U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

2020 Design Challenge Rules

January 2020

List of Acronyms

AH	Attached Housing
ANSI	American National Standards Institute
Btu	British thermal unit
DOE	U.S. Department of Energy
ES	Elementary School
EUI	energy use intensity
HERS	Home Energy Rating System
HVAC	heating, ventilating, and air conditioning
kBtu	kilo-British thermal unit
MM	Mixed-Use Multifamily
NREL	National Renewable Energy Laboratory
OB	Office Building
RESNET	Residential Energy Services Network
SSF	Suburban Single-Family
USF	Urban Single-Family

Foreword—Why Solar Decathlon Design Challenge?

High-performance building design includes comprehensive building science, energy efficiency, optimized mechanical systems, indoor air quality, resilience, and water conservation. These attributes will ultimately determine whether buildings succeed or fail in terms of the human experience: affordability, comfort, health, durability, safety, and adequate resources. Yet, professional curricula across the United States and around the globe do not consistently provide students the skills needed to effectively integrate high-performance measures into their design, engineering, and construction management careers moving forward. Moreover, emerging crises related to affordability, health, disaster risks, and water shortages are making these skills an imperative at the same time that degree programs are working to effectively integrate them into their curricula. Enter the U.S. Department of Energy (DOE) Solar Decathlon® Design Challenge.

Starting in 2014, the focus was on two critical goals. First, to integrate high-performance design into degree programs; and second, to inspire students to choose sustainable building careers. Both metrics demonstrate substantial success toward these goals. This includes more than 150% growth in the number of teams registering for participation, feedback from faculty advisors suggesting more than 500% growth in the number of participating programs that have integrated the Design Challenge into their curricula, and endless engagement with participating students reinforcing how life-changing the competition experience has been, solidifying their commitment to sustainable building careers. A movement has started. The Solar Decathlon Design Challenge is helping to create the next-generation workforce with the skills and passion to build or retrofit future-ready buildings.

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Solar Decathlon Design Challenge Competition Rules Authors: NREL's Rachel Romero, Joe Simon, Zachary Peterson, and Paul Torcellini.

Solar Decathlon Design Challenge Rules

The Solar Decathlon is a collegiate competition, comprising 10 Contests, that challenges student teams to design highly efficient and innovative buildings powered by renewable energy. For more information, read the Solar Decathlon Competition Guide.

The Design Challenge encourages student participation for one or two academic semesters. Participants prepare creative solutions for real-world issues in the building industry. Qualifying teams complete a design project and attend Design Challenge Weekend, where they present their designs to a panel of industry expert jurors, compare their projects to those of other teams, learn from presentations by national thought leaders and collegiate peers, experience zero energy ready building design in-person by touring the National Renewable Energy Laboratory (NREL) facilities, and engage with a variety of organizations about careers related to high-performance buildings. Finalist teams are recognized at an Awards Banquet, and winning Project Presentations are published on the Solar Decathlon website. The competition and winners are promoted through a variety of media outreach efforts, which provide participants and their collegiate institutions an opportunity for national exposure. First and second place winners in each Division are offered an opportunity to share their design as part of the Solar Decathlon Build Challenge event at the 2020 Smithsonian Folklife Festival in Washington, D.C. Select winners may receive further invitations to present at industry conferences following Design Challenge Weekend. Collegiate institutions that participate in the Design Challenge are recognized as leaders who are producing career-ready professionals with cutting-edge skills. Industry partners who collaborate with teams gain national and local recognition and have the opportunity to interact with knowledgeable future design and construction professionals.

1 Summary of Important Dates

Please note the following key milestones for the 2020 Design Challenge:

- **July 31, 2019:** The 2020 Design Challenge Rules are released; information about the team application is available on the Solar Decathlon website. Teams can begin work as early as the release of the Rules.
    - After a team completes its application, the team is provided access to Design Challenge communications and resources, including an on-demand building science training course, topical webinars, and energy modeling software. An important tool for communication with teams is the Project Site, an online forum for participating students to receive timely information from organizers and access necessary resources.
- **November 5, 2019, 5 p.m. Eastern Standard Time (EST):** All teams must submit their team application on the Project Site by this deadline. The team application must indicate which Division the team wants to enter. All teams that complete and submit their team application by this deadline are accepted as participants.
    - Each team must pay a nonrefundable $100 fee and identify a faculty lead and a student team lead (if available).
- **November 26, 2019, 5 p.m. EST:** Teams can submit an optional five-page Project Introduction, as detailed in Section 6.1.
    - The optional Project Introduction, as detailed in Section 6.1, must be submitted via the Project Site.
    - Submissions are evaluated against criteria indicated in Section 6.1, and teams will receive feedback on project compliance.
- **January 31, 2020:** An updated Solar Decathlon Competition Guide is released.
- **February 18, 2020, 5 p.m. EST:** All teams must complete the Project Progress Report, confirm their Division selection, and indicate which team members have completed the building science training course online or have received an equivalency waiver from their faculty by this deadline.
    - The Project Progress Report, as detailed in Section 6.2, must be submitted via the Project Site.
    - Submissions are evaluated against criteria indicated in Section 6.2. Based on the Project Progress Report evaluation, up to eight teams per Division are invited to participate in the final competition.
    - All participating teams are encouraged to complete their designs and the associated submissions. One team member from each nonselected team may be invited to attend Design Challenge Weekend and present an optional Project Poster.

    - Design Challenge Weekend registration opens with the announcement of the finalist teams. Up to five students, along with one faculty lead and/or advisor from each team, may attend in person.
- **March 31, 2020, 5 p.m. Eastern Daylight Time (EDT):** Teams must submit their Project Report and Team Photos by this deadline.
    - The Project Report, as detailed in Section 6.3, must be submitted via the Project Site.
    - Design Challenge Weekend registration closes. On-site or late event registration will not be offered.
- **April 14, 2020, 5 p.m. EDT:** Teams must submit their Project Presentations (both Division and Grand Jury presentations), optional Project Posters, and optional Film Submission, as detailed in Sections 6.4, 6.5, and 6.6, respectively. Presentations are not accepted after this date.
- **April 17–19, 2020:** Finalist teams present to industry leaders at Design Challenge Weekend on the NREL main campus in Golden, Colorado, and participant teams present a poster of their project. Teams also participate in related competition weekend events. Design Challenge winners are announced.
- **May 29, 2020:** The Faculty Report, as detailed in Section 6.7, is due to the organizers via the Project Site.

2 Design Challenge Description

2.1 Task Overview

- ☐ Read the Design Challenge Rules and form a multidisciplinary team.
- ☐ Review 2019 winning team presentations, 2019 event photographs, and the Solar Decathlon website to inform efforts.
- ☐ Obtain access to the Project Site, where competition updates, including attachments, are posted regularly.
- ☐ Submit a team application and register all team members on the Project Site.
- ☐ Complete the on-demand building science training course online or receive confirmation from the team's faculty lead that equivalent training is provided as part of the student's curriculum.
    - The building science training coursework from world-renowned experts is provided at no cost to every team member.
    - When each team member registers on the Project Site, an email will be sent within five business days about accessing the training.
    - The curriculum includes topics such as enclosure fundamentals; rain control; air flow control; heat flow control; vapor and condensation control; roofs; ventilation and air pressure management; windows; durable, healthy, efficient housing; unique solutions (optional); multifamily/multiunit housing (optional); elementary schools (optional); commercial buildings (optional); OpenStudio® (optional); REM/*Rate*™ (optional); and buildings and the grid (optional).
- ☐ Engage with industry mentors to supplement existing knowledge or provide valued feedback.
- ☐ Study the resources provided in the Resources document in Appendix A.
- ☐ Attend All Teams Calls as advertised on the Project Site for technical, design, and competition guidance. These calls are also available as recordings posted to the Project Site if attendance is not possible.
- ☐ Design and document a project compliant with the requirements listed in these Rules.
- ☐ Consult the Solar Decathlon website and Project Site for updates and announcements.
- ☐ Submit all materials prior to the deadlines.

For communications and questions, email the organizers. The Design Challenge email is SDdesign@nrel.gov.

2.2 Developing a Team

Each team must be associated with a collegiate institution and include a faculty lead. The competition is open to all collegiate and degree-issuing institutions, including community colleges. International institutions are welcome to participate. Each team must have at least three students, with one student designated as the student team lead. Typically, the strongest teams are multidisciplinary, composed of students from a variety of degree programs, and include architecture and engineering students. Multiple collegiate institutions may combine to form

teams. A collegiate institution may only submit one team application per Division (see Section 3.1). A team may choose to have several internal groups of students complete designs and then submit only one project design at the submission deadline. The team application costs $100 per team in each Division and is nonrefundable. If a school has multiple teams compete in the Solar Decathlon, across the Design and Build Challenges, each team must have distinct designs. Students are limited to one team for the competition year of the Design Challenge. A faculty advisor may counsel multiple teams. At Design Challenge Weekend, each finalist team is expected to send at least one student and one faculty advisor to the competition. A finalist team may send up to six team members total, including one spot reserved for a faculty advisor.

If a team member who is not a U.S. citizen wants to participate in person at Design Challenge Weekend events held on the NREL campus, he or she must submit a Foreign National Data Card. Additional information and requirements are provided upon registering on the Project Site. These requirements are subject to change, and NREL will follow the latest federal guidance.

2.3 Student Qualifications

Great teams are cross-functional. Student team members can be from any discipline and any level of collegiate schooling. Teams may also include students from more than one university. Past teams have included students who majored in fields such as architecture, engineering, building science, construction management, interior design, marketing, business, communications, management, and landscape architecture. Each student must be pursuing a degree and enrolled in at least one class at a participating collegiate institution at the time of Design Challenge Weekend.

