



U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

Building Code

July 2019

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Section 1. Introduction

Although there is some degree of overlap between the two, it is important to note some crucial distinctions between the Solar Decathlon Competition Guide/Rules documents and the Solar Decathlon Building Code. The Competition Guide and Rules exist primarily to promote a fair and interesting competition. The Building Code exists primarily to protect public health and ensure safety. Failure to comply with the Competition Guide and Rules may result in official warnings, point penalties, or disqualification from the competition. Failure to comply with the Building Code may prohibit the participation of your house in any aspect of the overall competition. Therefore, compliance with the Building Code is a prerequisite for participation in the competition. For the Solar Decathlon 2020 Build Challenge, note that those exhibits and tourable house models present on the National Mall as part of the Smithsonian Folklife Festival will be subject to requirements specific to that site.

Section 2. Adopted Codes

The 2018 International Residential Code (IRC), published by the International Code Council with 2018 International Build Code (IBC) amendments, and the 2017 National Electric Code (NEC), published by the National Fire Protection Agency (NFPA), have been adopted by reference as the Solar Decathlon Building Code and have the same force and effect as though fully set forth in the Solar Decathlon Competition Guide and Rules, except as specifically amended by provisions that follow. For any construction to remain permanently in their own community and not exhibited on the National Mall, the local code adopted by the local Authority Having Jurisdiction takes precedence over the codes listed above. For buildings constructed and displayed on the National Mall, the most restrictive requirements of either the Solar Decathlon Building Code or the locally adopted code shall apply.

Section 3. Building Planning and Construction

The building built as part of participation in the Solar Decathlon Build Challenge is intended to be representative of a residential dwelling constructed in accordance with the provisions contained in the IRC. Because portions of the building will be open to viewing by the general public, the IRC is amended with specific disabled accessibility provisions of the IBC, the Americans with Disabilities Act, and the Architectural Barriers Act as appropriate for the areas of the building subject to the public tour route determined by the team. Note that these accessibility provisions must be employed in addition to the locally adopted building code for all houses, whether or not the house is being exhibited on the National Mall. Ground embedment on the National Mall is prohibited.

For the duration of the competition exhibit period, the building shall not be occupied overnight and shall not be slept in at any time. The building is evaluated by Solar Decathlon organizers as a temporary exhibit with consideration only for provision of occupant safety and disabled access. Full intended use and occupancy of the building following the official conclusion of the Solar Decathlon competition is only allowed at the building's approved final location, in accordance with the conditions of the Certificate of Occupancy issued by the local jurisdiction.

The following provisions are amended and emphasized as they address the highest degree of risk to the building occupants during public exhibition. Compliance with the adopted code is mandatory in addition to the following items.

3-1. Fire Protection and Prevention

- a. **Fire and Occupant Protection Plan:** Each team, whether exhibiting locally or showcasing a house on the National Mall, shall provide a fire and occupant protection plan. This plan shall indicate how effective, fast, and orderly egress will be made from the unit, and who will be responsible (i.e., the team's health and safety officer) for public-tour life safety during the event. A written operations plan shall be provided to the Solar Decathlon organizers, discussing team-facilitated evacuation, fire control, electrical disconnection, and other hazard mitigation strategies. Plan approval with successful plan demonstration shall be required before any public tour of the building will be permitted.
- b. **Smoke and Fire Alarms:** Each house shall be required to have smoke or fire alarms per IRC requirements and one or more fire extinguisher(s) with a minimum Underwriters Laboratory (UL) rating of 2A-10BC. Smoke or fire alarms shall be connected to the AC voltage side of the inverter and provided with independent power (i.e., battery backup integral with the alarm). All smoke alarms shall be interconnected and all shall sound when one is activated (IRC, Sec. R314).
- c. **Carbon Monoxide Alarms:** Carbon monoxide alarms are required for houses provided with fuel-burning appliances or having attached garages. Fuel-burning appliances are prohibited per Solar Decathlon rules. Carbon monoxide alarms shall be required per IRC Section R315 for any attached garage, even those used exclusively for an electrical vehicle.
- d. **Evacuation Signage:** Each team shall provide exit signage above the main entrance and exit to the house. These signs may be hardwired or plug-in, but must be present and active at all times when the house is open to the public. Successful demonstration of the equipment shall be required before any public tour of the building will be permitted.
- e. **Fire Sprinklers:** IRC 2018 Section R313 requires fire-suppression sprinkler systems in all single-family dwellings. The provision of IRC R313 fire sprinklers is not mandatory in houses for the Solar Decathlon exhibition period unless required by the local Authority Having Jurisdiction for the final location of the house. Sprinkler systems required by the local authority are not required to be active during temporary exhibition on the National Mall. Teams required to have active fire suppression for reasons outside the constraints of this document will be required to provide sufficient fire water storage and pump capacity to meet the design hydraulics for a minimum duration of 7 minutes.

3-2. Means of Egress

The following means of egress components accessible to the public shall comply with Chapter 10 of the International Building Code.

- a. **Stairs:** Stairs are prohibited on the National Mall. All changes in elevation used as part of the public tour, accessible route, or means of egress shall be provided with sloped walking surfaces or ramps. Demonstration or mechanical-equipment-access stairs located within the interior of the dwelling and excluded from use by the public or any other individual during the public tours may be provided in accordance with IRC Section 311.7. Ladders or stairs that are not IRC-R311-compliant may be provided as "demonstrators" but the design team should be aware that U.S. building codes typically do not permit their use for access to habitable spaces. Stairs to habitable spaces excluded from use by the public or any other individual during public tours may be provided following specific approval by the Solar Decathlon Building Official.
- b. **Ramps:** Any sloped walking surface shall have a maximum slope of 8.33%. Any sloped walking surface with a slope greater than 5% and less than 8.33% shall be considered a ramp.
- c. **Handrails:** Handrails shall be provided on both sides of ramps used by the public during the display. All handrails shall be designed in accordance with 2010 Standard for Accessible Design Section 505.

- d. **Emergency Egress (Doors):** Door hardware shall be operable without the use of a key or special knowledge or effort. Any exhibit on the National Mall that has enclosed spaces for which visitors are expected to enter must have at least two compliant IRC R311.2 egress doors.

