7:00 P.M. Continuous light level readings\* will be taken at one of the same locations and with the same meter as the initial daytime and nighttime evaluations.

Scoring will be determined as follows:

| Scoring by Measure of Performance                                                                              | Points Available |
|----------------------------------------------------------------------------------------------------------------|------------------|
| Measured light level reading (footcandles)                                                                     |                  |
| Office Work Surface:<br>If light level reading < 50, $E = (50 - \text{light level reading})$<br>$PI = \sum E$  | 10               |
| Kitchen Work Surface:<br>If light level reading < 30, $E = (30 - \text{light level reading})$<br>$PI = \sum E$ | 10               |

Teams will be ranked according to the lowest performance index (lowest  $PI = 1^{\text{st}}$ ) for lighting levels.  $E$  represents the error or deviation from lighting levels.

To determine aesthetic appeal and the subjective achievement of the lighting design, Judges will award points in a subjective process using the following point system.

| Scoring by Panel of Five Judges            | Points Available |
|--------------------------------------------|------------------|
| Innovation of system/integration of system | 10               |
| Consumer appeal/lighting environment       | 10               |

\*Light level readings: Light level readings shall be made using a recently calibrated, cosine and color corrected illuminance field instrument. Measurements shall be taken carefully to avoid body shadow, preferably by using a meter with remote measuring head, or by “ducking” to prevent body shadow. The meter shall be laid flat or mounted to a tripod or similar device and leveled.

### 3.10 Contest 9: Home Business

**Goal**—To demonstrate that the house can provide adequate energy to power basic home business needs.

**Criteria**—The house must have an appropriately lit and conditioned space of at least 100 ft<sup>2</sup> dedicated for home office use. The home office space can be set up in the living or bedroom space. Homes will have a wireless Internet connection provided by EDS. Teams must provide a workstation, monitor, and printer as dedicated office equipment. This equipment must have its own separate circuit breaker to facilitate the monitoring of electrical energy consumed by the office equipment. Teams must have a workstation with a minimum 17-in. monitor (manufacturer’s stated monitor size will be the number used to evaluate compliance) and high-quality color printer (either an ink jet or laser printer that prints 4-color on 8.5 in. x 11 in. paper at 1200 dpi) for production of newsletters and other documents. The printer must be capable of printing on two sides. Whether you chose to physically turn the paper to print on both sides, or purchase a printer with a duplex feature, is up to you.

Teams are required to have the workstation and monitor turned on from 9:00 A.M. to 5:00 P.M. each day of the Competition. During the required operation time the workstation and monitor are permitted to “go to sleep” if not in use. Printing of all hardcopy newsletters will occur during the 9:00 A.M. to 5:00 P.M. hours of operation, using the required printer. The Organizers will provide the paper necessary for the printing of the newsletter and will verify printing during the office operation times. Students will receive and respond to regular e-mail requests via the workstation and wireless Internet connection in a timely manner. The period of time in which the e-mail response will be due will be between 9:00 A.M.–5:00 P.M.

E-mails will include:

- Details of Contest 3 requirements such as content (both text and graphic) direction for the daily newsletters and diaries.
- Competition-related communications

Teams will be expected to run a minimum 19-in. TV/video player (the manufacturer’s stated monitor size will be the number used to evaluate compliance) for at least 6 hours (cumulative) per day during the contests and for the duration any public tours.

| Scoring by Panel of Five Judges      | Points Available |
|--------------------------------------|------------------|
| Office space comfort and integration | 30               |

| Scoring by Measure of Performance | Points Available |
|-----------------------------------|------------------|
|-----------------------------------|------------------|

|                                                       |    |
|-------------------------------------------------------|----|
| Electrical energy consumed by home business equipment | 20 |
|-------------------------------------------------------|----|

The electrical energy consumed to provide power for the workstation, monitor, and printer will be measured, and teams will be ranked on the basis of minimizing electrical energy use (lowest electrical energy consumed = 1st).

| Scoring by Task Completion                                                                                     | Points Available |
|----------------------------------------------------------------------------------------------------------------|------------------|
| Completion of contest diaries                                                                                  | 25               |
| Operation of TV/video player during public tours and 6 hour (cumulative) operation during each Competition day | 25               |

### 3.11. Contest 10: Getting Around

**Goal**—As wonderful as your house will be, you won't spend all your time there, so this Contest evaluates how much "extra" energy your house can generate to let you get around town in a street-legal, commercially available electric vehicle.

**Criteria**—Excess energy from the house will be used to power a commercially available and street-legal electric vehicle. The intent of this Contest is to use excess energy from the house to accumulate mileage credit by driving the electric vehicle on set routes.

**NPS Rules:** Teams are permitted to drive the electric vehicles on the National Mall turf to enable charging or parking within a carport, garage, or in close proximity to the team's house. When an electric vehicle enters or exits the National Mall, it must be "walked" (accompanied by a student team member on foot in front of the car). The electric car must be walked from the parking area, carport, or garage to the street and vice versa.

**Driver Requirements:** Only decathletes are allowed to drive the team's electric vehicle. All drivers must have a valid driver's license and be 18 years of age or older.

**Passenger Requirements:** Teams are required to include one passenger for all driving activities. This requirement is intended to replace the previous requirement of ballasting a single driver as well as increasing the safety of those participating in the driving portion of the Event. Only decathletes or Officials are permitted to be passengers. All passengers must have a valid driver's license and be 18 years of age or older. Passengers must have a means of communicating with the decathletes that remain at the team's house on the National Mall at all times. Teams must provide for their own means of communication while operating the electric car.

**The Electric Vehicle:** Organizers will supply each team with a Ford TH!NK *neighbor*. Proof of insurance must be kept with the vehicle at all times. Teams cannot alter the vehicles in any way. Teams may start the Contest with fully charged batteries in the vehicle, but any subsequent recharging must be supplied from energy generated by the house. The vehicle features as purchased for the Event are as follows:

- Two-passenger TH!NK *neighbor*
- Family model (with trunk)
- Maintenance-free battery
- White color scheme
- Soft weather enclosures
- Wide steel wheels



- Turf tires for grass friendly operation (also operable on city streets).

**Post-dealership added features (mandatory):** Event decals (supplied by Solar Decathlon Organizers); space for a team logo will be available.

**Acquisition Requirements:** After the Solar Decathlon Rules and Regulations Committee approves a team's December 4, 2001, qualification documents, that team will get clearance to pick up their vehicle at a dealership. The vehicle then becomes property of the school. The school will need to title and license the vehicle in the school's name and will be required to carry all pertinent vehicle insurance. Teams will be responsible for transport of the vehicle from the dealership and all transport thereafter.