2.4 Faculty Lead Role

The faculty lead, with assistance from the student team lead, is responsible for communicating competition details from the organizers to the team members. A team may have more than one faculty advisor; a faculty advisor may counsel multiple teams. However, one faculty lead must be designated to serve as a primary contact, oversee and closely engage with the team, and provide support in the following areas:

- Ensuring familiarity with the Design Challenge Rules and guidance, as appropriate.
- Making sure that all student team members complete the building science training. The faculty lead must ensure that the team meets this requirement or indicate that building science is part of the core curriculum by providing an equivalency waiver. Also, by understanding the strengths of the students, the faculty lead can encourage the students to view additional webinars and access training materials that are most relevant to the team.
- Ensuring that the necessary information is provided to team members who will be on-site at Design Challenge Weekend. The faculty advisors may attend the competition in person or join the presentation remotely, subject to participant constraints outlined in Section 3.3.

2.5 Industry Engagement

Industry engagements are encouraged to provide a market-ready perspective for proposed solutions and to provide guidance for selecting and integrating building systems into the design. Successful teams often engage with industry professionals who have a wide range of expertise,

such as builders, architects, city officials, contractors, developers, energy auditors, engineers, manufacturers, and tradespeople in areas such as site development, codes, construction, building materials, mechanical systems, lighting systems, financing, and sales. This engagement can help inform the teams' decision-making processes and aid in the review of the project. Industry may provide support, donations, and guidance to students while the students remain responsible for design, detailing, documentation, construction, operation, and competition activities.

2.5.1 Design Partners Pilot Program

The Design Partners pilot program is an optional opportunity for teams to collaborate with organizations that are considering a zero energy ready design for a planned or existing building project. Teams will receive basic project information and requirements, and up to 30 hours of engagement from the Design Partner for activities including design charrette participation, design feedback, and requirements refinement over the course of the competition. The organizers will post a limited number of project profiles from participating Design Partners describing project elements, including project type, location, and requirements. A representative from each Design Partner organization may also attend Design Challenge Weekend at NREL. Design Partner project proposals and additional information about the program are posted on the Solar Decathlon website.

3 Design Challenge Project Requirements

Designs should represent a high-performance building so energy efficient that a renewable energy system could offset all the building's annual energy consumption. Along with achieving this level of performance, teams must demonstrate the effective integration of building science principles and best practice guidelines for the building enclosure and mechanical systems.

Designs should meet the following specifications:

- Teams may develop an original design or chose to retrofit or modernize an existing building. Eligible scenarios are varied, though the submission must conform to the listed conditions. Projects must be substantially different from any submitted to DOE competitions in the past.

- Buildings are often subject to local, state, and national codes or standards governing topics such as minimum bedroom size, fire protection requirements, classroom size, and restroom locations and quantities, along with other specific requirements. Teams should follow applicable codes for the building's jurisdiction. If there are conflicts between the Design Challenge conditions and local regulations, the local regulations supersede, and teams should clearly document these local requirements in their project submissions.

- English units of measurement are preferred; however, a submission with metric units and English units is acceptable. If metric units are used, state metric units first, followed by English equivalents in parentheses. Example: 38.1 meters (m) (125 feet [ft]).[1] While not required, it is helpful to the jurors that units be provided, especially for R-values and U-factors.

3.1 Design Challenge Divisions

Teams participating in the Design Challenge compete in one of six Divisions. In all Divisions, maximizing energy performance of the designed building is critical to success. Energy efficiency decisions significantly impact virtually all design decisions and submissions associated with the project. Project designs state a specific location, building lot or site, and local characteristics as context for the building design and its relationship to surrounding structures and the community.

Each collegiate institution may submit up to six applications, but may ***not*** have more than one team in any Division. Only one design per team may be submitted to the organizers at the Project Progress Report and Project Report deadlines. If more than one is submitted, the organizers will review only the last-received file up to the submission deadline from that team. Any school that has multiple teams must have substantially different designs for each, regardless of Challenge or Division.

Renewable energy should be evaluated and integrated into the project in some form, but it is not required to be on-site. If on-site generation is not feasible, other options—such as solar ready construction for future installation, participating in a community-scale renewable energy project,

[1] For quick online conversions of metric to English units of measurement, see the Digital Dutch Unit Converter or the Internet French Property Measuring Units Converter Table.

specifying utility-provided renewable power, or purchasing offsets—should be considered, and the associated costs should be factored into the financial analysis.

Suburban Single-Family (SSF)

The parameters for the Suburban Single-Family (SSF) Division of the Design Challenge are:

1. Building size: 1,000–3,000 square feet (ft^2) (93–279 square meters [m^2])
2. Lot size: at least 4,000 ft^2 (372 m^2)
3. Meets or exceeds the DOE Zero Energy Ready Home National Program Requirements (Rev. 07).

Urban Single-Family (USF)

The parameters for the Urban Single-Family (USF) Division of the Design Challenge are:

1. Building size: 300–2,500 ft^2 (28–232 m^2)
2. Lot size: up to 5,000 ft^2 (465 m^2)
3. Meets or exceeds the DOE Zero Energy Ready Home National Program Requirements (Rev. 07).

Attached Housing (AH)

The parameters for the Attached Housing (AH) Division of the Design Challenge are:

1. Row homes or flats, 2–12 dwelling units; building is up to three stories above grade
2. Building size: 500–2,500 ft^2 (46–232 m^2) per dwelling unit
3. Lot size: up to 3,000 ft^2 (279 m^2) per dwelling unit
4. Meets or exceeds the DOE Zero Energy Ready Home National Program Requirements (Rev. 07).

Mixed-Use Multifamily (MM)

The parameters for the Mixed-Use Multifamily (MM) Division of the Design Challenge are below. MM is defined as a blend of residential and commercial building area.

1. Minimum of eight dwelling units; building is 3–5 stories above grade
2. Building size: 350–2,000 ft^2 (33–186 m^2) per dwelling unit
3. Lot size: no minimum or maximum
4. Dwelling units meet or exceed the DOE Zero Energy Ready Home National Program Requirements (Rev. 07)
5. Between 80% and 90% of the building (by floor area) must be used for multifamily dwelling units. This includes circulation spaces required for the dwelling units, including common hallways and stairwells.

6. For the commercial portion of building, the source energy use intensity (EUI) must be less than the source EUI target shown in Section 3.2. As an alternative, the entire building can comply with the source EUI target as shown in Section 3.2.

Elementary School (ES)

The parameters for the Elementary School (ES) Division of the Design Challenge are below. An ES is defined as a complete educational facility for students in kindergarten through fifth grade, and it includes permanent provisions for a cafeteria; gym; offices; classrooms; and other support functions, such as mechanical spaces, circulation, and restrooms.

1. Occupancy: 300–600 students, equally distributed from kindergarten through fifth grade
2. Students per classroom: 20–30
3. Lot size: 15 acres (60,703 m^2) maximum
4. In addition to the classrooms, the following spaces must be included:
    i. Teacher work area (or lounge)
    ii. Office/administration area
    iii. Gym/recreation area
    iv. Music room
    v. Art room
    vi. Library/media center
    vii. Cafeteria, which could be combined with the gym/recreation area, if desired
    viii. Kitchen/service area, which could be used for light food preparation without cooking or ventilation requirements, if desired.
5. The source EUI target before renewables must be less than that shown in Section 3.2.

Office Building (OB)

The parameters for the Office Building (OB) Division of the Design Challenge are below. An OB is defined as a complete commercial facility with full fit and finish for a defined client(s), including support functions such as mechanical and electrical spaces, circulation, vertical transportation, and restrooms.

1. Building size: 30,000–250,000 ft^2 (2,787–23,226 m^2) comprising 2–15 stories
2. 250–350 gross ft^2 (23–33 m^2) per person
3. Lot size: up to five acres (20,234 m^2)
4. In addition to the office area, the following spaces must be included:
    i. Lobby
    ii. Conference rooms
    iii. Copy/print facilities and mail sorting
    iv. Loading dock and associated janitorial as well as waste disposal services

v. Break rooms with kitchenettes.

5. The source EUI target before renewables must be less than that shown in Section 3.2.

3.2 Additional Information for Evaluating Building Energy Performance

Energy efficiency analysis can be conducted through a variety of software programs. Tools and resources for these calculations are provided in Appendix A. Modeling tools are invaluable for predicting energy performance and evaluating trade-offs to achieve energy goals. The major focus of this competition is a goal of zero energy ready while creating an attractive and effective design.

Total Area

A dwelling unit, as defined by the 2018 International Energy Conservation Code, is a single unit that provides complete independent living facilities for one or more people, including permanent provisions for living, sleeping, eating, cooking, and sanitation. Total area compliance should be verified using Square Footage—Method for Calculating: American National Standards Institute (ANSI) Z765-2003 (R2013), which states that the finished area is the sum of the finished and conditioned areas measured at the floor level to the exterior finished surface of the outside walls.

For commercial buildings, gross area is calculated as the total conditioned space within the exterior dimension of the finished space enclosed by the outside walls.

Home Energy Rating System Index

The residential building industry commonly uses the Home Energy Rating System (HERS) Index to indicate energy efficiency. A lower score signifies a more energy-efficient home. To determine the score, homes are compared to a benchmark based on the 2006 International Energy Conservation Code. The HERS score can be calculated by using any Residential Energy Services Network (RESNET) accredited HERS software.

HERS rating software calculates heating, cooling, hot water, lighting, and appliance energy loads, consumption, and costs for new and existing single-family and multifamily homes. One of the RESNET-accredited programs, REM/*Rate*, is provided to teams at no charge after completing the team application; however, using it is not required.