3-3. Interior Finishes

Interior finishes must comply with IRC Section R302.9. Synthetic building materials, such as those using plastics, must be submitted for approval by providing the manufacturer's test documentation indicating compliance with ASTM E-84 or UL 723 demonstrating a minimum Class C. Exceptions:

- a. Materials tested to EN 13501 with a minimum Euro-Class C
- b. Materials tested to DIN 4102 with a minimum B1 classification
- c. Materials complying with other surface fire propagation and smoke development testing methods subject to approval by the Solar Decathlon Building Official.

3-4. Glazing

The following hazardous locations are subject to human impact and require safety glazing. See IRC Section 308 for specific locations and exceptions.

- a. Photovoltaic (PV) modules containing glazing materials and placed within any of the locations listed in Items b through g below
- b. Glazing in doors
- c. Glazing in doors, surrounds, and walls enclosing or facing bathtubs or showers where not located more than 60 in. (152 cm) above the finished floor
- d. Glazing located within a 24 in. (61.0 cm) arc of either vertical edge of a door and less than 60 in. (152.4 cm) above the floor
- e. Glazing within 36 in. (91.4 cm) of stairways and/or within 60 in. (152.4 cm) of the bottom edge of stair treads when the bottom edge of the glazing is less than 60 in. (152.4 cm) above a walking surface
- f. Glazing in overhead panels (including skylights and glazed solar panels) placed where glazing is not separated from the occupants by a solid surface such as a roof
- g. Glazing in panels located with all the following conditions present:
 - i. Pane of glazing is greater than 9 ft² (0.836 m²)
 - ii. Bottom edge of glazing is less than 18 in. (45.7 cm) above the floor
 - iii. Top edge of glazing is greater than 36 in. (91.4 cm) above the floor
 - iv. Walking surface is located within 36 in. (91.4 cm) of the glazing.

3-5. Solar Energy Systems

Solar energy systems shall comply with IRC Section R324 and R907, as applicable. Teams must comply with rooftop access provisions in R324.6. These provisions may significantly limit the area available for placement of PVs by requiring access paths and setbacks from roof edges. If application of R324.6 Exception 2 is desired, documentation must be provided that demonstrates approval by both the local Authority Having Jurisdiction and the Solar Decathlon Building Official, as well as an evaluation of the building and roof configuration by the local fire authority finding that roof ventilation or firefighting operations is highly unlikely to be necessary.

Solar thermal systems shall comply with IRC Chapter 23 and the International Fire Code.

PV panels and modules shall be listed and labeled in accordance with UL 1703. Inverters shall be listed and labeled in accordance with UL 1741. Systems connected to the utility grid shall use inverters listed for utility interaction.

3-6. Foam Plastic Insulation

Foam plastics used for building construction shall only be permitted if the foam plastic is isolated from the interior of the building by gypsum board that is at least 0.5 in. (1.3 cm) thick, wood structural panel with a 23/32-in. (58.42-cm/81.28-cm) minimum thickness, or materials applied that comply with NFPA 275. This applies to foams typically used in structural insulated panel walls, floors, and roof systems.

Provide documentation to demonstrate compliance (IRC, Sec. R316).

- a. Gypsum board containing phase-change materials and other combustible performance enhancements may not qualify as the required thermal barrier unless specifically approved.
- b. Exposed foam plastic located in attics or crawl spaces (interstitial space between the floor assembly and the competition site surface) shall be covered with an ignition barrier consisting of 1.5-in. (3.81-cm)-thick mineral fiber insulation, 0.25-in. (0.64-cm)-thick wood structural panels, 0.375-in. (0.95-cm)-thick particleboard, 0.25-in. (0.64-cm) hardboard, 0.375-in. (0.95-cm) gypsum board, or corrosion-resistant steel having a base metal thickness of 0.016 in. (0.41 mm).

3-7. Exterior Envelope

Drawings submitted for review shall contain section details of proposed wall assembly showing framing, sheathing, water-resistive barriers, flashing, and exterior cladding as applicable (IRC, Sec. R703). All walls and roofs shall be designed to inhibit water entry into respective assemblies. All wall and roof assemblies shall be designed to allow moisture to escape from interstitial spaces to either the inside or outside of the assembly.

3-8. Ceiling Height

Ceiling height shall provide a minimum of 7 ft (213.4 cm) of headroom in habitable locations and as otherwise specified in IRC, Sec. R305.

3-9. Skylights

IRC Section R308.6 regulates skylight glazing. Glazing is limited to certain types, and screening under the glazing may be required. Indicate which glazing products are to be used and provide sufficient details in the submitted plans to ensure compliance (IRC, Sec. 308.6). Glass PV or hydronic solar collectors used overhead without a solid surface underneath (such as a roof) will be regulated as skylights.

3-10. Energy Conservation

Design and construction for energy conservation shall be in accordance with the 2018 International Energy Conservation Code as duplicated in IRC Chapter 11. Buildings shall be designed using the climate zone specified at the final location for the structure. For areas outside of the United States, determination of climate zone equivalency shall be provided in accordance with IRC Section N1101.7.2. Teams are required to demonstrate compliance through approved software such as ResCheck, RESNET, or by other means prescribed by the IRC.

Section 4. Accessibility

4-1. Accessible Route—Interior

An accessible route shall be provided within the unit to all spaces accessible to the public as part of the tour. Components of the accessible route used by the touring public must comply with the U.S. Department of Justice 2010 Standards for Accessible Design. Other accessible features may be included in rooms, such as kitchens and bathrooms, at the discretion of the team. If any of the features are available and intended for use by the public, they shall be accessible in accordance with the 2010 Standard for Accessible Design. Voluntary accessibility provided outside of areas accessible to the touring public should comply with 2018 IBC Chapter 11 and ICC/ANSI A117.1-2009 for the level of accessibility desired.

4-2. Accessibility—Habitable Roof Deck and Interior Second Floor/Loft Levels

Solar Decathlon competition houses are intended to demonstrate single-family dwellings that are not normally regulated by federal accessibility standards. As these buildings are open to the public for educational purposes, they must be accessible for exhibition tours. Therefore, any portion of the building where the public is permitted must provide an accessible route to and from that location.