**Inspection:** Before the team will be allowed to compete with their THINK *neighbor*, it will be checked for compliance with manufacturer's specifications:

- Battery
- Tires
- Drive system
- Charging system
- Brakes
- 12 volt system (lights, horn, power plug)

The THINK *neighbor* will also have the following items installed at the Competition:

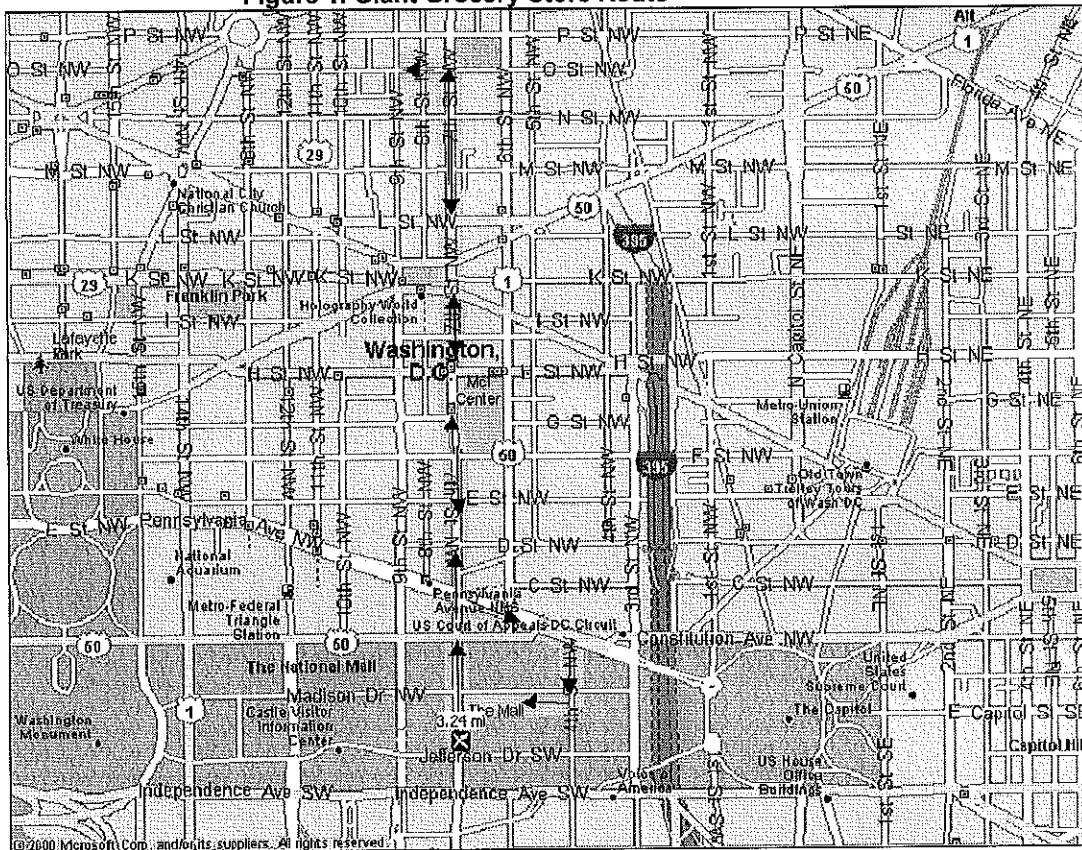
Charge port locks

Batteries sealed and marked to provide ready evidence of tampering after the start

A logbook will be assigned to each vehicle that will provide written back-up documentation to all vehicle activity.

**Routes for Accumulating Miles:** Maps identifying all routes are provided (see Figures 1–5).

**Figure 1. Giant Grocery Store Route**



***Directions for leaving the National Mall and going to Giant grocery store:***

**Start:** Depart National Mall at exit onto 7th St SW (north)

**1:** Turn **LEFT** (west) onto **O St NW**

**2:** **End:** Arrive at the Giant Grocery Store at 1414 8th St NW (check in with Observer to validate trip).

**Returning to the National Mall:**

**3:** **Start:** Depart the Giant Grocery Store at 1414 8th St NW, on **O St NW** (east)

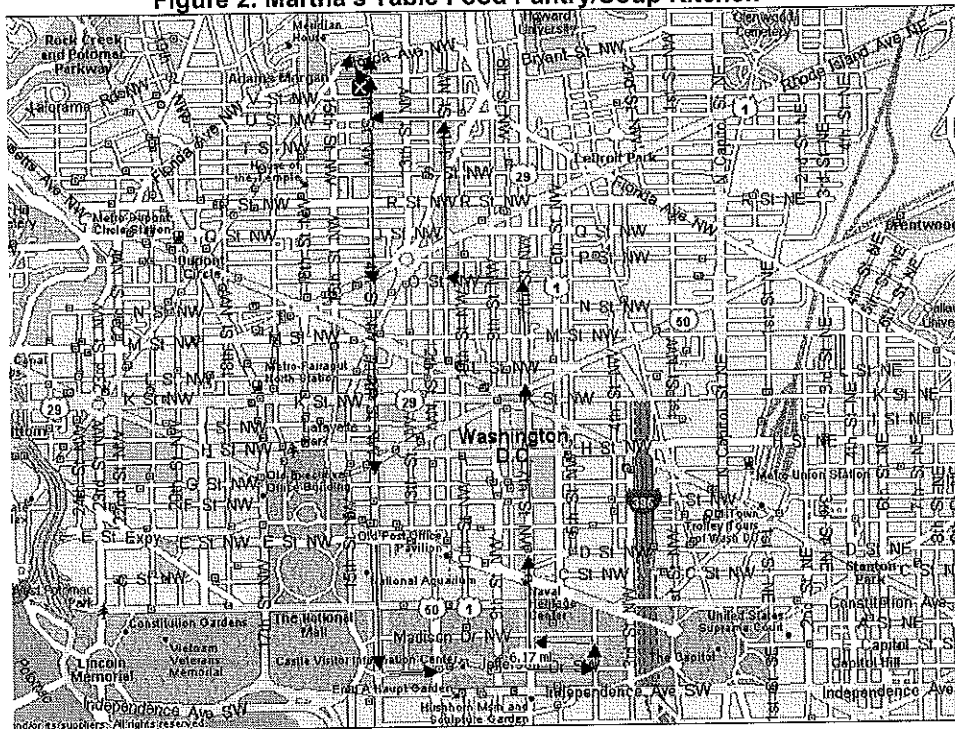
**4:** Turn **RIGHT** (south) onto **7<sup>th</sup> St NW**