Energy Use Intensity

Building energy consumption is often evaluated based on the EUI, which is measured as the total energy consumed annually divided by the gross floor area (kilo-British thermal unit [kBtu]/ft^2 or kilowatt-hours/m^2). These numbers can be calculated with respect to source energy as well as site energy. Site energy is measured at the boundary of the site, often by electric or natural gas meters. Source energy accounts for all the upstream losses associated with converting and transporting energy to the building site. It is calculated by taking the site energy and applying a site-to-source multiplier for each energy source.[2] In the case of electricity, it is based on a fuel mix and the mining/extraction of those resources, the power plant losses, and the losses with

[2] See "A Common Definition for Zero Energy Buildings" for calculating EUI.

transmission and distribution of electricity. Alternative metrics for comparison are also useful, such as energy divided by total students (kBtu/student) for the Elementary School Division.

Target EUIs based on source energy for Elementary Schools, Mixed-Use Multifamily, and Office Buildings are shown below in Table 1. These EUI values include all building loads, including plug loads; heating, ventilating, air conditioning (HVAC); and lighting. Plug loads include vertical transportation and any other load in the building. The targets do not include exterior lighting loads, which are covered in Table 2.

Table 1. Source Energy[3] Use Intensity Targets for Elementary Schools,[4] Mixed-Use Multifamily Buildings with a Commercial Retail or Office Space,[5] and Office Buildings[6]

Climate Zone	Elementary School Source EUI (kBtu/ft²·yr)	Mixed-Use Multifamily[7] Source EUI (kBtu/ft²·yr)	Office Building Source EUI (kBtu/ft²·yr)
0A	69	80	80
0B	71	96	96
1A	66	81	81
1B	67	89	89
2A	64	77	77
2B	60	79	79
3A	57	74	74
3B	58	73	73
3C	53	55	55
4A	56	75	75
4B	55	71	71
4C	52	60	60
5A	57	80	80
5B	56	79	79
5C	50	61	61
6A	63	96	96
6B	58	86	86
7	66	88	88
8	71	100	100

[3] For the calculation methodology on calculating source energy from site energy, see https://buildingdata.energy.gov/cbrd/resource/1938.

[4] This is adapted from the "Advanced Energy Design Guide for K–12 School Buildings: Achieving Zero Energy"; see https://www.ashrae.org/technical-resources/aedgs.

[5] This is based on a simulation result for office and light retail. Documentation is not available at this time.

[6] This is based on preliminary simulations from "Advanced Energy Design Guide for Small to Medium Office Buildings: Achieving Zero Energy," see https://www.ashrae.org/technical-resources/aedgs/50-percent-aedg-free-download.

[7] EUI values for Mixed-Use Multifamily can be applied to either the commercial portion of the space or the entire building, including vertical transportation, common areas, plug loads, HVAC, and lighting.

Table 2. Exterior Lighting Allowances for Mixed-Use Multifamily, Elementary Schools, and Office Buildings

Exterior Location	Lighting Power Allowance	Controls
Entry doors	13 watts/linear foot of doorway	Dusk to dawn, reduction of 75% when no motion detected
Exterior stairs	0.70 watt/ft^2	Dusk to dawn, reduction optional depending on local codes
Walkways	0.10 watt/ft^2	Dusk to dawn, reduction of 75% when no motion detected
Driveways and parking lots	0.04 watt/ft^2	Dusk to dawn, reduction of 75% when no motion detected

3.3 Design Challenge Weekend Details

Based on the quality of the Project Progress Reports submitted in February 2020, up to eight Design Challenge finalist teams in each Division will be invited to attend and compete at Design Challenge Weekend, to be held in April at NREL in Golden, Colorado. This event provides a rich experience for on-site participants to engage in networking opportunities and attend other team and professional presentations. Each team is expected to send at least one student and one faculty advisor to the competition. A team may send up to six team members total, including one spot reserved for a faculty advisor.

Teams who complete their designs and the final submissions, even if not selected to compete at Design Challenge Weekend, are invited to have ***one team member attend Design Challenge Weekend and present an optional Project Poster.***

All students who are on-site are encouraged to participate in the team presentation; faculty may not participate in the team presentation.

The organizers do not provide financial assistance for lodging or travel expenses. However, a block of rooms is available at a discounted rate at a hotel near the NREL campus. Meals and snacks will be provided at no cost over the weekend thanks to the generosity of event sponsors. More information will be provided via the Project Site prior to the event.

When registering for Design Challenge Weekend, teams are expected to indicate interest in bringing an architectural-scale model, wall section, or related exhibit. The exhibits may be on display during the team's Division presentation, the Poster Session, and if applicable, the Grand Jury Presentation. Exhibits should be stand-alone and not require power or additional supplies for display. These exhibits are optional; all shipping/transportation costs are the responsibility of the teams.

4 Design Challenge Contests

Teams submitting projects to the Design Challenge demonstrate competency by applying principles of building science and best-practice solutions. Teams are assessed on their Project Report submissions, including design and technical documentation, project plans, reports on required analyses, and the quality and content of their presentations. These submissions should demonstrate the team's ability to design, analyze, and plan for the construction of quality, high-performance buildings.

The jurors evaluate how well teams meet or exceed each Contest criterion and complete the requirements of the project submission.

The project submissions are evaluated by jurors according to the 10 Contests in Table 3. All Contests are equally weighted. More details on each Contest are provided in the following sections (Sections 4.1 through 4.10).

Table 3. Contests

Contests
1. Energy Performance
2. Engineering
3. Financial Feasibility & Affordability
4. Resilience
5. Architecture
6. Operations
7. Market Potential
8. Comfort & Environmental Quality
9. Innovation
10. Presentation

4.1 Energy Performance

Contest Intent

This Contest evaluates the building's energy use and production, as well as its capability to provide energy services—whether connected to the electricity grid or operating with on-site and/or stored power.

Superior energy performance is at the heart of the Solar Decathlon. Energy modeling can help inform design choices as well as estimate a building's likely energy performance. Energy performance is verified by measuring building loads and on-site generation. The capabilities of the building to interact with the grid, and potentially address the needs of a local electric utility, are also part of its overall energy performance. Finally, thoughtful selection and operation of lighting, plug loads, appliances, and other components are increasingly important, because they commonly represent more than 50% of total energy consumption in high-performance buildings.

Evaluation Criteria

The jury evaluates teams on each of the following:

- Comprehensive energy analysis showing energy performance targets will be achieved (i.e., HERS and/or EUI), including calculations with and without renewable energy[8]
- Seamless integration of energy systems into architectural design
- Discussion of lighting system effectiveness, including ability for daylighting and electric lighting to provide ambient, task, and mood lighting
- Strategy for reducing plug loads and appliance loads
- Grid-interaction capabilities to include responsiveness of building systems to electric grid conditions to avert system stress and enhance grid reliability
- Strategies for effectively integrating sufficient renewable energy generation (on-site or off-site) to achieve zero annual energy use and offset nonrenewable energy sources.

4.2 Engineering

Contest Intent

This Contest evaluates the effective integration of high-performance engineering systems in energy-efficient and energy-producing buildings.

Structural and engineering systems should be effectively integrated with natural heating and cooling opportunities, including solar orientation, thermal mass storage, solar shading, and convective cross-ventilation. Heating, cooling, water, and ventilating system types and designs should reflect thoughtful consideration of different technology and integration options, including analysis of implications for energy and environmental performance, up-front and long-term costs, and reliability. The space-conditioning system must be designed to maintain comfort with extremely low-load conditions via effective temperature control, humidity control, air mixing, and distribution systems. Opportunities for water efficiency should be reflected in smart engineering solutions for domestic hot water delivery and landscaping irrigation, as well as selection of plumbing fixtures and landscaping.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Building enclosure integration of all four building science control layers (e.g., thermal, air, bulk moisture, and moisture vapor), including foundation, walls, roof, and openings
- Space-conditioning system integration within the building's structural system
- System configuration of building electrical systems with on-site generation and storage equipment (if applicable)
- Plumbing system layout for efficient hot water delivery to minimize wait time, losses, and wasted water

[8] For residential buildings, use a HERS score. For commercial buildings, use the EUI. Mixed-use multifamily buildings should use both methods for their specific building.

- Selection of water conservation fixtures, estimated loads, supply piping, rainwater or gray water systems, and landscaping systems for minimizing water use
- Engineering systems are thoughtfully integrated into the building's architectural design.

4.3 Financial Feasibility & Affordability

Contest Intent

This Contest evaluates the building's financial costs and ability to address growing affordability challenges in the housing industry.

The purpose of this Contest is to ensure that the team's unique solution is affordable and cost-effective for occupants. Financial analysis should include up-front cost to the consumer, monthly utilities, and maintenance to determine an overall cost of ownership and provide a basis for comparison to the financial capabilities of the target market. The cost of construction, and the extent to which the design would cost more than a minimally code-compliant building, should be carefully considered and justified.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Construction cost of the design and the cost relationship to the target market
- Life cycle cost comparison between a minimally code-compliant building to the proposed design
- Financial feasibility analysis and understanding of affordability in the target market as presented to the consumer
- Operational and maintenance cost estimate.

4.4 Resilience

Contest Intent

This Contest evaluates the building's ability to withstand and recover from prevailing disaster risks for its intended location, maintain critical operations during grid disruptions that commonly occur post-disasters, and ensure long-term durability in response to local climatic conditions.