- a. The Americans with Disabilities Act (ADA) requires an elevator to be installed in buildings (funded pursuant to Title II) where an accessible route is required to stories above the first floor (such as the roof deck, second floor, or loft). The 3,000 ft² (278.7 m²) exception located in IBC Section 1104.4 Exc. 1 is superseded by this federal regulation.
- b. The ADA Technical Assistance Center has stated that it is acceptable to “demonstrate” a roof deck, loft, or upper level accessed via stairs, or other means of inaccessible access, as long as no member of the public, organizers, or competing teams are allowed to access the space during public exhibit periods. Any provided means of access shall be fully gated or cordoned off to inhibit entry. Adherence to these guidelines is intended to remove any perception that the upper level is being used as for public access and therefore subject to the accessibility provisions of the ADA. Access to these levels is permitted by team members, organizers, and jurors only outside of times when the public is present.

4-3. Accessibility—Ramps

Regardless of whether the house is built locally or exhibited on the National Mall, each team must provide an accessible tour route for visitors through the house. The following are the most important regulations and specific Solar Decathlon criteria regarding ramps:

- a. A ramp is any sloping surface used as part of the circulation path that has a slope in excess of 1:20. Sloping surfaces less than 1:20 shall comply with 2010 Standard for Accessible Design Section 403.
- b. The slope of a ramp cannot exceed 1:12.
- c. At the top and bottom of any ramp, a minimum landing 60 in. (152.4 cm) long is required and the landing clear width shall be at least as wide as the widest ramp run leading to the landing. For ramps with an elevation change in excess of 30 in. (76 cm), an intermediate landing is required. Teams exhibiting a house module on the National Mall must design their structure such that the finished floor would be no more than 27” above grade when in the exhibit configuration.
- d. A minimum 60-in.-by-60-in. (152.4-cm-by-152.4-cm) landing is required at any point where a ramp changes direction.

- e. Handrails are required if the ramp's rise exceeds 6 in. (15 cm) (2010 Standards for Accessible Design Section 405). Handrails shall be continuous and be provided with 12-in. (305-mm) extensions beyond the top and bottom of the ramp's sloping surface. Handrails with a circular cross section shall have an outside diameter of at least 1.25 in. (32 mm) and not greater than 2 in. (51 mm). If the handrail is not circular, it shall have a perimeter dimension of at least 4 in. (102 mm) and not greater than 6.25 in. (160 mm) with a maximum cross section dimension of 2.25 in. (57 mm). Handrails shall be uniform in height, not less than 34 in. (864 mm) and not more than 38 in. (965 mm) above the walking surface of the ramp.
- f. At times when the team is responsible for construction and installation of the ramps to their house, teams must design and provide a metal plate transition component between the access ramp and the walking surface of the site or otherwise have permanent construction that is compliant with the relevant requirements of the ADA 2010 Standards for Accessible Design. Such transition shall be no greater than 0.5 in. (12.7 mm) in height at the edge contacting the walking surface of the competition site. If the edge exceeds 0.25 in. (6.3 mm) in height, it shall be provided with a 1:2 bevel. If the connected ramp exceeds 5% slope, the transition plate and the ramp must be provided with handrails and edge protection. Both shall extend onto the transition plate with the handrails extending 12 in. (305 mm) beyond the termination of the transition plate. The design of the transition plate shall accommodate the lateral loads placed on the handrails and extensions without relying on ground embedment for support.

4-4. Changes in Elevation

All changes in elevation (including even minor changes in areas such as door thresholds) must be considered along an accessible route. Changes not exceeding 0.25 in. (0.64 cm) are acceptable without edge treatment.

- a. Elevation changes between 0.25 in. and 0.5 in. (0.64 cm and 1.3 cm) shall be beveled at a maximum of 1:2 slope.
- b. Any change in elevation exceeding 0.5 in. (1.3 cm) shall be by a ramp with a maximum slope of 1:12 (2010 Standards for Accessible Design, Section 405). Sloped surfaces in excess of 2% are not permitted within the door approach clearances required by 2010 Standard for Accessible Design, Section 404.
- c. Sloped walking surfaces (5% or less slope) complying with 2010 Standards for Accessible Design, Section 403, shall be permitted.

4-5. Doors and Door Approaches

All doors shall comply with the 2010 Standards for Accessible Design, Section 404.

- a. Doors that can be fixed in an open position may be accepted as part of the accessible route if 32-in. (81.3-cm) minimum clearance is provided through the door opening with the door secured in the fully open position. Clear openings of doorways with swinging doors shall be measured between the face of the door and the stop, with the door open 90 degrees.
- b. Doors without required maneuvering clearances that are intended to remain open during the public tour must be clearly identified on the plans and approved by the Solar Decathlon Building Official and local Authority Having Jurisdiction.

Section 5. Structural

The structural drawings and calculations shall be stamped by a qualified, licensed design professional. Such licensed design professional shall be registered in in the jurisdiction of the expected final location for the house. Obtaining the stamp is the responsibility of the teams, not the organizers. The organizers

will submit stamped structural drawings and calculations to the Smithsonian Folklife Festival and National Park Service for final approval. It is strongly recommended that teams involve a qualified, licensed professional throughout the design process because he or she could require structural design changes that could affect other aspects of the house. In addition to meeting applicable IRC requirements, special attention must be given to the structural design challenges unique to the temporary exhibit. These challenges include, but are not limited to:

- a. Increased live loads because of public access to the house.
- b. Necessity for non-earth-embedded foundations because of the lack of a permanent foundation for temporary exhibits and unique wind-loading conditions because of roof-mounted solar systems.
- c. Increased dead loads because of unusual or concentrated mechanical and electrical equipment.