**5:** Turn **LEFT** (southeast) onto **Pennsylvania NW**

**6:** Turn **RIGHT** (south) onto **4th St SW**

**7:** **End:** Arrive back at National Mall at **4th St NW** entrance.

**Figure 2. Martha's Table Food Pantry/Soup Kitchen**



**Directions for leaving the National Mall and going to Martha's Table Food Pantry/Soup Kitchen:**

**Start: Depart National Mall at exit onto 7th St SW (north)**

**1: Turn LEFT (west) onto O St NW**

**2: Turn RIGHT (north) onto 11th St NW**

**3: Turn LEFT (west) onto U St NW**

**4: Turn RIGHT (north) onto 14th St NW**

**5: Turn LEFT (west) onto Florida Ave. NW**

**6: Turn LEFT (east) onto W St. NW**

**7: Turn RIGHT (south) onto 14th St. NW**

**8: End: Arrive at Martha's Table at 2114 14th St NW (check in with Observer to validate trip)**

**Returning to the National Mall: Proceed South on 14th**

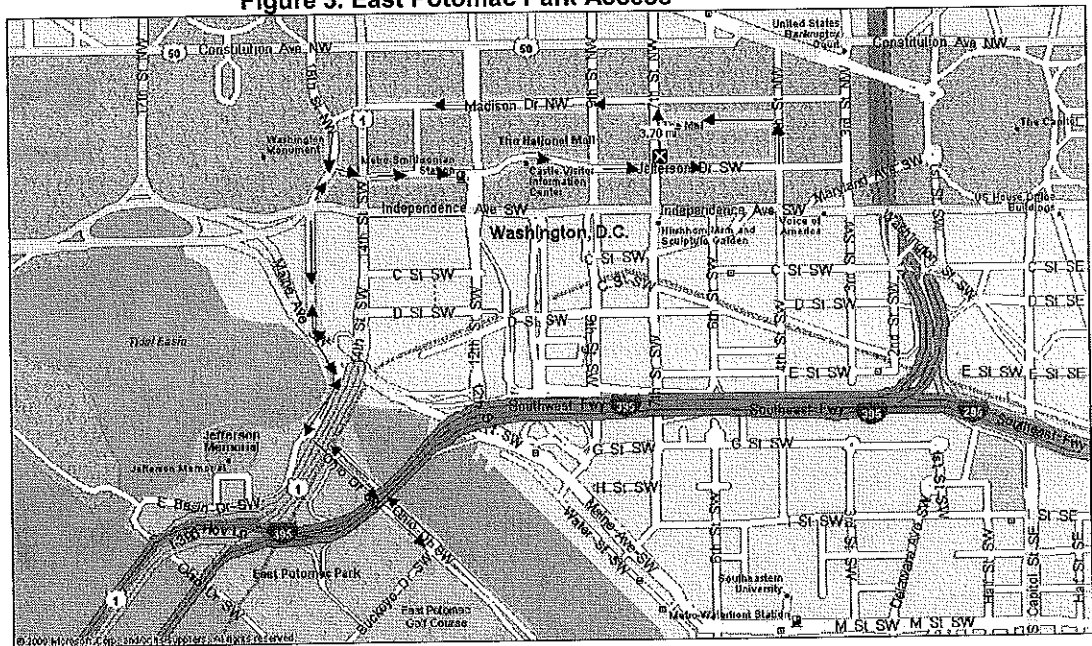
**9: Start: Depart Martha's Table at 2114 14th Street NW on 14th Street NW (south)**

**10: Turn LEFT (east) onto Jefferson Dr SW**

**11: Turn LEFT (north) onto 4th St SW**

**12: End: Arrive back at National Mall at 4th St NW entrance.**

**Figure 3. East Potomac Park Access**



**Directions for leaving the National Mall and going to the Access Point for the East Potomac Park Loop:**

**Start:** Depart National Mall at exit onto 7th St SW (north)

**1:** Turn **LEFT** (west) onto **Madison Dr NW**

**2:** Turn **LEFT** (south) onto **15th St NW**

**3:** Veer **LEFT** (south) to follow **15th St SW/Raoul Wallenburg Pl SW** as it crosses Independence Ave. SW

**4:** Turn **LEFT** (southeast) onto **Maine Ave. SW**. Get in **RIGHT** lane.

**5:** Veer **RIGHT** (south) onto **Basin Dr SW**

**6:** Turn **LEFT** (Southeast) onto **Ohio Dr SW**

**7: End:** Arrive at intersection of **Ohio Dr SW** and **Buckeye Dr SW** (check in with Observer to validate trip)

**At this point teams may return to the Mall or proceed to laps around East Potomac Park for additional mileage accumulation.**

**Returning to the National Mall:**

**8: Start:** at intersection of **Ohio Dr SW** and **Buckeye Dr SW**

**9:** Turn **RIGHT** (northeast) onto **Basin Dr SW**

**10:** Turn **LEFT** (northwest) onto **Maine Ave SW**

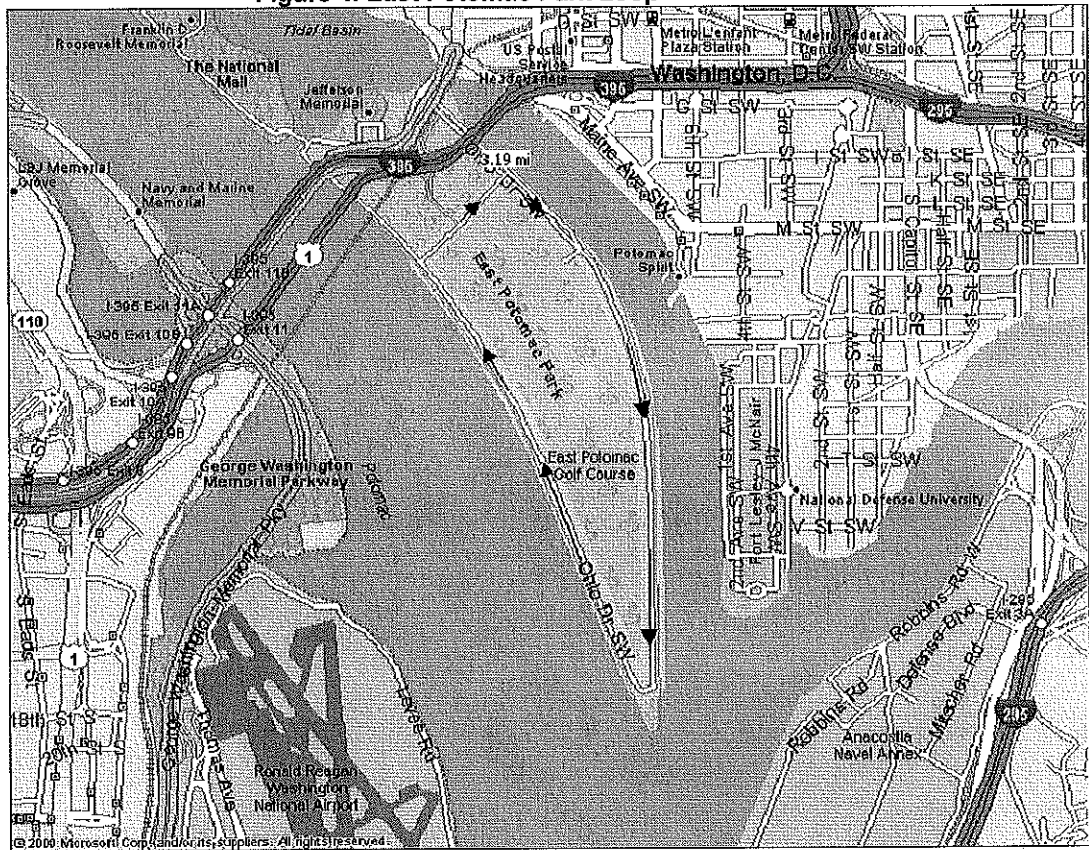
**11:** Turn **RIGHT** (north) to follow **15th St SW/Raoul Wallenburg Pl SW**