Resilience is the ability to anticipate, withstand, respond to, and recover from disruptions. The benefits of investing in highly efficient buildings are protected by also investing in resilient design. Buildings must demonstrate how they effectively address these challenges.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Analysis of the prevailing resilience risks associated with weather, natural or man-made events, and grid disruptions
- Identification of building design and construction strategies to withstand and recover from identified resilience risks

- Integration of these resilience strategies for mitigating location-specific risks into the building's design, including design details and construction practices
- Recovery plan to sustain critical operations after a disaster event or supply outage.

4.5 Architecture

Contest Intent

This Contest evaluates the building architectural design for its creativity, overall integration of systems, and ability to deliver outstanding aesthetics and functionality along with energy-efficient performance.

Cutting-edge energy-efficient building performance is better positioned to achieve market acceptance if integrated into architectural designs that creatively meet or exceed aesthetic and functional expectations of both industry and consumers. Specifically, good design marries aesthetics with sound building science, energy efficiency, natural comfort (e.g., glare-free views, natural heating, natural fresh air, and natural lighting), energy production, and resilience.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- A strong conceptual strategy executed as a compelling, integrated design
- Potential to influence or inspire subsequent designs for the project type
- Integration of building form and function, including exterior and interior architecture with respect to the target market
- Quality of the design and project appearance, including floor plan and interior details for flow, furnishings, storage, linkages to outdoors, and efficient use of space
- Architectural design that integrates climatic considerations toward achieving zero energy ready goals
- Consideration of specified site, including views, drainage, regionally appropriate materials, and community connection.

4.6 Operations

Contest Intent

This Contest evaluates how effectively and efficiently the building operates to carry out intended functions while also ensuring persistence of performance.

Building systems, appliances, and features should be thoughtfully selected and integrated into the overall design. Buildings should incorporate creative and technical solutions that work seamlessly with energy efficiency and energy production strategies. This includes strategies for persistence of performance (e.g., efficiency, comfort, health, safety, and durability) that address operation limitations of typical occupants.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Strategies for minimizing occupant maintenance
- Advanced smart building control technologies for appliances, equipment, security, and lighting systems that provide comfort, convenience, and safety
- Incorporation of technologies and operational strategies to improve grid interaction
- Appliance (e.g., kitchen, hot water, laundry, lighting) selection and design integration for optimum efficiency and convenience.

4.7 Market Potential

Contest Intent

This Contest evaluates the building's responsiveness to its stated target market, likely appeal to intended occupants and construction industry, and ability to transform how energy is used in buildings given its approach and wide-scale desirability.

To ensure uptake in the market and drive both demand and supply, effective energy-efficient designs take into account the interests of intended building occupants and owners as well as the construction industry. On the consumer side, designs should reflect how occupants can best use and enjoy the built environment and accommodate potentially changing preferences of occupants over time. On the supply side, a successful design will consider how to reduce construction cycle time, ensure outstanding quality, and improve construction productivity. It will also include construction documentation that helps ensure best practices and quality workmanship.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Design's functionality, attractiveness, and enhancement of the occupants' quality of life, health, and well-being
- Application of market-ready construction materials and practices that allow zero energy ready buildings to be adopted at scale, including enhanced affordability, productivity, quality, and solutions for current labor shortage
- Use of design solutions that meet current market expectations for owner experience
- Execution of market analysis and integration of key findings in design
- Ability to replicate design and concepts to a large market.

4.8 Comfort & Environmental Quality

Contest Intent

This Contest evaluates the building's capability to integrate comfort and indoor environmental quality with energy-efficient performance.

Well-designed buildings provide both a comfortable and healthy indoor environment. For occupants to be comfortable, the building must be able to control temperature and relative humidity levels, as well as reduce disturbances from interior and exterior sources of noise. To provide a healthy indoor environment, the design must include a comprehensive approach to

indoor air quality that incorporates ventilation, filtration, dilution, and material selection strategies.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Effective use of passive design strategies to meet heating, cooling, ventilation, and lighting needs
- Complete indoor environmental quality strategy, including HVAC system design, load calculations, equipment sizing, and duct sizing
- Comprehensive source control (e.g., chemicals, dust, pollen, biologicals, radon, and moisture) through material selection, details, and construction practices
- Whole-house ventilation and strategies for spot ventilation (e.g., controlling moisture in bathrooms as well as moisture and particulates from cooking in kitchens) and filtration (e.g., high-capture filters)
- Acoustical design strategies for controlling unwanted interior and exterior noise.

4.9 Innovation

Contest Intent

This Contest evaluates the design's success incorporating innovations and/or creative approaches that enhance energy efficiency, energy production, grid interaction, and building operations, as well as overall functionality and appeal.

Effective designs incorporate innovations that can be embraced by the construction industry and consumers on a large scale. Teams are encouraged to find solutions that use innovative technologies as well as other creative measures to improve building operations and desirability.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Overall ability for design to effectively enhance the life of intended occupants
- Application of innovations to improve quality, cost, and productivity
- Validation of innovation, including feasibility and long-term impacts, through collaboration with industry
- Alignment of innovations with project intent and needs of the target market
- Analysis of innovation technology and its ability to move to a wide-scale adoption, if successful.

4.10 Presentation

Contest Intent

This Contest evaluates the team's ability to accurately and effectively convey its design and energy performance strategy to relevant audiences.

The value proposition of energy efficiency and renewable energy opportunities must be clearly conveyed to industry leaders and the public at large. A smart design on its own is insufficient. Presentation quality can dramatically affect market perception and the likelihood of innovation adoption.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Completion, quality, and timeliness of Project Report submission
- Quality of presentation package, spoken remarks, and any visual aids (if applicable)
- Ability to prioritize and convey key points about creating a zero energy ready building with enough detail to be convincing that the project will achieve its goals
- Completeness and professionalism of presentation within the 25-minute time limit
- Command of the design solution through effective response to juror questions.

5 Design Challenge Evaluation Process

The evaluation process is multifaceted and includes the following:

- Division juries (each with 3–5 jurors) assess the team designs.
- One jury convenes for each of the Divisions. Each juror reviews up to eight Project Reports within his or her assigned Division.
- Division jurors individually determine preliminary evaluation results based on the Project Reports.
- Preliminary team evaluation results are modified by the jurors based on the Project Presentations and associated question-and-answer period.
- Division juror panels select first-place, second-place, and honorable mention award winners in each Division based on the following attributes:
    - Excellence in design intent of the competition
    - Excellence in the Contest criteria subject areas.
- Each first-place team delivers an 8-minute short version of its full presentation at the Awards Banquet for evaluation by the Grand Jury, which chooses two Grand Winners according to the process described in Section 5.2.
- Division jurors develop written feedback for the teams that is shared with the teams within 2 weeks of Design Challenge Weekend's conclusion.

5.1 Evaluation Rating Scale

The jury scores each Contest according to the following scale:

Table 4. Evaluation Scale

0-1	MISSES EXPECTATIONS: Missing all items; no explanation of how the design addresses the criteria
2-3	APPROACHES EXPECTATIONS: Missing some items; minimal explanation of how the design addresses the criteria
4-5	MEETS EXPECTATIONS: All minimum requirements met; acceptable explanation of how the design addresses the criteria
6-8	EXCEEDS EXPECTATIONS: All minimum requirements met; full demonstration of how the design solution addresses the criteria
9-10	ECLIPSES EXPECTATIONS: All minimum requirements met; distinguished excellence in the explanations describing how the design exceeds the criteria

5.2 Grand Jury Award

The Grand Jury selects two Grand Winners from among the first-place teams based on the 8-minute presentations given at the Awards Banquet. One Grand Winner is selected from the residential Divisions, including SSF, USF, and AH; the other is selected from the commercial Divisions, including MMF, ES, and OB.

The Grand Jury enters the review process with the understanding that all the first-place winners have demonstrated a design that represents the quality expected for zero energy ready buildings.

The Grand Jury is tasked with evaluating which projects are most inspiring. The 8-minute summary presentations are evaluated against the following criteria:

- Level of inspiration
- Attractiveness to the team-defined target market
- Financial feasibility
- Responsiveness of design to community, occupant, and climatic factors
- Architectural design aesthetics and functionality
- Constructability
- Innovation
- Presentation quality within 8-minute time limit.

The Grand Jury evaluates each of these criteria on the scale shown in Table 4 to facilitate its selection of the Grand Winners.

5.3 Bonus Awards for Creativity

Bonus awards are given in addition to the Grand Winner awards and the Division awards. These awards are intended to recognize excellence, professionalism, hard work, and enthusiasm that teams provide beyond the required deliverables. These awards recognize:

- Best team spirit during Design Challenge Weekend
- Superb first-year team
- Best social media engagement
- Excellence in industry engagement
- Best exhibit at Design Challenge Weekend
- Excellence in Project Poster
- Fantastic Film Submission.

6 Design Challenge Deliverables

Throughout the Design Challenge, the organizers will require teams to submit deliverables necessary for evaluating teams' progress and design. The Design Challenge deliverables, file naming conventions, and due dates are listed in Table 5.