5-1. Prescriptive Requirements

- a. **Structural Systems:** Structural systems shall be designed in accordance with the appropriate prescriptive provisions of the IRC where practical. Engineered design may be employed using accepted engineering practice in accordance with the International Building Code. Alternate structural materials and systems shall comply with IRC Section 104.11 and Sec. CC2.6.
- b. **Structural Framing:** A detailed one-line structural plan view drawing is required at a minimum. Successive plan sheets shall be provided and shall include foundation footings, anchorage details (where permitted), floor framing, wall locations, and roof framing. All structural components shall be listed, including sizes, species and grade, orientation of the structural components, and repetitive spacing (on-center distances). Include details on connections between joists and beams, floor systems and foundations, walls and floors, rafters and beams, and so on. Specify proprietary hangers or other mechanical connections as appropriate (IRC, Sec. R301.1).

5-2. Design Loads

The following minimum loads must be used in the structural design:

- a. **Wind:** 90 mph (40.2 m/s) (3-second gust), exposure category C (the design must show that there is no overturning, uplifting, or sliding with a safety factor of 1.5). Ground embedment anchorage strategies are prohibited on the National Mall. See National Mall ballast criteria in Section 5-5.
- b. **Soil Site Class for the National Mall:** 3,000-psf (143.64-kPa) maximum load-bearing pressure on presumptive compacted gravel materials.
- c. **Railings:** 200-lb (890-N) concentrated load applied in any direction at any point at the top of the rail.
- d. **Interior Floor, Decks, Ramps:** 50 psf (2.39 kPa) live load.
- e. **Exterior Floor, Decks, Ramps Used for Tour Staging and Egress Purposes:** 100-psf (4.79-kPa) live load.
- f. **Roof:** 20-psf (.96-kPa) live load.
- g. **Snow:** Ground snow load p_g for use with ASCE 7-10: 20 psf (0.96 kPa).

Structural plans shall indicate the design live loads and the location, size, and weight of special loads, such as liquid storage tanks and mass or trombe walls. These loads are considered minimums for the public period of the event. Higher design loads may be mandated by the local Authority Having Jurisdiction in the location where the house will be permanently sited. The design should accommodate the higher of the design values required by the Solar Decathlon Building Code or the local Authority Having Jurisdiction. The engineer should be advised on the National Mall ground penetration prohibition and should accommodate loading without reliance on ground embedment. See National Mall ballast guidance in Section 5-5.

5-3. Exterior Construction

Structural plans shall include design details for any exterior appurtenances such as decks, stairs, ramps, awnings, canopies, and roof projections (IRC, Sec. R301.1). Deck structural framing shall include full details for house ledger connections, joist-to-beam connections, and beam-to-column/footing connections. Special design attention shall be paid to load path for deck foundation systems for concealed footing systems.

5-4. Specific Loads

Provide wind-analysis calculations for column and footing pad load-transfer connections demonstrating the components' abilities to transmit gravity loads and to withstand 90 mph (40.2 m/s) (3 second gust), exposure category C wind conditions used for the temporary event site on the National Mall. Provide point-load connection details for all solar panel building connections to demonstrate that the connections will resist uplift (IRC, Sec. R301.1 and R907.2).

5-5. Foundation

Provide a plan for temporary setup on the competition site. The design must accommodate design loads, including gravity and lateral derived from wind and seismic, as applicable. Plans shall include location and size of all elements transferring load from the house structure to the ground and any required ballast anchorage to prevent wind uplift or overturning (IRC, Sec. R401.1 and R401.2) and to provide adequate lateral load transference. Please provide consideration for sloping or variable site conditions. Gravel surface is rough, washboarded, and pot-holed. Variance over 50 ft can be 6 in. Single point features may exceed 3 in.

General Requirements:

- a. All houses, decks, and other structures shall be provided with foundations sufficient to safely transmit gravity, lateral, and uplift loads. For purposes of design, the presumptive site surface bearing capacity shall be 3,000-psf (143.64-kPa) maximum load-bearing pressure on presumptive compacted gravel materials). Design wind speed shall be 90 mph (40.2 m/s) (3-second gust) with a C exposure.
- b. Houses and connected structures placed on the National Mall must have foundation designs that accommodate gravity load transference and resist wind displacement, uplift, and overturning.
- c. Wind design may employ dead load ballast, building dead-load analysis, or a combination of both. Teams are encouraged to configure their structures to take advantage of the building's dead loads to resist wind uplift as well as seismic- and wind-generated overturning and sliding. All designs shall be supported by calculations demonstrating the efficacy of the designed system.
- d. Ballasted anchorage on the National Mall will consist of organizer-provided, precast concrete traffic safety "Jersey" barriers. Teams will be responsible for determining whether ballast is required for their structure to resist the prescribed design wind speed. If ballast is needed, teams are responsible for determining the numbers and location of the ballast. Teams shall design appropriate connections between the ballasts and the building structure as part of the ballast anchorage design. Teams are responsible for providing and attaching the connections from the ballast to the team's house. Teams should anticipate that each ballast will weight approximately 4,000 lb (1,820 kg). Final weight and dimensions of the ballasts will be provided by the organizers prior to August 31, 2019.

5-6. Alternate Materials

Alternate materials are permitted as follows:

- a. **Structurally Insulated Panel Systems Pursuant to Specific Manufacturer’s Design Data:** Wall panels not in compliance with IRC Section R610 will require an evaluation report from a credible and approved evaluation agency. Also be advised that foam plastics used in Structurally Insulated Panels (SIPs) or other systems must be thermally isolated from the interior of the dwelling (see Section 3-6 for more details).
- b. **Engineered Trusses (Floor or Roof):** Engineered trusses must be designed in accordance with IRC Sections R502.11 or R802.10, as appropriate. Individual truss reports shall be provided for review and shall bear the seal of a registered design professional.
- c. **Alternate Materials/Methods:** Alternate materials and methods of construction not otherwise prescribed by the code may be permitted, pursuant to approval by written request under IRC Section 104.11. It is the responsibility of the applicant to provide adequate proof to document the alternate as meeting the intent of the prescriptive code requirements. The organizers reserve the right to deny any alternate for failure to clearly demonstrate code equivalence.
- d. **Phase-Change Materials:** Phase-change materials included within building components must be identified on the plans in all locations intended for use. Specifications for the material composition must be provided with fire-performance testing data, as appropriate. Be advised that phase-change embedment in gypsum board or interior wall or ceiling finishes may affect the ability of these materials to pass IRC required fire tests.
- e. **Electrical Components:** Unlisted electrical components intended to be used must be fully disclosed no later than 12 months prior to the start of the competition. Such unlisted components are limited to 60 volts. Such components shall be fully described in a written proposal format with competent technical substantiation provided. The proposal is subject to approval by the event organizers subject to stipulated minimum testing to ensure safe operation during the public event.