**12:** Turn **RIGHT** (east) onto **Jefferson Dr SW**

**13:** Turn **LEFT** (north) onto **4th St SW**

**14: End:** Arrive back at National Mall at **4th St NW** entrance.

Figure 4. East Potomac Park Loop



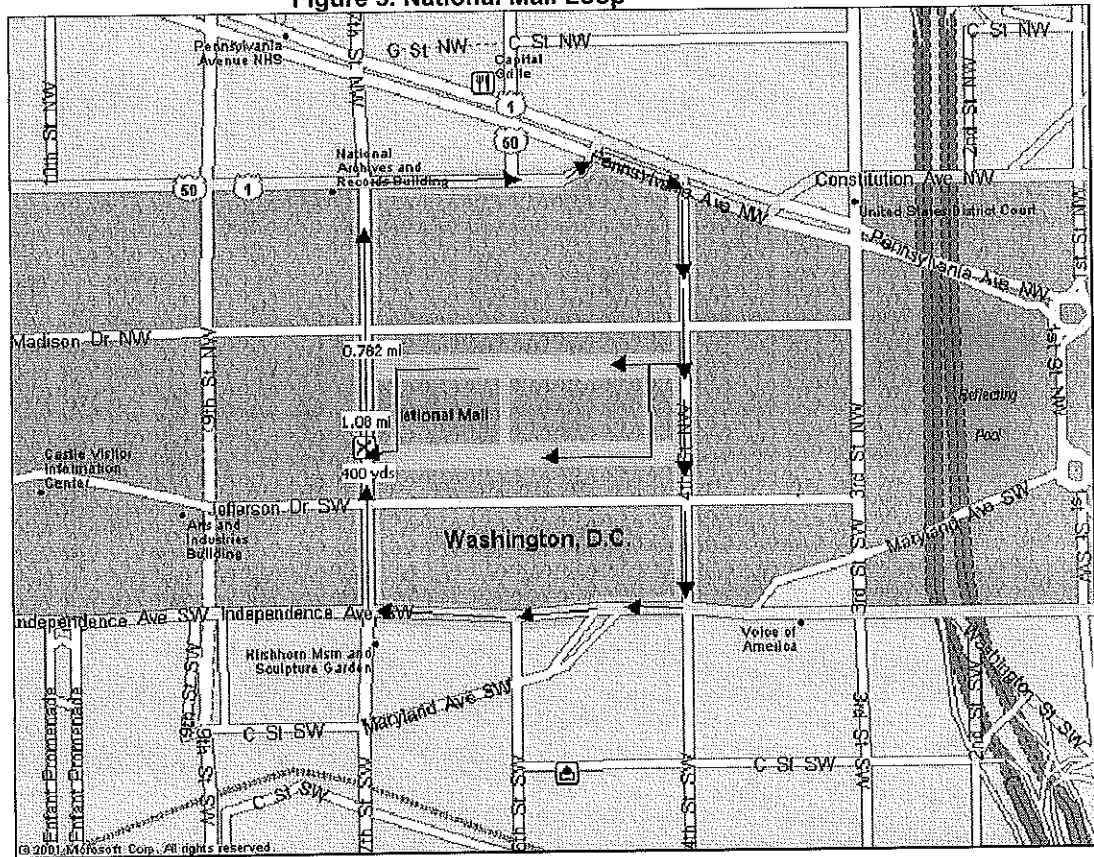
*Directions for leaving the intersection of Ohio Dr SW and Buckeye Dr SW to drive laps on the East Potomac Park Loop:*

- Start:** Depart intersection of Ohio Dr SW and Buckeye Dr SW (southeast)
- 1:** Turn **RIGHT** (west) at apex of Ohio Dr SW on East Potomac Park Loop
  - 2:** Turn **RIGHT** (south) onto **Buckeye Dr SW**
  - 3: End:** Check in with Observer at intersection of Ohio Dr SW and **Buckeye Dr SW** to validate lap count.

To begin another lap:

- 4:** Turn **RIGHT** (southeast) onto **Ohio Dr SW** and repeat steps beginning with step 2.

Figure 5. National Mall Loop



*Directions for leaving the National Mall and making a clockwise loop:*

**Start:** Depart National Mall at exit onto 7th St SW (north)

**1:** Turn **RIGHT** (east) onto **Constitution St NW**

**2:** Turn **RIGHT** (southeast) onto **Pennsylvania Ave. NW**

**3:** Turn **RIGHT** (south) onto **4th St NW**

**To return to the Mall/home and receive 0.7 miles credit added to total, enter at 4th St NW Mall entrance—otherwise continue:**

**4:** Turn **RIGHT** (west) onto **Independence Ave. SW**

**5:** Turn **RIGHT** (north) onto **7th St SW**

**6: End:** Pass the Mall Exit and check in with the Observer.

**To begin another lap:**

**7: Continue straight** on 7<sup>th</sup> St SW (North) and repeat steps beginning with step 1.

### ***Driving Route Availability***

***(1) Sunday, September 29, and Wednesday, October 2, 9 A.M. to 7 P.M.***

***The Giant grocery store:*** On Sunday, September 29, and Wednesday, October 2, teams may receive mileage credit for trips to pick up groceries for cooking tasks or for soup kitchen donations.

***Martha's Table Food Pantry/Soup Kitchen delivery:*** On Sunday, September 29, and Wednesday, October 2, teams may receive mileage credit for trips to Martha's Table Food Pantry/Soup Kitchen. Suggested donations to Martha's Table include:

- Beverages (soda, juice)
- Can goods (soup, beans, vegetables, etc.)
- Cereal
- Cheese
- Cold cuts
- Jars of jam or jellies
- Pasta
- Peanut butter

***(2) Sunday, September 29 – Thursday, October 3, 9 A.M. to 7 P.M. and Friday, October 4, 9 A.M. to 5 P.M.***

***East Potomac Park Loop:*** Teams may drive the East Potomac Park route as excess energy permits from Sunday, September 29 – Friday, October 4.

***(3) Friday, October 4, 5 P.M.***

All contests end on Friday, October 4 at 5:00 P.M. with the exception of Contest 10. At that time teams must announce if they wish to continue competing in Contest 10. Those teams that announce intention to continue competing in Contest 10 will not be permitted to charge their electric car after 5 P.M. on Friday, October 4, but will be permitted to accumulate mileage credits for laps around the National Mall Loop on Saturday, October 5, 10 A.M. to NOON. Teams that do not wish to continue competing in Contest 10 on Saturday, October 5, will still be ranked according to the final mileage credits (in comparison to mileage credits accumulated by other teams as of Saturday, October 5 at NOON) and have the option to charge their electric cars Friday after 5 P.M.

***(4) Saturday, October 5, 10 A.M. to NOON***

***National Mall Loop:*** Teams may drive the National Mall loop as excess energy permits on Saturday, October 5. Note that all teams must cross the finish line on Saturday, October 5, to receive mileage credit accumulated for driving on Friday, October 4, or Saturday, October 5.



Scoring will be determined as follows:

| Route                                                                   | Mileage Credit (miles) |
|-------------------------------------------------------------------------|------------------------|
| The Giant Grocery Store (round trip)                                    | 3.3                    |
| Martha's Table Food Pantry (round trip)                                 | 6.2                    |
| The Giant Grocery Store and Martha's Table and Food Pantry (round trip) | 10                     |
| East Potomac Park (round trip)                                          | 3.7                    |
| East Potomac Park (each lap around one way loop)                        | 3.2                    |
| National Mall Loop (each lap around one way loop)                       | 1.1*                   |

\*See directions for National Mall Loop for more detail on mileage credit awarded.

Note that miles for any driving route will only be awarded for completed routes or laps; partial routes or laps will not accumulate mileage credit. Teams may use the electric cars at their discretion but will only be credited for mileage on the routes and during the times shown here. Rank (see Appendix B) will be determined based on accumulating the most mileage credits during the week of contests.

| Scoring by Measure of Performance | Points Available |
|-----------------------------------|------------------|
| Mileage credit accumulated        | 100              |

## 4. INSPECTION

### 4.1. Pre-Competition

*On-Site Inspections:* Solar Decathlon Officials will visit each team at its university and inspect the works in progress for International Residential Code 2000 (IRC 2000), Americans with Disabilities Act (ADA), National Electric Code 1999 (NEC1999), and Rules and Regulations compliance. Officials anticipate spending 1–2 days with each team for pre-contest inspection and identification of areas requiring corrective action.

### 4.2. Competition

*Inspection*—Each team participating in the Competition must present its house for inspection prior to the contests to verify compliance with these Rules and Regulations. In addition, spot checks for regulation compliance may take place during and immediately after the contests. The top five overall finishing houses and cars will be impounded immediately following the contests for a final inspection.