Table 5. Design Challenge Deliverables, File Naming Conventions, and Due Dates

Deliverable	Required Content	File Name	Due Date
Project Introduction (optional)	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_INTRO_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	Nov. 26, 2019, 5 p.m. EST
Project Progress Report	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_PROGRESS_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	Feb. 18, 2020, 5 p.m. EST
Project Report	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_REPORT_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	March 31, 2020, 5 p.m. EDT
Supplemental Documentation (optional)	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_SUP_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	March 31, 2020, 5 p.m. EDT
Project Images	Three images as files such as .jpg, .tiff, or .png	PHOTO1, PHOTO2, TEAMPHOTO e.g.: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_PHOTO1_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	March 31, 2020, 5 p.m. EDT
Division Presentation	PDF and/or PPTX	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_PRESDIV_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	April 14, 2020, 5 p.m. EDT
Grand Winner Presentation	PDF and/or PPTX	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_PRESGRAND_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	April 14, 2020, 5 p.m. EDT
Short Film (optional)	.mov or mp4	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_FILM_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	April 14, 2020, 5 p.m. EDT
Project Poster (optional)	Single, PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_POSTER_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	April 14, 2020, 5 p.m. EDT
Faculty Report	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_FACULTY_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	May 29, 2020, 5 p.m. EDT

See the following Sections 6.1 through 6.7 for the requirements for each Design Challenge deliverable, as well as instructions for their submission.

6.1 Project Introduction Submission Instructions

The Project Introduction communicates the salient points of the project to all competition participants. It should be considered a high-level summary to describe the project with key points.

Teams submit the optional Project Introduction first as a stand-alone document and then integrate it into the required Project Progress Report and the Project Report.

Teams use the Project Summary template for inclusion in the Project Introduction; past project summaries can be viewed on the history web page and an example is provided on the Project Site. The template uses filler text as a placeholder for the content that teams insert. It is understood that for the initial submission, the project details might be considerations, aspirations, or otherwise tentative and subject to change in future submissions.

Project Introduction Format Requirements

☐	Paper size: Standard 8.5 inches (in.) × 11 in. (216 millimeters [mm] × 279 mm), ANSI A
☐	Formatting: Single-spaced, 11-point font for body text (diagrams may have smaller fonts)
☐	Borders: 0.5-in. (12.7-mm) minimum, except for tables, figures, and images
☐	Maximum page length: Five
☐	File type: Single, bookmarked PDF
☐	File size: Less than 10 MB
☐	File name: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_INTRO_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]

(Continued)

Project Introduction Content Requirements

Project Summary (two-page maximum for all submissions)	
☐	List the project name, team name, Division, and collegiate institution(s) in the header.
☐	Replace the logo in the upper right with the team or collegiate institution's logo.
☐	Replace the building image with one or two graphics that best represent the project.
☐	Provide a concise description of the project, including a brief identification of the target market.
☐	Describe the relevance of the project to the goals of the competition.
☐	Summarize the design strategy and relevant key points.
☐	List the relevant project data, including cost estimates.
☐	Provide technical specifications for the project.
☐	Provide project highlights. Briefly explain how the design meets or exceeds the criteria in each Contest: 1. Energy Performance 2. Engineering 3. Financial Feasibility & Affordability 4. Resilience 5. Architecture 6. Operations 7. Market Potential 8. Comfort & Environmental Quality 9. Innovation.
Team Information (up to one page)	
☐	Include an academic institution profile with particular focus on building science coursework, extracurricular activities, and/or resources.
☐	Include the names of the student team members, their academic majors, and levels; identify the student team lead.
☐	Include a summary of industry partners and their form of support.
Additional Information (as available, up to two pages)	
☐	Note the structural and mechanical systems or approach.
☐	Include floor plans, exterior renderings, and/or interior renderings.
☐	Provide a timeline of team's next steps for completion of competition deliverables.

Feedback Criteria

The organizers provide feedback on the following:

- Compliance with Division definition
- Submission formatting compliance.

6.2 Project Progress Report Submission Instructions

The Project Progress Report provides an interim submission to demonstrate the team's progress toward completing the Project Report and likelihood of a complete design and submission at the Project Report deadline. It includes an updated Project Introduction with additional project information and details. If a team conducts an internal competition and creates multiple projects, only one Project Progress Report per team can be submitted and reviewed for acceptance as a finalist team. Teams submit the Project Progress Report via the Project Site.

Teams also submit this Project Progress Report, including a further refined Project Introduction, as part of the Project Report.

Project Progress Report Format Requirements

☐	Paper size: Standard 8.5 in. × 11 in. (216 mm × 279 mm), ANSI A
☐	Formatting: Single-spaced, 11-point font for body text (diagrams may have smaller fonts); add page numbers for reviewer convenience
☐	Borders: 0.5-in. (12.7-mm) minimum, except for tables, figures, and images
☐	Maximum page length: No more than nine pages; the cover, back pages, and table of contents are not included in this count
☐	File type: Single, bookmarked PDF
☐	File name: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_PROGRESS_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]

Project Progress Report Content Requirements

Front Matter	
☐	Cover (list collegiate institution, team name, and Division name)
☐	Table of Contents
☐	List of Tables and/or List of Figures (as applicable)
☐	Project Introduction revised as necessary (up to five pages, see Section 6.1): o Project Summary o Team Information o Additional Information.
Design Constraints Description (one–three pages)	
☐	Summarize the lot location, size, shape, orientation, climate, and relationship to road(s).
☐	Summarize the intended occupants and their characteristics.
☐	Describe the neighborhood and/or community setting, including density, access to, and reliance on various transportation modes.
☐	Describe how existing codes, standards, and programs influence the building's design and achieve competition goals.

(Continued)

Design Goals (one page)
☐ Summarize the goals the team considered when creating and developing the design.
Plans for Completing Project Deliverables (one page, not to be included in Project Report)
☐ Summarize the building systems anticipated for the design.
☐ Provide a timeline of team's next steps for completion of competition deliverables.

Evaluation Criteria

The organizers evaluate the submissions according to the following criteria:

- Compliance with Division definitions
- Compliance with submission formatting
- Quality of target market description and associated design strategy constraints and goals, including local climate or building code constraints
- Consideration of the building science issues in the selected climate
- Level of inclusion and completion of content
- Quality of project design
- Other factors, such as geographic locations and technology choices, that help optimize program diversity and fairness
- Plan for completing the design and submitting final Project Report.

6.3 Project Report Submission Instructions

The Project Report provides a complete submission to be reviewed by jurors in advance of the competition. It includes an updated Project Introduction as well as construction details and Contest narratives. Only one Project Report per team is reviewed for each finalist team. Teams submit the Project Report and related Project Images via the Project Site.

Only the Project Report and the three specified Project Images are required. Organizers use images to recognize individual team performance, to integrate into event materials, or for outreach, as appropriate.

The Project Report is limited to 65 pages, including appendices, and must contain all the information the team deems essential to effectively communicate its competition solution to the jury. A summary and discussion of analytical results should be provided in the Project Report. Supporting information—such as detailed calculations or equipment data sheets—should be relegated to Supplemental Documentation. Citations may be in the team's chosen format, but they should be consistent throughout the submission. Supplemental Documentation is not required.

Project Report Format Requirements

Project Report and Supplemental Documentation
☐ Paper size: Standard 8.5 in. × 11 in. (216 mm × 279 mm), ANSI A
☐ Formatting: Single-spaced, 11-point font for body text (diagrams may have smaller fonts)
☐ Borders: 0.5-in. (12.7-mm) minimum, except for tables, figures, and images
☐ File type: Single, bookmarked PDF
Project Report (no more than 65 pages)
☐ Limit content to no more than 65 pages; the cover, back page, and table of contents are not included in this count
☐ Number pages; front-matter page numbers can use Roman numerals (e.g., i, ii, iii, etc.)
☐ Construction drawings: 11 in. x 17 in. (279 mm x 432 mm), ANSI B
File Name: • Project Report: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_REPORT_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]
Supplemental Documentation (not required; no more than 100 pages)
☐ Number pages
☐ Plan accordingly. Jurors evaluating submissions have a limited amount of time to review the entire submission. They might not read all of the Supplemental Documentation in detail, and they are not expected to open any hyperlinks contained within.
File names: • Supplemental Documentation: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_SUP_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]

(Continued)

Project Report Content Requirements

Front Matter
☐ Cover (list collegiate institution, team name, and Division name)
☐ Table of Contents
☐ List of Tables and/or List of Figures (as applicable)
Section 1: Project Progress Report (up to nine pages, see Section 6.2)
☐ Project Introduction, revised as necessary (up to five pages, see Section 6.1): o Project Summary o Team Information o Additional Information.
☐ Design Constraints Description (one–three pages)
☐ Design Goals (one page)
Section 2: Contest narratives, including relevant images and figures (up to 27 pages)
☐ 1. Energy Performance
☐ 2. Engineering
☐ 3. Financial Feasibility & Affordability
☐ 4. Resilience
☐ 5. Architecture
☐ 6. Operations
☐ 7. Market Potential
☐ 8. Comfort & Environmental Quality
☐ 9. Innovation.

(Continued)

Appendices
☐ A. Design renderings (up to five pages)
☐ B. Construction documentation highlights (up to 20 pages)
☐ a. Site plan
☐ b. Representative floor plan(s) with dimensions
☐ c. Building elevations
☐ d. Building sections, including building science control layers
☐ e. Interior details, including a rendered floor plan showing typical furniture layout and option details on finishes, cabinetry, and other fixtures
☐ f. Wall, window, door, floor, and roof details, including building science control layers, schedule, and specifications
☐ g. Mechanical plans and schedules,[9] indicating equipment locations and specifications as well as heating and cooling system capacity diagrams (Btu/hr·ft^2, tons/ft^2, or kilowatt/m^2)
☐ h. Plumbing plans and schedules,[9] including fixture locations, piping system layout and design, and equipment location and specifications
☐ i. Electrical and lighting plans and schedules,[9] including installed lighting (watt/ft^2 or watt/m^2) levels, control systems, and renewable systems.
☐ C. Energy performance (up to three pages) (HERS Index rating and/**or** EUI target)
☐ 1. HERS Index Rating Documentation Summary
☐ 1. Include the house size adjustment factor calculations as required for homes exceeding the area specified in the size adjustment factor table.
☐ 2. Perform a HERS Index analysis to include the home with and without the renewable energy system.
☐ 2. EUI Target Documentation Summary
☐ 1. Summarize major inputs for the energy model, including envelope characteristics, lighting power densities, plug load densities, HVAC sizing capacities, HVAC system efficiencies, and overview equipment schedules.
☐ 2. Demonstrate compliance with the Division definition. EUI should be provided in both site and source metrics. Show summary calculations of the potential for on-site or off-site renewable energy to offset the annual energy consumption of the building on a source basis.
Supplemental Documentation (optional)
☐ This is optional and might not be read in detail by jurors. This includes additional documentation to support the team's design goals and submission, such as energy analysis reports, financial analysis details, equipment specifications, quantity takeoffs, supplemental construction details, or supporting design calculations.