5-7. Structural Steel

Provide structural details for load-carrying structural steel assemblies. Include welded or bolted connections within the assembly and where attached to other structures (IRC, Sec. R301.1.3).

Section 6. Electrical

6-1. Governing Code

Each team’s design must comply with the adopted codes of the local Authority Having Jurisdiction. For any elements to be exhibited on the National Mall, the provisions of the 2017 NEC supersede the limited prescriptive electrical requirements contained in Chapters 33–42 of the IRC. The following requirements must be met regardless of requirements for locally adopted electrical codes.

Exception: Electrical system design methods required by non-U.S. entrants for compliance in the jurisdiction of final placement may be permitted following review and approval by the Solar Decathlon Building Official. Such approval will require compliance with an approved national or international electrical code or standard. Teams seeking approval must submit English-translated copies of the referenced code for evaluation prior to approval. If approved, such teams shall be required to provide special inspection of the electrical system prior to placement of the structure in Washington, D.C. Solar Decathlon temporary site final inspections of the visible electrical system will be performed by Solar Decathlon electrical inspectors using team-supplied electrical test equipment suitable for the approved NEC-alternate electrical system.

6-2. Drawing Requirements

- a. Electrical plan(s) must include layouts of proposed receptacles, switches, light fixtures, smoke alarms, ceiling fans, and so on.
- b. Provide details on the proposed PV system along with a key for symbols used in the drawings. Such details shall include information on the PV panels, distribution (e.g., wiring, inverters, switch gear, and over-current protection), and storage equipment (IRC, Sec. R106.1.1).
- c. Provide a key for electrical symbols used in the electrical plans (IRC, Sec. R106.1.1).
- d. A professional engineer's seal and signature shall be required for PV solar installations that include provisions for battery backup.

6-3. Tamper-Resistant Receptacles

Tamper-resistant receptacles shall be provided as specified in 2017 NEC Section 406.12. This includes all receptacles located less than 5.5 ft (1.7 m) from the finished floor or ground surface.

6-4. Outdoor Receptacles

Any receptacles used on the exterior of the building must be protected with ground fault circuit interrupters (GFCI) or residual current devices (RCD) for non-U.S. based teams. Enclosures provided must be suitable for damp or wet locations. See NEC Section 406.9 for full requirements.

6-5. Arc-Fault Circuit Protection

Combination arc-fault circuit interruption protection shall be provided in accordance with 2017 NEC Section 210.12. Non-U.S. teams may use other protection methods appropriate to their national standard upon approval of the Solar Decathlon Building Official.

6-6. Ground-Fault Circuit Protection

Any AC receptacles located in kitchens, bathrooms, laundry areas, and outdoors shall be GFCI protected. Non-U.S. 240-volt systems may use RCD protection where the NEC specifies GFCI. See NEC Section 210.8 for specific locations requiring GFCI protection.

6-7. Equipment Listings

All electrical equipment shall carry an approved testing agency's listing or shall have been approved by the Solar Decathlon Building Official and Solar Decathlon electrical inspectors for temporary use during the event in accordance with Section 104.11 of the IRC and Section 110.2 of the NEC.

- a. Unlisted PV modules may be used in a system with a DC bus voltage of no greater than 60 volts (open-circuit) at 32°F (0°C) if, and only if, such equipment has been evaluated and approved by the Solar Decathlon Building Official and Solar Decathlon electrical inspector. PV cell and module mounting means are subject to increased scrutiny in custom, unlisted, building-integrated PV applications.
- b. The use of unlisted PV modules and the installation of listed PV modules in an unapproved manner in a system with a DC bus voltage of greater than 60 volts (open-circuit) at 32°F (0°C) are prohibited. Listings shall be to United States UL Standards and shall be issued by an approved, accredited testing laboratory.
- c. The attachment of PV modules to any material where the PV module is not listed for such an application is prohibited, regardless of the bus voltage.
- d. All DC-to-AC utility-interactive inverters must be fully listed to UL Standard 1741.

6-8. Photovoltaics

Particular attention should be paid to Articles 690, 480, 445, 250, 310, 400, and 240 of the NEC, which refer to PV system design, storage batteries, generators, grounding, conductors for general wiring, flexible cords and cables, and over-current protection devices, respectively.

The maximum size of the PV array shall be 10 kW, DC.

Rapid Shutdown for PV Systems on Buildings

- a. Teams shall meet the requirements of NEC 690.12, Rapid Shutdown for PV systems on buildings.

6-9. Grounding

Each team shall provide a grounding electrode conductor (GEC) from the dwelling's main service equipment to the organizer utility panel. The grounding electrode conductor shall be a minimum size of 4 AWG copper, either bare or insulated. The organizers will bond the dwelling grounding electrode conductor to the organizer grounding electrode. A GEC shall also be connected to all the available electrodes that are required by NEC 250.50, or if applicable NEC 250.32(A).

6-10. Inverter Disconnect

Each team shall provide a disconnecting means located between the inverter and the solar array where panel-integrated microinverters are not employed. The disconnecting means should be capable of ready lockout/tagout to facilitate safe service of the inverter(s).

6-11. Batteries

a. Battery Storage Systems—Smoke Detection

All battery systems must be provided with automatic smoke detection. Lithium ion and lithium metal cell systems shall have at least one interconnected smoke alarm placed within the same room or compartment as the battery system(s). Lead acid, flooded nickel-cadmium (Ni-Cd), or other battery systems employing any form of electrolyte must be provided with at least one interconnected smoke alarm located within each separated battery compartment required by Section 6-11(b).

b. Battery Enclosure Separation

Lead acid, flooded Ni-Cd, or other battery systems employing any form of electrolyte must be provided with a battery enclosure consisting of either an isolated battery box or separated battery compartment. Isolated battery boxes must be placed a minimum of 10 ft from any building wall. Battery compartments may be located within the building provided that minimum 5/8-in (16-mm) Type X or Type C gypsum board is placed on the interior of the compartment on all walls, floors, or ceilings common with the building. Any penetrations from the compartment into the interior of the building shall be sealed to resist the passage of smoke, flame, and hot gasses with approved materials.