*Inspection Time and Location*—Order of inspection will be determined by a drawing. Teams that fail to present their house at their designated time will drop to the back of the queue and will risk not having enough time to complete the inspection process.

*Inspection Format*—Inspection will involve inspection of sizes, of structural, electrical, and mechanical systems, and of team compliance to the Rules and Regulations, ADA, NEC1999, and IRC2000. Instructions for Inspection and a detailed description of the inspections and tests will be distributed in advance to all participating teams.

## 5. REGULATIONS



## 5.1. The Site

*Vegetation*—Teams are permitted to bring potted vegetation to enhance the aesthetic or energy characteristics of their houses, provided that the vegetation does not violate the solar envelope. Vegetation will not be considered part of the solar array. Vegetation may be placed and moved around each team's lot until the end of the construction phase. After that, the vegetation will remain stationary until the conclusion of all the contests and tours.

*Solar House Entryways*—Teams will have the freedom to place the entry to their house on any side of the house. Teams should provide a walkway leading to the entrance of the house.

*ADA Requirements*—The public will have access to these structures at various times during the Competition; therefore, all structures must meet ADA accessibility requirements. Teams are required to provide an accessible route through their houses for tour purposes. This does not mean that the entire house needs to be ADA compliant.

*Construction*—The NPS, the government agency that manages the National Mall, has criteria that must be met by all teams building houses on the National Mall. On the grassy areas, teams will be permitted to use a forklift or similar small lifting equipment to aid in the construction of their houses. However, forklifts or other small vehicles used during construction may be driven on the grass portion of the National Mall only if these vehicles are driven on a plywood path (to protect the grass). Cranes will not be permitted, according to the NPS. Trailers, semi-trailer trucks, etc., are limited to the gravel paths and may not be driven on the grass at any time. Cinder block or similar pylons must support structures on the grass portion of the National Mall. Teams will not be permitted to build or place floors directly on the grass. The individual teams must provide all equipment, tools, and labor necessary to construct the house.

*Team Lots*—Teams will be allowed roughly 5500 ft<sup>2</sup> of level, unobstructed land and will have 3–4 days to assemble their house on site. Assume that some minor leveling of the floor deck will be necessary. There are no limits on materials or type of construction. The house can either be transported to the site already assembled or transported and assembled on site, as long as it does not damage the site. No digging will be permitted except for tie-downs needed to meet wind-loading requirements. Large stakes or screws, similar to those used for circus tents, may be used to anchor the structures. Screws or stakes used with tie-downs are limited to 18-in. vertical depth. The lot size will be 82 ft east to west by 67 ft north to south. Please refer to Figures 6–9 below.

*Solar Envelope*—To protect a neighbor's right to the sun, each house and all items associated with the house must stay within the solar envelope shown in Figures 6–9.

**Figure 6: Isometric view of solar envelope**  
**Figure 7: Top view of solar envelope**  
**Figure 8: Front view (south side) of solar envelope**  
**Figure 9: Left view (east side) of solar envelope**

## **5.2. Event**

**Safety**—Each team is responsible for the safety of its house, car, and team members. Passing inspection or implementing changes suggested in the team's structural report does not release the team from liability. All houses, cars, and support vehicles must be maintained and operated safely at all times. A team will be disqualified and withdrawn from the Event at any time if they operate in an unsafe manner.

Each house will be required to have smoke detectors per IRC2000 requirements and a fire extinguisher with a minimum Underwriters Laboratory (UL) rating of 2A-10BC. All battery system rooms or rooms containing a battery system enclosure must have a smoke detector that is either audible from outside the room or has a remote indicator that is monitored by the team.

Each house must be equipped with proper personal protective equipment (PPE) (a minimum of chemical resistant gloves, apron and eye protection) to service their battery bank and as protection from any other thermal, electrical, mechanical or fluid system that presents any sort of hazard.

Each house must be equipped with the proper spill-clean-up kits for their battery bank or fluid systems. All batteries, regardless of placement on a rack or otherwise, must have a spill containment system in compliance with Uniform Fire Code (UFC) 1997 6404.4 Spill Control and 6404.5 Neutralization or IFC2000 608.4 Spill Control and Neutralization.

**Withdrawals**—Any team wishing to withdraw must notify the Solar Decathlon Headquarters in writing. All written withdrawals signed by the team representative are final. The Solar Decathlon Headquarters may disqualify teams that do not meet the technical document deadlines or that fail to present a house at inspection or the Contest.

**Team Uniforms**—During the Competition from 7:00 A.M. to 10:00 P.M., team members shall wear uniforms representing their institution(s) (i.e., school, college, university). The only information or graphics approved to be visible from the front of the team uniform (jacket, shirt, hat, or other wearable item) shall be the institution and its logo, the team name and logo, the Solar Decathlon logo and Event sponsor logos. Team sponsor logos may only be visible from the back of the team uniform shirt or jacket. Artwork for the Solar Decathlon logo and for the Event sponsors may be obtained from the Solar Decathlon Sub site at [http://www.eren.doe.gov/solar\\_decathlon/intro.html](http://www.eren.doe.gov/solar_decathlon/intro.html).

**Impound**—All houses and cars must be impounded overnight under the direct supervision of Officials. No team members are allowed to occupy, move, or conduct maintenance on any part of the house or car during impound hours.

**Impound Times**—Impound will begin at 10:00 P.M. each evening and end at 7:00 A.M. the following morning.

**Electric Car**—In no case shall regenerative braking be engaged while pushing or pulling the car.

Except for the following situations, the team's car may not be pushed or pulled during Contest hours:

- **Emergency:** In an emergency or breakdown situation, the car must be removed from the road. In this circumstance, the car may be towed back to Headquarters for inspection and repair.
- **Accidents and Re-inspection:** All accidents involving the car or support vehicles must be reported immediately to Solar Decathlon Headquarters. In the case of an accident involving personal injury and/or property damage, notification of the appropriate emergency medical services and public safety officials shall take priority. If a car is involved in an accident, it must be re-inspected by an Inspector before reentering the Contest. The Inspector may require that repairs be made before the team can resume the Contest.
- **Impound:** It may be necessary to push or pull the car to the impound area.

*Accommodations and Lodging*—All teams are responsible for team accommodations, lodging, and food during the Competition. Teams are responsible for making their own reservations.

### **5.3. Structural**

*Code Compliance*—Houses will be constructed to meet or exceed applicable sections of IRC 2000 for a single-family residential dwelling. In particular, houses must have tie-downs sufficient to withstand 90-mph winds (IRC2000 Sec. 301.2.1 and Fig R301.2 (4)).

*Engineering Drawings*—The NPS requires that engineering drawings be stamped by a Professional Engineer (PE) certifying that the structures are safe for the public to enter.

*House Sizing*—Houses are restricted to a maximum of 800 ft<sup>2</sup> of total building footprint. The perimeter of the projection of the house onto a horizontal plane from plan view cannot contain an area greater than 800 ft<sup>2</sup>. Any structure (e.g., ADA ramps, decks, porches, wastewater drum) that is not part of the enclosed space and is not part of the solar array (see Regulations, Energy Collection and Storage, Solar Array) or energy storage system will be excluded from the 800-ft<sup>2</sup> footprint limitation but must be within the solar envelope (see Regulations, The Site, Solar Envelope). The house must have a minimum of 450 ft<sup>2</sup> of conditioned interior space measured as floor area from the inside of the exterior walls.