[9] Teams should indicate system type, size, and quantity; however, full system layout and specifications are not required.

Project Images
☐ Submit three images:
☐ Two (2) images that best represent the project, such as renderings, drawings, photographs of scale models, or other team-generated content.
☐ One (1) image of your team.
☐ Ensure all images have a minimum resolution of 1920 x 1080 pixels.
☐ Ensure the images have an aspect ratio of 16:9.
☐ Submit the images as files such as .jpg, .tiff, or .png.
☐ File names: • DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_PHOTO1_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION] • DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_PHOTO2_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION] • DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_TEAMPHOTO_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]

6.4 Project Presentations Submission Instructions

Each team develops two presentations for the competition event: Division and Grand Winner presentation. The Project Presentations are NOT submitted via the Project Site. Project Presentations are submitted via Box.

Project Presentation Format Requirements

☐	File type: PDF and/or PPTX (Ensure that presentation slides have an aspect ratio of 16:9.)
☐	To ensure that all electronically submitted materials work with the organizers' presentation computers, teams should embed all videos in the team submission. If videos are included, teams must notify the organizers at SDdesign@nrel.gov before arriving at the competition to ensure that the appropriate software is available to play the video.
☐	File sizes: • Division presentation: No maximum • Grand Winner presentation: 60 MB.
☐	File names: • Division presentation: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_PRESDIV_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION] • Grand Winner presentation: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_PRESGRAND_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]

Project Presentation Content Requirements

☐	Division presentation: A 25-minute presentation on the project to be delivered in person to the jurors during Design Challenge Weekend, with an additional 10 minutes for questions, for a total 35-minute team presentation.
☐	Grand Winner presentation: An 8-minute short version of the 25-minute presentation with no additional time reserved for questions. Only the first-place winners in each Division give this 8-minute presentation to the competition participants during the Awards Banquet.

6.5 Project Poster Submission Instructions

Each team may develop an optional Project Poster that showcases its design and response to Contest criteria. A Poster Session during Design Challenge Weekend displays all team projects. Project Posters are submitted via Box. Teams should print and bring their posters with them to Design Challenge Weekend.

Project Poster Format Requirements

☐	Size: 3 ft wide x 2 ft tall (0.9 m wide x 0.6 m tall)
☐	File type: PDF
☐	File name: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_POSTER_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]
☐	Teams should print their poster and bring it to the competition event, labeled with their collegiate institution and Division.

Project Poster Content Requirements

☐	Include the Project Summary information, at a minimum.
☐	Include additional information, graphics, and images as desired.

6.6 Film Submission Instructions

Teams can submit an optional short film, 3 minutes or less, to highlight how the design impacts the target market or talk about the team's experience with the Solar Decathlon. All content in the films, including graphics, must be original and may not include any copyrighted material. By submitting the video, the team grants the U.S. Department of Energy and the Solar Decathlon organizers the right to edit the video in alignment with Solar Decathlon branding and post to Solar Decathlon YouTube, including amplification through social media and other channels. Films are submitted via Box.

Film Format Requirements

☐	Length: 3 minutes or less
☐	File type: .mov or .mp4
☐	File name: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_FILM_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]

Film Content Requirements

☐	Describe the team's experience with the Solar Decathlon Design Challenge, lessons learned, and impact on stakeholders.

6.7 Faculty Report Submission Instructions

The Faculty Report should reflect the results of the team's Design Challenge project. It will be used by the organizers to improve future events and identify lessons-learned opportunities. Faculty Reports should be submitted via the Project Site.

Faculty Report Format Requirements

☐	File type: Single, bookmarked PDF
☐	Length: Up to 20 pages
☐	File name: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_FACULTY_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]

Faculty Report Content Requirements

☐	Summarize degree program(s) of the participating students.
☐	Summarize how the Design Challenge was integrated into coursework.
☐	Summarize the team perspective on the effectiveness of the organizers' communications efforts with both the teams and the public.
☐	Describe next steps for the team project, if applicable.
☐	Provide a short description of team members' future plans for employment, continued study, or other endeavors.
☐	Include suggested competition improvements.
☐	Include any other information that would be helpful to the organizers or future teams.
☐	Include a contact list of all team members who worked on the project, including permanent (noncollegiate institution) email addresses.

Glossary

Challenge
Each of two avenues of participation for Solar Decathlon Competition teams: the Design Challenge and the Build Challenge

Competition
All aspects of the Solar Decathlon related to the Challenges, the 10 Contests, and the scoring of those Contests within each Challenge

Contest
The Solar Decathlon competition consists of 10 separately scored Contests

Decathlete
A team member who meets the decathlete eligibility rules, as defined in Section 2.2 and 2.3

Design Challenge
A Challenge of the Solar Decathlon competition that tasks teams to design and present complete building designs

Design Challenge Manager
The head rules official responsible for writing and enforcing the Rules and conducting the Design Challenge

Design Partner
A client partner to the collegiate institution that presents a design challenge and customer for the team and their building

Director
The organizer representing the U.S. Department of Energy who has final decision-making authority regarding all aspects of the Solar Decathlon

Division Jury
A group of jurors evaluating a Division of the Build Challenge or a Division of the Design Challenge

Dwelling unit
A single unit that provides complete independent living facilities for one or more people, including permanent provisions for living, sleeping, eating, cooking, and sanitation

Elementary School
A complete educational facility for students in kindergarten through fifth grade that includes permanent provisions for a cafeteria; gym; offices; classrooms; and other support functions, such as mechanical spaces, circulation, and restrooms

Faculty advisor
A team member who is a faculty member and representative of a participating collegiate institution in the project

Faculty lead
A faculty advisor who serves as a primary contact for the team and is responsible for communicating competition details from the organizers to the team members, overseeing and closely engaging with the team

Faculty Report
A 20-page maximum Design Challenge deliverable that reflects the results of a team's Design Challenge project

Finished area
The sum of the finished and conditioned areas measured at the floor level to the exterior finished surface of the outside walls

Grand Jury
A group of jurors evaluating the first place Division Winners of the Design Challenge

Industry engagement
The team's involvement with industry professionals who offer expertise and experience to the project

Juror
An organizer selected by the appropriate Challenge Manager to participate as a member of a specific Division jury

Mixed-Use Multifamily
A blend of residential and commercial building area

Multidisciplinary team
An educationally diverse team that includes students from more than one field of study, including, but not limited to, engineering, architecture, graphic design, construction, interior design, and more

Office Building
A complete commercial facility with full fit and finish for a defined client(s), including support functions such as mechanical and electrical spaces, circulation, vertical transportation, and restrooms

Organizer
A DOE or NREL employee, subcontractor, juror, or observer working on the project

Project
All activities related to the U.S. Department of Energy Solar Decathlon

Project Introduction
A five-page optional deliverable for the Design Challenge deliverable that communicates the salient points of the projects to all competition participants

Project Poster
A Design Challenge deliverable that showcases a team's design and response to Contest criteria

Project Progress Report
A nine-page maximum Design Challenge deliverable that provides an interim submission to demonstrate a team's progress toward completing the Project Report and likelihood of a complete design and submission at the Project Report deadline

Project Report
A 65-page maximum Design Challenge deliverable that provides a complete submission to be reviewed by jurors in advance of the competition

Project Site
An online site that includes official communications suitable for viewing by all teams and organizers

Project Summary
A two-page summary of the Design Challenge project that gives key points of the design

Resilience
The ability to anticipate, withstand, respond to, and recover from disruptions

Rules
All principles or regulations governing conduct, action, procedure, arrangement, etc., for the duration of the project

Rules Official
An organizer authorized to interpret the Rules and officiate one or more of the Contests

Sponsor
A business or organization that provides funds for the competition

Staff
An individual working for the organizers whose role is not described elsewhere in these definitions

Team
The combination of team members representing a single entry to a Challenge of the competition

Team member
An enrolled student, faculty member, or other person who is affiliated with one of the participating collegiate institutions and is integrally involved with a team's project activities

U.S. Department of Energy Solar Decathlon
A collegiate competition, comprising 10 Contests, that challenges student teams to design and build highly efficient and innovative buildings powered by renewable energy

Appendix A: Resources

High-Level Resources

Professional Organization Websites

1. Air Conditioning Contractors of America (ACCA)

ACCA is a nonprofit association with a membership that includes more than 60,000 professionals and 4,000 businesses in the indoor environment and energy services community. ACCA works together to promote professional contracting, energy efficiency, and healthy, comfortable indoor environments.

2. The American Institute of Architects (AIA)

AIA is a member organization that advocates for the value of architecture and give architects the resources they need to do their best work. Their website has information on project awards, courses on trending topics, events, and various topics including building science and technology.