Battery compartments containing more than 100 gallons (379 liters) of total liquid electrolyte capacity shall be separated from the remainder of the building by a 1-hour fire barrier constructed in accordance with 2018 International Building Code. Openings and penetrations in the fire barrier shall be provided with an approved firestop system having a minimum 1-Hour F Rating.

c. Battery Enclosure Ventilation

All battery enclosures required by 6-11(c) shall be provided with either passive or active ventilation.

PASSIVE VENTILATION REQUIREMENTS:

- Passive ventilation shall consist of a lower gravity vent and an upper gravity vent.
- The top of the lower gravity vent shall be located no more than 12 in. (30.5 cm) from the lowest point of the battery enclosure. The vent shall be unobstructed to allow fresh air intake into the enclosure and shall be sized to provide a minimum of 28 in.² (181 cm²) of net-free ventilating area.
- The upper vent shall be located in either the battery enclosure ceiling or in a battery enclosure sidewall. A ceiling vent shall be located at the highest point of the battery enclosure ceiling. The top of a sidewall vent shall be coincident with highest point of the battery enclosure ceiling. The vent shall discharge outside of the building at least 5 ft (1.52 m) away from sources of air intake into the building and shall be sized to provide a minimum of 28 in.² (181 cm²) of net-free ventilating area. If the upper vent is ducted outside, the duct must be level or sloped upward from the battery room to the outside. These requirements prevent the accumulation of hydrogen gas near the ceiling of a battery enclosure.

ACTIVE VENTILATION REQUIREMENTS:

- Active ventilation shall consist of a lower fan-powered vent and an upper gravity vent.
- Active ventilation shall be powered by a continuously operating, DC brushless fan. The fan shall provide a minimum of 1 cfm (0.47 L/s) of air supply for each square foot of floor area in the battery enclosure. The fan shall be oriented to generate a positive pressure in the battery compartment. The top of the fan inlet shall be located no more than 12 in. (30.5 cm) from the lowest point of the battery enclosure.
- The upper vent shall be located in either the battery enclosure ceiling or in a battery enclosure sidewall. A ceiling vent shall be located at the highest point of the battery enclosure ceiling. The top of a sidewall vent shall be coincident with the highest point of the battery enclosure ceiling. The vent shall discharge outside of the building, at least 5 ft (1.52 m) away from sources of air intake into the building and shall be sized to provide a minimum of 28 in.² (181 cm²) of net-free ventilating area. If the upper vent is ducted outside, the duct must be level or sloped upward from the battery room to the outside. These requirements prevent the accumulation of hydrogen gas near the ceiling of a battery enclosure.

d. Batteries

Electrolyte-containing battery systems with greater than 50 gallons of electrolytes shall comply with 2018 International Fire Code Section 1206.3.5.4 Spill Control and Neutralization.

Section 7. Mechanical

7-1. Drawing Requirements

Provide a key for symbols used in the drawings (IRC, Sec. R106.1.1).

7-2. Return Air

Return air shall not be taken from a bathroom, kitchen, mechanical, or furnace room. (IRC, Sec. M1602.2).

7-3. Outside and Exhaust Air

- a. **Outside Air:** Outside air shall not be taken closer than 10 ft (304.8 cm) from an appliance or plumbing vent, or discharge outlet of an exhaust fan [unless the intake is located at least 3 ft (91.4 cm) below the vent or fan discharge] (IRC, Sec. R303.5.1.).
- b. **Screens:** Outside air inlets shall be equipped with a screen with openings 0.25 in. to 0.5 in. (0.64 cm to 1.3 cm) (IRC, Sec. R303.6).
- c. **Mechanical Ventilation:** The dwelling unit shall be provided with whole-house mechanical ventilation in accordance with IRC Section M1505.4 when determined to have 5 ACH or less per IRC Section R303.4.

7-4. Bathroom Ventilation

Bathrooms shall be provided with mechanical ventilation systems capable of providing 50 cfm (23.6 L/s) for intermittent ventilation or 20 cfm (9.4 L/s) for continuous ventilation (R1505.4), or with windows allowing a 1.5 ft² (0.14 m²) opening for natural ventilation (IRC, Sec. R303.3).

Section 8. Solar Mechanical

8-1. Drawing Requirements

Provide plan details for any proposed solar mechanical systems. Provide details on collectors, fluid distribution, heat exchangers, and so on, along with a key for symbols used in the drawings (IRC, Sec. 106.1.1). Plans should emphasize compliance with IRC Chapter 23 requirements.

8-2. Cross Connection

Provide details for the solar hot-water system. Provide details indicating if potable water or other heat transfer liquids will be employed. If other than potable water is used, an approved heat exchanger shall be employed to isolate potable water from transfer fluids (IRC Section R106.1.1).

8-3. Access

Solar collectors, controls, dampers, fans, and pumps shall be accessible for inspection, maintenance, repair, and replacement (IRC, Sec. M2301.2.1).

8-4. Roof-Mounted Collectors

The roof shall be constructed to support all loads imposed by the collectors. If collectors are intended to serve as the roof covering, documentation shall be provided to determine compliance with the roofing provisions in IRC, Chapter 9. If the collectors will be placed over the roof covering, the collectors and supporting structure shall be constructed of noncombustible material or fire-retardant-treated wood equivalent to that required for the roof covering (IRC, Sec. M2301.2.2.1).

8-5. Pressure and Temperature Relief

Pressure- and temperature-relief valves shall be provided for components under pressure. Relief devices shall be installed in sections of the system so that a section cannot be valved off or isolated from a relief device (IRC, Sec. M2301.2.3). Pressure and temperature relief devices shall have the capacity to be removed and capped prior to inspection to accommodate the required 100-psi (690-kPa) system pressure test required by Section 8-13.