### **5.4. Electrical**

*Code Compliance*—All houses must meet all applicable electrical requirements stated in NEC1999. Particular attention should be paid to Articles 690, 480, 445, 250, 400, and 240, which reference proper photovoltaic system design, storage batteries, generators, grounding, conductors and conductor ampacity ratings, overcurrent protection devices and warning labels, respectively.

Specific alterations to the code requirements are included in Regulations, Event, Safety; Regulations, Electrical, Code Compliance, Battery Ventilation, Battery Stacking; and Regulations, Energy Collection and Storage, Storage Batteries. Additional code requirements from UFC1997, IFC2000, IMC2000, and IBC2000 will supercede NEC1999 requirements as noted. Teams are also encouraged to read the following publication: Wiles, John C. (2001). *Photovoltaic Power Systems and the National Electric Code: Suggested Practices*. Sandia Report SAND2001-0674.

**Battery Enclosures**—Battery systems must be fully contained in enclosures or rooms that remain within the 800-ft<sup>2</sup> footprint. The cover must be locked so access to batteries inside the enclosure is limited to the team's decathletes. A battery system room will be permitted in lieu of a separate battery system enclosure if designed in accordance to UFC1997 Article 64: Stationary Lead-Acid Battery Systems or IFC2000 Section 608: Stationary Lead-Acid Battery Systems, as if the room contained corrosive liquids in excess of 100 gallons regardless of battery type.

**Battery Ventilation**—Battery system enclosures or rooms must be equipped with a passive or mechanical ventilation system per IFC2000 608.5 Ventilation, UFC1997 6404.6 Ventilation, or IMC2000 502.4 Stationary Lead-acid Battery Systems. Teams are required to provide either calculations or empirical evidence to demonstrate compliance. Such ventilation systems must exhaust or vent to the outdoors. The vent must be designed so wind cannot push hydrogen gas back down the vent. This requirement includes all battery types, because any battery type will vent hydrogen gas under certain conditions.

**Battery Stacking**—Stacking the batteries is discouraged. If it is necessary to stack the batteries, a battery system rack must be used. The rack must meet the requirements of IBC2000 1621.3.13 Electrical Equipment Attachments and Supports.

The rack must also meet the requirements of NEC1999 480-7 Racks and Trays. All racks containing flooded lead-acid batteries must provide 18 in. of clearance from the top of the battery or top of the battery post (whichever is greater) to the bottom of the next shelf for inspection and maintenance. All racks containing sealed batteries must provide adequate space for access with tools to verify tightness of terminal connections.

**Circuit Panel(s)**—The circuit panel(s) for the house must be wired such that lighting, appliances, refrigeration equipment, space-conditioning equipment (including fans attached to HVAC equipment but not ceiling fans), water pumps, office equipment, and hot-water heat are on individual circuits for monitoring purposes. Separate circuit panels are required for AC and DC systems.

**Solar Cell Technology Limitation**—Photovoltaics must be commercially available to all registered teams at a price not exceeding US \$5 per watt (watt peak at Standard Test Conditions [STC]) for bare cells (teams may pay extra for cutting, tabbing, or lamination of the cells). For encapsulated modules, photovoltaics must be commercially available to all registered teams at a price not exceeding US \$10 per watt (watt peak at STC). Substantial modification of the crystal structure, junction, or metallization constitutes manufacture of a new cell.

**Generators**—Teams may provide an approved generator from which they may charge their energy storage devices. Teams may opt at any time to charge their energy storage devices to complete contests that they would otherwise be unable to finish with power supplied by their solar array. Teams will be assessed a penalty for charging their energy storage devices (see Penalties, Energy Penalties). Generators will be used only after notifying the Chief Inspector of the intention to use the generator. Refueling of generators is limited to times approved by the Officials. Generators must be equipped with secondary containment systems capable of accommodating all of the oil, fuel, and coolant that the generator contains at maximum capacities.

**Electrical System Labels and Warnings**—In addition to any NEC requirements regarding the entire house electrical system, all battery enclosures shall be marked with the National Fire Protection Association's (NFPA) Hazard Warning Diamond suited to the battery technology contained within the enclosure.

## **5.5. Mechanical**

*Code Compliance*—All houses will be expected to meet all applicable mechanical requirements stated in IRC 2000.

*Thermal Storage*—All thermal storage devices (“mass”) must be made of stable, nontoxic materials. MSDS must be submitted for all heat transfer fluids for approval.

*Liquid Based Thermal Storage System Labels and Warnings*—All liquid based thermal storage systems shall be marked with the NFPA’s Hazard Warning Diamond suited to the technology.

*Desiccant Systems*—If a desiccant system is used for the house, it must be regenerative. To ensure that desiccant systems function in a steady-state fashion, the desiccant material or device must be easily weighable. The device or material will be weighed before and after the contests. Teams will be assessed a penalty at the end of the contests for having a desiccant material or device that weighs more than its initial weight (see Penalties, Energy Penalties).

## **5.6. Energy Collection and Storage**

*Energy Storage*—All energy storage devices (e.g., tanks, batteries, bladders, mass components) must be located within the 800-ft<sup>2</sup> footprint.

*Flywheel Storage*—No flywheels of any kind will be permitted for electrical or any other type of energy storage.

*Storage Batteries*—Teams are allowed to use battery systems in their houses and cars for storage of solar-generated energy. The battery system for the car must be the car manufacturer’s original equipment. Battery data submittal shall be based on the manufacturer’s published specifications provided by the team. Batteries must be available in sufficient quantities to be accessible to all participating teams. The battery modules may not be modified in any manner, including the addition of electrolyte additives; case modification; or plate addition, removal, or modification. However, teams are permitted to add distilled water to vented (flooded) lead-acid batteries for maintenance purposes.

- Primary Batteries: The use of primary (non-rechargeable) batteries is limited to smoke detectors only.
- Secondary Batteries: The use of secondary batteries (rechargeable) for items such as laptop computers is permitted provided that all laptops or similar devices used for Contest purposes are to be recharged from the house electrical system.

*Energy*—Global solar radiation received by the house without artificial external augmentation is the only source of energy with which houses, tasks, and the electric car will be permitted to operate. Direct and diffuse radiation are considered forms of global solar radiation. All components used to convert global solar radiation to thermal, electrical, or mechanical energy shall be considered part of the solar array regulation.

The following exceptions to the Energy Regulation apply:

- Energy stored in the house battery system or other Contest-related secondary batteries (e.g. laptop batteries, uninterruptible power supply systems) and vehicle battery system at the conclusion of construction
- Use of a generator or other non-solar-power source to charge the electrical-storage system (see Regulations, Electrical, Generators and Penalties, Energy Penalties, Generator Use)
- Additional water associated with the supply and consumption of energy above and beyond the water supplied at the beginning of the Contest (see Penalties, Energy Penalties, Receiving Additional Water).

*Solar Array*—At any given moment, the solar array comprises all components that are involved in the conversion of solar energy for use by the house, for tasks, and by the vehicle. In addition to direct energy conversion components (such as photovoltaic cells), the solar array includes any reflective surfaces, shading surfaces, refractive lenses, solar thermal collectors, or any means of passive solar collection. The solar array cannot in any way be outside the 800-ft<sup>2</sup> footprint (see Regulations, Structural, House Sizing). The entire solar array must be integrated into the structural envelope, or skin, of the building.

*Thermal and Electrical Storage System Sizing*—Thermal and electrical storage systems sized for annual loads may be very large and costly as opposed to what would be necessary for purposes of the Competition. Therefore, teams are permitted to present a house that has thermal and electrical storage systems downsized from the sizing indicated by the annual simulation results.