Resources include:

- AIA Committee on the Environment Top Ten Awards

  The Committee on the Environment (COTE) works to advance, disseminate, and advocate—to the profession, the building industry, the academy, and the public—design practices that integrate built and natural systems and enhance both the design quality and environmental performance of the built environment. The AIA's COTE oversees the annual Top Ten and Top Ten+ Project Awards. This site features winning projects from 1997 to 2016. Go to 2018 and 2017 to view the winners.

- AIA Construction Documentation Drawings (publication)

  13th edition, published in 2000 by Ernest L. Grigsby, AIA. Register to download the full document.

3. The American Institute of Architecture Students (AIAS)

AIAS is an independent, nonprofit, student-run organization dedicated to providing unmatched progressive programs, information, and resources on issues critical to architecture and the experience of education. AIAS aims to promote excellence in architectural education, training, and practice; to foster an appreciation of architecture and related disciplines; to enrich communities in a spirit of collaboration; and to organize students and combine their efforts to advance the art and science of architecture.

4. ASHRAE

ASHRAE is a diverse organization dedicated to advancing the arts and sciences of heating, ventilation, air conditioning, and refrigeration to serve humanity and promote a sustainable world.

Resources include:

- ASHRAE Advanced and Zero Energy Design Guides (publication)

  Free downloads (PDF). The Guides offer designers and contractors the tools needed for achieving significant energy savings compared to buildings that meet the minimum requirements of Standard 90.1-2004.

- ASHRAE Education & Certification Fundamentals of Air System Design

  This is an online, self-directed course to develop an understanding of the basics of air movement; the components of air distribution systems; considerations of human comfort; load and occupancy demand; duct system design; sound and vibration; and how codes and standards affect the design of air systems. Course pricing is available for members and nonmembers.

- Advanced Energy Design Guide – Achieving Zero Energy series (publication)

  This is an ASHRAE publication for small to medium office buildings as well as K–12 school buildings, and applies to all sizes and classifications (elementary, middle, high). This Guide establishes a set of energy performance goals for achieving zero energy. The goals are provided for all ASHRAE climate zones, in both site and source energy. Strategies on how to achieve these energy targets are provided throughout the guide.

- ASHRAE GreenGuide (publication)

  This is the complete 5th edition of the *Green Building Guidance from Planning to Operation*, available for purchase.

- ASHRAE Handbook—Fundamentals (Edition 2017) (publication)

  The ASHRAE Handbook is published in a series of four volumes, one of which is revised each year, ensuring that no volume is older than four years. Document is available for purchase or can be viewed online by subscribers.

- ASHRAE 10 Tips for Home Indoor Air Quality (publication)

  Downloadable PDF of tips that engineers have identified regarding ways to move air in and out of homes to minimize the factors that lead to indoor air quality problems.

- ASHRAE Standard 55—Thermal Environmental Conditions for Human Occupancy (document)

  Standard 55 specifies conditions for acceptable thermal environments and is intended for use in design, operation, and commissioning of buildings and other occupied spaces. Document is available for purchase.

- ASHRAE Standard 62.1-2016—Ventilation for Acceptable Indoor Air Quality and 62.2-2016—Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings (document)

  ANSI/ASHRAE Standards 62.1 and 62.2 are the recognized standards for ventilation system design and acceptable indoor air quality. Documents are available for purchase.

- ASHRAE Standard 90.1-2016—Energy Standard for Buildings Except Low-Rise Residential Buildings (document)

  Standard 90.1 has been a benchmark for commercial building energy codes in the United States and a key basis for codes and standards around the world for more than 35 years. Document is available for purchase.

- ASHRAE Standard 105-2014 (publication)

  This is the *Expressing, and Comparing Building Energy Performance and Greenhouse Gas Emissions* publication, available for purchase.

- ASHRAE Standard 189.1—Standard for the Design of High-Performance Green Buildings (document)

  Standard 189.1 provides total building sustainability guidance for designing, building, and operating high-performance green buildings. From site location to energy use to recycling, this standard sets the foundation for green buildings by addressing site sustainability, water use efficiency, energy efficiency, indoor environmental quality, and the building's impact on the atmosphere, materials, and resources. Document is available for purchase.

5. Association of Energy Engineers

AEE operates in the dynamic fields of energy engineering, energy management, renewables, power generation, energy services and sustainability. Website has membership information, as well as information on certification programs, and events.

6. Indoor Air Quality Association (IAQA)

IAQA is dedicated to bringing practitioners together to prevent and solve indoor environmental problems for the benefit of consumers and the public. Their website has membership information along with resources and access to training.

7. National Association of Homebuilders (NAHB)

NAHB is a professional association for home builders and remodelers that helps its members build communities. Create a login to sign in.

8. National Association of Realtors (NAR)

NAR is America's largest trade association, representing 1.3 million members, including NAR's institutes, societies, and councils. NAR is involved in all aspects of the residential and commercial real estate industries. Their website includes a link to the Homeownership Opportunities and Market Experience (HOME) Survey.

9. Urban Land Institute (ULI)

ULI is the oldest and largest network of cross-disciplinary real estate and land use experts in the world. Through its members' dedication to the mission and their shared expertise, ULI has been able to set standards of excellence in development practice.

U.S. Department of Energy

1. U.S. Department of Energy

The mission of the Energy Department is to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions.

Resources include:

- Advanced Strategy Guideline: Air Distribution Basics and Duct Design (publication)

  This is a Building Technologies Program 2011 publication (PDF).

- Achieving 50% Energy Savings in New Schools (document)

  This is a 2014 fact sheet (PDF) that summarizes recommendations for designing elementary, middle, and high school buildings that will result in 50% less energy use than conventional new schools built to minimum code requirements. The recommendations are drawn from the Advanced Energy Design Guide for K-12 School Buildings, an ASHRAE publication that provides comprehensive recommendations for designing low-energy-use school buildings.

- Building America: Bringing Building Innovations to Market

  The Building America Program has been a source of innovations in residential building energy performance, durability, quality, affordability, and comfort for 20 years. This world-class research program partners with industry (including many of the top U.S. home builders) to bring cutting-edge innovations and resources to market.

- Building America Strategy Guideline: Advanced Construction Documentation Recommendations for High Performance Homes (publication)

  This is a 2011 publication from the Building Technologies Program by A. Lukachko, C. Gates, and J. Straube.

- Building America Top Innovations Profile: Model Simulating Real Domestic Hot Water Use (document)

  This is a 2014 document from the Building Technologies Program.

- Building America Top Innovations

  New Top Innovations are awarded annually for outstanding Building America research achievements. Each year, Building America selects cutting-edge Top Innovations that demonstrate the value of investing in high-performance research

and development and guide the industry toward more energy-efficient, healthier, and longer lasting homes.

- Building America Solution Center

  The Building America Solution Center provides access to expert information on hundreds of high-performance construction topics, including air sealing and insulation, HVAC components, windows, indoor air quality, and more.

- Buildings Catalog

  These are helpful case studies of high-performance buildings.

- Building Science Education

  The Building America Program recognizes that the education of future design/construction industry professionals in solid building science principles is critical to widespread development of high-performance homes that are energy efficient, healthy, and durable. Website has a link to the 2013 Building Science Roadmap PDF.

- Commercial Buildings Resource Database

  Resources include:

  - Reducing Data Center Loads for a Large-Scale, Net Zero Energy Office Building
  - Technical Support Document: Development of the Advanced Energy Design Guide for Medium to Big Box Retail Buildings for 50% Energy Savings
  - Advanced Energy Retrofit Guide for K-12 Schools
  - A Common Definition for Zero Energy Buildings
  - Refrigeration Commissioning Guide for Commercial and Industrial Systems.

- Excellence in Building Science Education

  This Joint Committee on Building Science Education webpage provides information on programs/task groups and resources.

- Guidelines for Participating in the DOE Zero Energy Ready Home

  This program builds upon the comprehensive building science requirements of ENERGY STAR® for Homes Version 3, along with proven Building America innovations and best practices. Other special attribute programs are incorporated to help builders reach unparalleled levels of performance with homes designed to last hundreds of years.

  DOE Zero Energy Ready Homes are verified by a qualified third-party and are at least 40%–50% more energy efficient than a typical new home. This generally corresponds to a Home Energy Rating System (HERS) Index Score in the low- to mid-50s, depending on the size of the home and region in which it is built.

Also see the DOE Zero Energy Ready Home (virtual tour of Zero Energy Ready Homes across the Country and map of builders) and DOE Zero Energy Ready Home Recommended Quality Management Provisions (PDF document from April 2014) websites.

- Housing Innovation Awards

  Since 2013, the Housing Innovation Awards have recognized the very best in innovation on the path to zero energy ready homes. These awards recognize forward-thinking builders for delivering American homebuyers with the home of the future, today. More information on these award-winning homes is available on the Tour of Zero.

- Teach and Learn

  This website includes links to lesson plans, energy basics, videos and other downloads for K–12 teachers, university administrators, or students interested in building a clean energy career.

- Technical Feasibility Study for Zero Energy K-12 Schools (technical report)

  This study includes energy use intensity targets for all climate zones, a pathway for how to achieve these EUIs by climate zone, and case studies of actual K–12 school applications.

- Technical Support Document: Development of the Advanced Energy Design Guide for K-12 School Buildings for 50% Energy Savings (document)

  This document describes the process and methodology for the development of the Advanced Energy Design Guide for K–12 School Buildings: Achieving 50% Energy Savings Toward a Net Zero Energy Building (AEDG-K12) (ASHRAE et al. 2011a).

- Toolkit: K-12 Solutions for Building Energy Excellence

  This toolkit highlights Better Buildings Challenge projects.

- U.S. Department of Education Green Ribbon Schools

  This program inspires schools, districts, and institutions of higher education to strive for 21st-century excellence by highlighting promising practices and resources that all can employ. This website includes information on student loans, grants, laws, and data.