8-6. Vacuum Relief

A vacuum relief valve shall protect system components that might be subjected to pressure drops below atmospheric pressure during operation or shutdown. Plans shall indicate if this system is subject to vacuum conditions (IRC, Sec. M2301.2.4).

8-7. Expansion Tanks

Expansion tanks in solar systems shall be installed in accordance with IRC, Section M2301 in pressurized closed-fluid loops that contain heat-transfer fluid (IRC, Sec. M2301.2.8).

8-8. Solar Loop Isolation

Valves shall be installed to allow isolation of the solar collectors from the remainder of the system (IRC, Sec. M2301.2.11.1).

8-9. Maximum Temperature Limitation

Systems shall be equipped with means to limit the maximum water temperature of the system fluid entering or exchanging heat with any pressurized vessel inside the dwelling to 180°F (82°C). This protection is required in addition to required temperature and pressure relief valves stated in IRC, Section M2301.2.3 (IRC, Sec. M2301.2.12).

8-10. Collector and Thermal Storage Unit Labeling

- a. Collectors and storage units shall be listed and labeled to show the manufacturer's name, model number, serial number, collector weight, collector maximum allowable temperatures and pressures, and the type of heat transfer fluids that are compatible with the collector and storage units (IRC, Sec. 2301.3).
- b. Solar thermal collectors and panels shall be listed and labeled in accordance with ICC901/SRCC 100. Solar collection equipment not listed must be fully disclosed and be subject to the alternate methods and materials process at IRC R104.11.
- c. Identification of system components. All components of the solar hydronic system shall be identified with permanent identification labels. Such labels shall indicate the function of the component (i.e., panel loop supply or return, heat exchanger, domestic loop, and so on) and flow direction.

Exception: Domestic plumbing fixture supply and in-floor radiant heat loops.

8-11. Permitted Heat-Transfer Media

Only water- and food-grade propylene glycol is permitted as heat transfer fluid during Solar Decathlon competition exhibition. Alternative fluids may be used subject to special review and approval by the Solar Decathlon Building Official.

8-12. Backflow Prevention

All connections from the potable water supply to solar systems shall comply with IRC, Section P2902.5.5 (IRC, Sec.M2301.5).

8-13. Pressure Test

All solar hydronic piping shall be tested hydrostatically at a pressure of not less than 100 psi (690 kPa) for no fewer than 15 minutes. Temperature and pressure relief devices that operate at or less than 100 psi (690 kPa) shall be removed and plugged during the test.

Exception: Systems designed for pressures under 100 psi (690 kPa) may be tested at lower pressures when approved by the Solar Decathlon Building Official. Such systems and their testing method must be approved prior to the final construction phase for the public exhibit.

Section 9. Plumbing

9-1. Drawing Requirements

- a. Provide a labeled isometric diagram of the proposed plumbing system for review. Clearly indicate waste lines, vent lines, potable water supply, heat exchange equipment, and the type of any heat transferring fluid used other than potable water.
- b. Provide a key for symbols used in the drawings (IRC, Sec. 106.1.1).

9-2. Water Closet Demonstration

Water closets present on the National Mall are to be installed for demonstration only and shall not be connected to any portion of the sewage disposal system. The water closet may be attached to the building's drainage system provided that the toilet flange test cap remains in place or that an inflatable test plug is installed. Toilet bowls shall be provided with a concealed opaque cover or other approved means to discourage use of the toilet during the temporary exhibit. No water supply shall be extended to the water closet unless otherwise approved by the Solar Decathlon Building Official.

Toilet Room Plumbing Wall Structural Recommendation: Create a dedicated plumbing wall with thickness sufficient to allow pipe penetrations within the studs not exceeding 60% of the stud width in nonbearing walls (IRC, Sec. 602.6).

9-3. Shower Mixing Valves

Shower mixing valves shall be pressure balanced, thermostatic mixing or a combination of the two, with the high limit set at 120°F (48.9°C) to prevent scalding (IRC, Sec. P2708.4).

9-4. Backflow Prevention

Backflow prevention is required to isolate the potable water supply from the solar systems. See IRC Section P2902.3 for permissible devices. Because the temporary event may use supply tanks for potable water, the use of a separate and isolated fill system for the solar component may be deemed acceptable backflow prevention.

9-5. Supply

Should a team choose to use a temporary water supply tank for testing, demonstration, or exhibition purposes, either locally or on the National Mall, then no additives of any kind may be placed within the team's supply tank. **Water served by a temporary water supply tank is not for consumption at any time.** Should a team choose to use a water supply tank, it must have a support structure sufficient to mitigate damage to the competition site. All tanks and supply lines placed on the National Mall will be rigorously inspected for leakage.

9-6. Waste

Should a team choose to use a temporary wastewater tank for testing, demonstration, or exhibition purposes, either locally or on the National Mall, then substances used in combination with water to clean the house, dishes, utensils, and so on, must be nontoxic and preferably biodegradable. Teams may incur a point penalty for any toxic substances that are found in the wastewater tank.

9-7. Water Feature Safety

- a. Water features shall not exceed a depth of 2 ft (61 cm).
- b. For water features >1 ft but <2 ft (>30.5 cm but <61 cm), there shall be a representative from the team positioned at the water feature when the house is open to the public to monitor the area and act as a lifeguard if necessary. During times when the area is not open to the public, the water feature shall be covered or guarded in a manner to prevent access.
- c. To ensure safe access, a 44-in. (111.8-cm) accessible surface shall be maintained all around the water feature.
- d. Visitor flow patterns shall be considered in the placement of the water feature.
- e. The water feature should have sufficient circulation/treatment/measures taken to ensure the water does not become stagnant and a nuisance hazard.

9-8. Rainwater Harvesting

Teams may demonstrate the harvesting and utilization of rainwater provided that the team understands the following conditions and agrees to comply with the following minimum criteria:

- a. Rainwater harvesting and utilization may be demonstrated provided that any “collected” and “utilized” rainwater is actively diverted to bypass intentional collection systems. This may be performed via a hidden valve and diversion tee within the rainwater piping system prior to reaching a storage vessel. During tour and jury communications, the team may discuss the rainwater collection system.
- b. The act of harvesting rainwater must be permitted within the jurisdiction where the house is intended to be permanently placed.
- c. The rainwater harvesting system must comply with the Solar Decathlon Building Code and the team’s relevant International Residential Code and local regulations.