## **5.7. Water Supply and Distribution**

*Water Quantity*—In their design reports, teams must indicate all of the water that their entry requires for the contests.

*Water Supply*—Water will be supplied to teams at the conclusion of the construction phase. A water truck will be available to fill house-water storage systems. When the Organizers know what type of truck will provide the water, connection requirements will be provided to teams. Water will be supplied only once without penalty. After that, teams may request additional water, which may be subject to a penalty (see Penalties, Energy Penalties, Receiving Additional Water). No additives of any kind may be added to this water.

*Water Distribution*—Teams are responsible for distributing water within their houses. This includes all necessary pumps, tanks, lines, valves, etc. All pumping power to distribute water must come from the house energy system.

*Rainwater Collection*—After construction, teams may gather rainwater from their building footprints (see Regulations, Structural, House Sizing) and use this water for any purpose.

*Water as Thermal Mass*—Any water used for thermal mass must be contained in a stand-alone system, which will be sealed off after the initial filling. Teams may use water as thermal mass to substitute for more common materials such as concrete masonry units (CMUs), concrete floor slabs, or brick. Water used for this purpose cannot be mixed with any other substance.

*Evaporation*—Teams may use water for evaporation purposes. Teams may request additional water for evaporation after scoring begins, but water provided will be subject to penalty (see Penalties, Energy Penalties, Receiving Additional Water).

*Vegetation*—Water from the house water system may be used to water any vegetation associated with the house.

*Wastewater*—All drains for appliances or sinks will need to be routed back to a 300-gallon minimum capacity drum to ensure that wastewater is not dispersed on to the National Mall turf or storm drains. All wastewater and water used in Contest 6: Hot Water must be stored in the wastewater drum. During the Competition, dumping of water to the lot will not be permitted according to the NPS. Any dumping of water will incur an energy penalty. All substances used in combination with water to clean the house, dishes, utensils, etc., must be non-toxic and preferably biodegradable. Teams may incur a penalty for any toxic substances that are found in the wastewater drum. Teams will be required to provide the drum and support this drum such that it does not damage the National Mall turf. Teams are not required to place the wastewater drum within the 800-ft<sup>2</sup> footprint (see Regulations, Structural, House Sizing) but the drum must be located within the solar envelope (see Regulations, The Site, Solar Envelope).

## **6. PENALTIES**

### **6.1. Application**

*General*—Any team failing to comply with these Rules and Regulations during the Event will be penalized. Penalties range from official warnings to disqualification from the Event. During the Competition it is the Chief Inspector's responsibility to determine whether an infraction has occurred. If an infraction has occurred, the Chief Judge shall determine the severity of the incident and the appropriate penalty. All point penalties will be submitted by the Chief Judge to Solar Decathlon Headquarters for subsequent posting. Disqualification of a team from the Event requires the concurrence of the Director. The Solar Decathlon Rules and Regulations Committee reserves the right to assess penalties at any time during the Event.

*Posting of Penalties*—On the last day of the Contest, point penalties will be assessed and posted after the scoring of all contests.

*Protests*—Any team desiring to file a protest must do so by submitting an official protest (signed by the team leader) to Solar Decathlon Headquarters. Protests may be filed for any reason, including disputing a penalty levied against any team, correcting point errors, or protesting the actions of another team. A "filing fee" of 10 points, which may be refundable (see Penalties, Protest Judgments), will be assessed against the team's Official Point Total. The Jury will hear all protests.

*Protest Judgments*—The decision of the Jury is final and no further appeals are allowed. The Jury will notify Solar Decathlon Headquarters of its decision, and Headquarters will then inform the affected teams. The Jury may refund some or the entire filing fee to the filing teams point total.

*Opportunity to Be Heard*—Protests will normally be heard by the Jury at the earliest possible Jury sitting.

*Time Limit*—Except for the last day of the contests, all protests against penalties must be filed by 8:30 P.M. the day the penalty is assessed. Protests that do not directly relate to a penalty must be filed by 8:30 P.M. on the day after the offense occurred. After completion of the contests, any protest must be filed within 30 minutes after the final assessment of penalties.

## **6.2. Electric Car**

*Car Batteries*—Car batteries are subject to penalties regarding seals, charging and replacement (see Penalties, Charging of Batteries; Penalties, Replacement of Batteries). In addition, teams will be disqualified for using any battery in the car that is not the manufacturer's original equipment. Charging the house battery system from the car battery system is not permitted.

*Pushing*—Teams will not receive mileage credit for pushing or pulling their electric cars. Use of regenerative brakes will not be permitted during pushing or pulling and is grounds for disqualification.

## **6.3. Site**

*Site Violations*—Teams may be assessed a penalty for damaging the site on which their house is constructed. Depending on the extent of the damage, the penalty assessed could be as severe as disqualification.

*Solar Violations*—Exterior finishes such as shiny aluminum that exhibit specular reflections and might adversely affect the thermal performance of other Solar Decathlon houses are not permitted. Depending on the extent of the solar violation, the penalty assessed could be as severe as disqualification.

*ADA Violation*—Teams not meeting ADA requirements will be subject to disqualification.

## **6.4. Event**

*Conduct*—Penalties, including disqualification from the Event, may be imposed for improper conduct or for the use of alcohol or illegal substances. Improper conduct may include but is not limited to improper language, unsportsmanlike conduct, unsafe behavior, distribution of inappropriate media, or cheating.

*Tampering with Official Battery Seals*—All batteries will be marked with an official seal. Disturbing these seals in a manner that prevents proper identification by Inspectors will be penalized as if the battery affected had been replaced.

*Failure to Impound*—A 2-point penalty will be assessed for every minute between 10:00 P.M. and 7:00 A.M., that a team's house and car are not closed and locked for impound.

*Inspection Violations*—Violations of structural, mechanical, and electrical codes will result in a point penalty and possible disqualification. Any modifications to the team's electrical car beyond the manufacturer's specifications will result in disqualification. After inspections, teams will have 24 hours to bring the identified violation into compliance, or the team will be subject to penalty. Teams may not be able to compete in any Contest until code, ADA, and Solar Decathlon Rules and Regulations compliance is established.



*Technology Limitations*—Any team found to be violating technology limitations will be subject to a penalty up to and including disqualification.

*Tampering with Sensors*—Teams will be disqualified if they are found to be tampering with any aspect of the monitoring system placed in the house by Inspectors. Any accidental damage to the monitoring system or a monitoring system malfunction must be reported to an Inspector immediately.

## 6.5. Energy

*Charging of Batteries*—Decisions to charge the battery storage system from a non-solar source once solar operation of houses has begun must be communicated formally to the Chief Inspector. Teams will be assessed a penalty for charging a battery (see Energy Penalties). Charging the building's or car's storage batteries from any source of energy other than the solar array without specific permission and under the observation of the Chief Inspector or his/her designated representative is not permitted and will be grounds for disqualification.

*Replacement of Batteries*—Decisions to exchange all or part of a battery must be communicated formally to the Chief Judge. Teams will be assessed a penalty for replacing a battery (see Energy Penalties). Replacing part or all of the building's or car's storage batteries without specific permission and under the observation of the Chief Judge or his/her representative is not permitted and will be grounds for disqualification.