Rainwater Harvesting Systems for Nonpotable Irrigation Use

Rainwater harvesting systems used exclusively for irrigation or other nonpotable purposes shall comply with the gray water recycling provisions contained in International Residential Code Section P3009. Roof gutters or downspout entrances providing captured rainwater intended to be processed and used shall be provided with an effective means to prevent leaf and other roof debris from entering the collection piping. Screening providing 0.25-in (6-mm) maximum openings located immediately upstream of conveyance piping including exterior downspouts shall be deemed compliant.

Rainwater Harvesting Systems for Potable Use

Demonstration of such systems is permitted.

- a. **Rainwater Harvesting Systems:** Systems used for potable and combination potable and nonpotable applications must be permitted by the Authority Having Jurisdiction over the house’s permanent location and must comply with this section.
- b. **Leaf and Debris Screens:** Roof gutters or downspout entrances shall be provided with an effective means to prevent leaf and other roof debris from entering the collection piping. Screening providing 0.25-inch (6-mm) maximum openings located immediately upstream of conveyance piping including exterior downspouts shall be deemed compliant.
- c. **Initial Discharge Diversion System:** Rainwater collection systems shall be provided with an initial discharge diversion (first flush) system to reduce collection of accumulated roof surface contaminants. The system shall incorporate an adequately sized standpipe or other approved

collection container with a floating ball shut-off or other approved separating mechanism providing the minimum collection volume as follows:

- i. **Serving a Low Slope Roof with 2:12 Pitch or Less:** 2 gallons (7.5 liters) per 100 ft² (9.3m²) of projected roof surface.
 - ii. **Serving a High Slope Roof with Greater Than 2:12 Pitch:** 1 gallon (3.75 liters) per 100 ft² (9.3m²) of projected roof surface.
- d. **Documentation:** The team shall produce construction documents with calculations necessary to show the projected area of roof being discharged into the rainwater collection system, the pitch of the roof, the calculated and provided volume capacity of the initial diversion standpipe, and all associated connecting piping to the point of entry into the potable water piping or gray water recycling system.
 - e. **Water Recycling:** Water collected within the initial discharge diversion system shall be permitted to be demonstrated as part of a gray water recycling system in accordance with International Residential Code Section P3009. Clear water passing after the initial discharge diversion system shall not be connected to a gray water recycling system unless provided with an air gap or other approved cross contamination backflow prevention device.
 - f. **Drinking Water Treatment System:** Rainwater system piping upstream of an approved drinking water treatment system shall not be connected to any portion of the house's potable water system. Rainwater treatment and use within the potable water piping system shall only be permitted to be demonstrated provided that it is first treated by an approved drinking water treatment system complying with International Residential Code Section P2908. An approved backflow prevention method shall be provided immediately downstream of the drinking water treatment system unless provided integrally within a listed and approved treatment unit. Teams are responsible to determine more restrictive treatment requirements mandated by the Authority Having Jurisdiction in the house's final location.
 - g. **Roofing Materials:** Roof cladding surfaces, gutters, and downspouts used for potable rainwater collection systems must comprise metal or other impermeable surfaces that are unlikely to release toxic products that will negatively affect water quality. Roofs containing asphalt, wood products, or similar materials shall not be used for potable rainwater harvesting systems. Roofs, gutters, and downspouts using plastics or flexible membranes shall be permitted when sufficient evidence is submitted by the team to show that the surface materials will not discharge harmful contaminants into the collected rainwater.

Section 10. Material Safety

10-1. Thermal Storage

All thermal storage devices ("mass") must be made of stable, nontoxic materials. Phase-change materials are permitted only by special approval of the Solar Decathlon Building Official. The chemical makeup of these materials must be fully disclosed. For all heat-transfer fluids, Material Safety Data Sheets (MSDS) must be submitted for approval. All liquid-based thermal storage systems must be marked with the NFPA's hazard warning diamond appropriate to the technology.

10-2. Paint Disposal

Teams are not permitted to dispose of paint on the National Mall site. Teams are responsible for finding a local facility that disposes of or recycles paint.

10-3. Material Safety Data Sheets

MSDS are required for all potentially hazardous materials to be used as part of activities taking place on the National Mall, such as cleaning solvents, glycol, rubber cement, rubbing alcohol, and so on.

Section 11. Moveable Features

Teams planning to move or transform major components of their houses beyond the setup and teardown phases are required to obtain special approval from a Solar Decathlon organizer. Possible design features meeting this description include large, unusual, and potentially dangerous features, such as moveable rooms and walls, changeable façades, collapsible spaces, and folding beds. This requirement does not apply to smaller, more typical house features that may be reconfigured, such as awnings, operable windows and window coverings, and doors. The following rules apply to qualifying features:

- a. After the houses are assembled on the competition site, the Solar Decathlon organizer shall inspect every house and inform each team whether it has any qualifying features.
- b. Teams wanting to determine before the event whether their house has any qualifying features should contact sdbuild@nrel.gov
- c. The Solar Decathlon organizer cannot thoroughly evaluate the safety of a particular house feature until it is seen in operation; however, the safety officer will try to indicate with a reasonable degree of confidence whether certain features are subject to these rules.
- d. Qualifying features shall not be reconfigured during impound.
- e. Qualifying features shall not be reconfigured during public exhibit hours unless approved by the Solar Decathlon organizer. To receive approval, a team must:
 - i. Include in its Health and Safety Plan an explanation of how it will ensure safety during the movement of qualifying features.
 - ii. Demonstrate the successful execution of the safety plan for qualifying features at some point before public exhibit hours begin.
 - iii. Continue to demonstrate the successful execution of the safety plan for qualifying features during public exhibit hours.
- f. If, at any time, the Solar Decathlon organizers witness unsafe conditions, the movement of qualifying features during public tours may be prohibited for the duration of the event.
- g. Moveable features shall not create an obstruction to any fire suppression sprinkler that may be present within the buildings.