*Energy Penalties*—Teams will be assessed energy penalties that will be applied to the electrical consumption for the Contest indicated as follows:

| Penalty Type                             | Penalty                                                                                                                                                             | Contest                   |
|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| Replacement of a battery                 | (Manufacturer's rated amp-hour capacity @ a 20-hr discharge rate) x (System voltage) x 1.25 per occurrence                                                          | Energy Balance            |
| Generator use                            | (kWh into energy storage system) x 1.25 per occurrence                                                                                                              | Energy Balance            |
| Failure to regenerate desiccant material | $0.000293(\text{kWh/Btu}) \times 1.25 \times [\text{Mass difference (lbm)}] \times \{[1.00(\text{Btu/lbmR}) \times (162\text{R})] + [1065.2(\text{Btu/lbm})]\}$     | Comfort Zone              |
| Receiving additional water               | $0.000293(\text{kWh/Btu}) \times 1.25 \times [\text{Mass of water added (lbm)}] \times \{[1.00(\text{Btu/lbmR}) \times (162\text{R})] + [1065.2(\text{Btu/lbm})]\}$ | Hot Water or Comfort Zone |
| Failure to wash laundry                  | 4.1 kWh per occurrence                                                                                                                                              | Hot Water                 |
| Failure to dry laundry                   | 2.4 kWh per occurrence                                                                                                                                              | Energy Balance            |
| Failure to wash dishes                   | 2.6 kWh per occurrence                                                                                                                                              | Hot Water                 |
| Failure to cook                          | 0.7 kWh per occurrence                                                                                                                                              | Energy Balance            |

Energy penalties will be effective once solar operation of the houses begins.

## 7. APPENDICES

### 7.1 Appendix A: Internal Gains and Setpoint Schedules for Simulation

For single-zoned simulations, all annual models will reflect Table A-1, which is based on a 450-ft<sup>2</sup> conditioned-space footprint. For multiple-zoned models, teams may use American National Standards Institute/American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ANSI/ASHRAE) 90.2-1993 *Energy-Efficient Design of New Low-Rise Residential Buildings* (pages 49–50) based on a 450-ft<sup>2</sup> conditioned-space footprint.

**Table A-1. Single-Zone Internal-Gains Schedule**

| Time                   | Multiplier | Sensible Gain (Btu) | Latent Gain (Btu) |
|------------------------|------------|---------------------|-------------------|
| 12:00–1:00 A.M.        | 0.024      | 642                 | 128.4             |
| 1:00–2:00 A.M.         | 0.022      | 588.5               | 117.7             |
| 2:00–3:00 A.M.         | 0.021      | 561.75              | 112.35            |
| 3:00–4:00 A.M.         | 0.021      | 561.75              | 112.35            |
| 4:00–5:00 A.M.         | 0.021      | 561.75              | 112.35            |
| 5:00–6:00 A.M.         | 0.026      | 695.5               | 139.1             |
| 6:00–7:00 A.M.         | 0.038      | 1016.5              | 203.3             |
| 7:00–8:00 A.M.         | 0.059      | 1578.25             | 315.65            |
| 8:00–9:00 A.M.         | 0.056      | 1498                | 299.6             |
| 9:00–10:00 A.M.        | 0.06       | 1605                | 321               |
| 10:00–11:00 A.M.       | 0.059      | 1578.25             | 315.65            |
| 11:00–12:00 P.M.       | 0.046      | 1230.5              | 246.1             |
| 12:00–1:00 P.M.        | 0.045      | 1203.75             | 240.75            |
| 1:00–2:00 P.M.         | 0.03       | 802.5               | 160.5             |
| 2:00–3:00 P.M.         | 0.028      | 749                 | 149.8             |
| 3:00–4:00 P.M.         | 0.031      | 829.25              | 165.85            |
| 4:00–5:00 P.M.         | 0.057      | 1524.75             | 304.95            |
| 5:00–6:00 P.M.         | 0.054      | 1444.5              | 288.9             |
| 6:00–7:00 P.M.         | 0.064      | 1712                | 342.4             |
| 7:00–8:00 P.M.         | 0.052      | 1391                | 278.2             |
| 8:00–9:00 P.M.         | 0.05       | 1337.5              | 267.5             |
| 9:00–10:00 P.M.        | 0.055      | 1471.25             | 294.25            |
| 10:00–11:00 P.M.       | 0.044      | 1177                | 235.4             |
| 11:00 P.M. –12:00 A.M. | 0.027      | 722.25              | 144.45            |

Illumination setpoints for the simulation are set to 50 foot-candles for a single-zoned simulation. For multizoned simulations, refer to Table A-2 for the appropriate setpoint values.

**Table A-2. Lighting Setpoints for Simulation**

| Space    | Foot-candle Setpoint |
|----------|----------------------|
| Living   | 50                   |
| Kitchen  | 50                   |
| Bedroom  | 30                   |
| Bathroom | 30                   |

Heating and cooling setpoints for single- and multi-zoned simulations are shown in Tables A-3 and A-4.

**Table A-3. Heating and Cooling Setpoints for Single-Zoned Simulations**

| Time                 | Heat (°F) | Cool (°F) |
|----------------------|-----------|-----------|
| 6:00–9:00 A.M.       | 69        | 78        |
| 9:00 A.M.–5:00 P.M.  | 69        | 78        |
| 5:00–11:00 P.M.      | 69        | 78        |
| 11:00 P.M.–6:00 A.M. | 69        | 78        |

**Table A-4. Heating and Cooling Setpoints for Multizoned Simulations**

| Time                 | Primary Zone |           | Auxiliary Zone(s) |           |
|----------------------|--------------|-----------|-------------------|-----------|
|                      | Heat (°F)    | Cool (°F) | Heat (°F)         | Cool (°F) |
| 6:00–9:00 A.M.       | 69           | 78        | 69                | 78        |
| 9:00 A.M.–5:00 P.M.  | 69           | 78        | 60                | 85        |
| 5:00–11:00 P.M.      | 69           | 78        | 69                | 78        |
| 11:00 P.M.–6:00 A.M. | 60           | 85        | 60                | 78        |

## 7.2. Appendix B: Scoring

The 10 contests will be scored using some or all of the following methods: panel of judges, task completion, and measure of performance. Methods of scoring and value of awarded points for each Contest are specified in the discussions of the individual contests in this document. In the case of scoring by a panel of judges, points are assigned based on specific criteria. In the case of scoring by task completion, full points will be awarded for completing assigned tasks. In the case of scoring by measure of performance, teams will be ranked by level of performance, and points will be awarded based on that ranking (see Table B-1).

**Table B-1. Point Awards by Rank**

| Points Available | 100            | 35             | 30             | 20             |
|------------------|----------------|----------------|----------------|----------------|
| Rank             | Points Awarded | Points Awarded | Points Awarded | Points Awarded |
| 1                | 100.0          | 35.00          | 30.00          | 20.00          |
| 2                | 92.3           | 32.31          | 27.69          | 18.46          |
| 3                | 84.6           | 29.62          | 25.38          | 16.92          |
| 4                | 76.9           | 26.92          | 23.08          | 15.38          |
| 5                | 69.2           | 24.23          | 20.77          | 13.85          |
| 6                | 61.5           | 21.54          | 18.46          | 12.31          |
| 7                | 53.8           | 18.85          | 16.15          | 10.77          |
| 8                | 46.2           | 16.15          | 13.85          | 9.23           |
| 9                | 38.5           | 13.46          | 11.54          | 7.69           |
| 10               | 30.8           | 10.77          | 9.23           | 6.15           |
| 11               | 23.1           | 8.08           | 6.92           | 4.62           |
| 12               | 15.4           | 5.38           | 4.62           | 3.08           |
| 13               | 7.7            | 2.69           | 2.31           | 1.54           |
| 14               | 0.0            | 0.00           | 0.00           | 0.00           |