- Zero Energy Buildings Resource Hub

  This website includes information and resources for zero energy ready buildings.

- Zero Energy Ready Home National Program Requirements (Rev. 07) (document)

  This document includes requirements for Zero Energy Ready Homes, to be verified and field-tested in accordance with HERS Standards.

U.S. Department of Energy Student Building Competitions

1. The U.S. Department of Energy Solar Decathlon 2017

Each individual team page on the Solar Decathlon 2017 website includes links to download the complete set of Construction Drawings, Construction Specification, Jury Narratives, and other deliverables. These documents can provide important context and examples of successful past entries.

2. The U.S. Department of Energy Solar Decathlon 2015

This technical resources page includes links to download the complete set of final results, Construction Drawings, and Project Manuals for all teams. These documents can provide important context and examples of successful past entries. The individual team pages provide the team's Jury Narratives and other deliverables.

3. The U.S. Department of Energy Solar Decathlon 2013

This technical resources page includes links to download the complete set of final results, Construction Drawings, and Project Manuals for all teams. These documents can provide important context and examples of successful past entries. In addition individual team pages provide the team's received jury feedback.

4. The U.S. Department of Energy Solar Decathlon 2011

Each individual team page includes links to download the complete set of Construction Drawings, Construction Specification, Jury Presentations, Jury Feedback, and other deliverables. These documents can provide important context and examples of successful past entries.

5. The U.S. Department of Energy Solar Decathlon 2009

Each individual team page on the Solar Decathlon 2009 website includes links to download the complete set of Construction Drawings and Project Manuals. These documents can provide important context and examples of successful past entries.

6. The U.S. Department of Energy Solar Decathlon 2007

This technical resources page includes links to download the complete set of Construction Drawings, Construction Specifications, final scoring, summary of innovations, instrumentation and monitoring equipment, and more. These documents can provide important context and examples of successful past entries.

7. The U.S. Department of Energy Solar Decathlon 2005

This website includes information about each team and a technical report that summarizes the entire competition. These documents can provide important context and examples of successful past entries.

8. The U.S. Department of Energy Solar Decathlon 2002

This website includes information about each team and the original competition rules. These documents can provide important context and examples of successful past entries.

9. The U.S. Department of Energy Race to Zero (now Solar Decathlon Design Challenge)

The Race to Zero history website provides links pages that provide the winners of each competition, including their presentation files and project summaries. These documents can provide important context and examples of successful past entries.

Other Organizations

1. Center for Sustainable Energy Webinars

The CSE Webinar Series provides information and tools to help accelerate the transition to a sustainable world powered by clean energy. Each webinar features insights from subject matter experts and/or industry experts and all are free to attend.

2. New Buildings Institute (NBI): Zero Net Energy

NBI is a nonprofit organization driving better energy performance in commercial buildings by working collaboratively with industry market players—governments, utilities, energy efficiency advocates and building professionals—to promote advanced design practices, innovative technologies, public policies and programs that improve energy efficiency. NBI also develops and offers guidance and tools to support the design and construction of energy-efficient buildings.

3. New York State Energy Research and Development Authority (NYSERDA)

NYSERDA is a state organization that promotes energy efficiency and renewable energy to reduce greenhouse gas emissions, accelerate economic growth, and reduce energy bills. NYSERDA works with stakeholders throughout New York, including through training courses on topics such as Passive House.

4. WoodWorks

WoodWorks is a nonprofit that provides education and free technical support related to the design, engineering, and construction of commercial and multifamily wood buildings in the United States.

- Structural Design of Mass Timber Framing Systems
  Mass timber structural framing systems have high strength-to-weight ratios, are dimensionally stable, and are quickly becoming systems of choice for sustainably minded designers. This presentation provides a detailed look at the structural design processes associated with a variety of mass timber products, including glulam, cross-laminated timber, and nail-laminated timber. Applications for the use of these products in gravity force-resisting systems under modern building codes are discussed. Other technical topics include use of mass timber panels as two-way spanning slabs, connection options and design considerations, and detailing and construction best practices. For more information, see the recorded seminar (Vimeo) and presentation slides.
- Mass Timber Building Systems: Understanding the Options
  Mass timber represents a rapidly advancing technology that can be utilized as an alternative to steel and concrete to frame a variety of mid- and high-rise building types. This presentation provides an overview of available mass timber systems, with an emphasis on their advantages and unique design considerations. Topics include

connections and fasteners, which differ from those used in light-frame wood construction, including available options and code requirements. Practical design considerations with regard to project location, climate, material sourcing, weather and fire protection, as well as detailing for dimensional variability, are also reviewed. Cost estimating is discussed, as successful mass timber projects require a complete understanding of both the system itself and impact on trades. Recorded Seminar (Vimeo)

- Exploring Efficient Design for a Mass Timber Office: The Nail Laminated Timber Solution
  The architectural and environmental success of The Bullitt Center in Seattle has made heavy timber office buildings a topic of great interest within the design community. Now, with ground broken on a new seven-story example in Minneapolis, cost-effectiveness can be added to the potential benefits achieved with a mass timber structural solution. Presented by the timber specialists responsible for such iconic structures as the Richmond Olympic Oval, this presentation explores the aesthetic potential and efficiency of nail laminated timber systems, while touching on relevant engineering, manufacturing and erection techniques used in other timber projects. Examples demonstrate opportunities for prefabrication and sophisticated erection techniques, while emphasizing the importance of efficient structural engineering, product choice, connections and fasteners to creating economical timber structures. Recorded Seminar (Vimeo)
- University of Arkansas Mass Timber Residence Halls: Design and Construction Insights
  At over 202,000 square feet, Stadium Drive at the University of Arkansas is the nation's first large-scale mass timber residence hall project. Framed with cross-laminated timber (CLT) floor and roof panels and glued-laminated timber (glulam) columns and beams, the project creates a vibrant new destination with retail dining, classrooms, maker-spaces, performance spaces, communal spaces, administrative offices, and faculty housing, along with a mix of semisuites and pods totaling 708 beds. Presented by the project manager, this webinar will provide insights gained from the design and construction of this project, including building official review and code approval, interdisciplinary coordination, shop drawings, construction sequencing and field modifications. This session will equip attendees with the knowledge required to approach the design and construction administration phase of innovative CLT buildings. Recorded Seminar (Vimeo)

Resources by Contest

Energy Performance

1. ENERGY STAR® Energy Efficient New Homes

This website describes features and benefits of an ENERGY STAR certified home, along with benefits for homeowners, and information on how integrated systems and features (such as complete thermal enclosure system; efficient lighting and appliances, and high-efficiency heating and cooling) make a difference.

2. ENERGY STAR Renewable Energy Ready Homes (RERH)

The RERH Specifications were developed by the U.S. Environmental Protection Agency to educate builders on how to assess and equip new homes with a set of features that make it easier and less expensive for homeowners to install solar energy systems after the home is constructed. Website includes links to Solar Photovoltaic RERH Specifications, PV RERH Checklist, and the RERH Solar Site Assessment Tool.

3. EnergyGauge Energy and Economic Analysis Software (software tool)

This software tool was developed by the University of Central Florida's Florida Solar Energy Center. Software licenses are available for purchase for Residential and Commercial Buildings.

4. Green Globes

Green Globes is an online assessment protocol, rating system, and guidance for green building design, operation and management. It is interactive, flexible and affordable, and provides market recognition of a building's environmental attributes through third-party assessment. A free 30-day trial is available.

5. GridOptimal Initiative

The New Buildings Institute and the U.S. Green Building Council are launching a multiyear comprehensive grid edge initiative that will refine and disseminate a new building rating system called GridOptimal.

6. The International Association of Plumbing and Mechanical Officials (IAPMO)

The IAPMO Group is a complete service organization, providing code development assistance, industry-leading education, plumbing and mechanical product testing and certification, building product evaluation and a manufacturer-preferred quality assurance program. Website resources includes product listing directory and access to list of IAPMO Codes.

7. Lawrence Berkeley National Laboratory—Hot Water Draw Patterns in Single-Family Houses (publication)

This 2011 report describes data regarding hot water draw patterns that Lawrence Berkeley National Laboratory obtained from 10 studies.

8. National Institute of Building Sciences, Whole Building Design Guide (WBDG)

WBDG is a gateway to up-to-date information on integrated whole building design techniques and technologies. The goal of whole building design is to create a successful high-performance building by applying an integrated design and team approach to the project during the planning and programming phases.

9. National Renewable Energy Laboratory (NREL) Building Energy Optimization (BEopt™) (software tool)

The BEopt software provides capabilities to evaluate residential building designs and identify cost-optimal efficiency packages at various levels of whole-house energy savings along the path to zero net energy.

BEopt can be used to analyze both new construction and existing home retrofits, as well as single-family detached and multi-family buildings, through evaluation of single building designs, parametric sweeps, and cost-based optimizations.

Version 28.0.0 is available for download after registering for an account. The program is currently available for Windows operating system but can be used on other operating systems via virtual machines (e.g., Parallels) or via dual booting.

10. OpenStudio® (software tools)

This is a cross-platform (Windows, Mac, and Linux) collection of software tools to support whole building energy modeling using EnergyPlus and advanced daylight analysis using Radiance. OpenStudio is an open source (LGPL) project to facilitate community development, extension, and private sector adoption. OpenStudio includes graphical interfaces along with a Software Development Kit (SDK).

OpenStudio is developed in collaboration by NREL, ANL, LBNL, ORNL, and PNNL.

11. NREL Tool for Generating Realistic Residential Hot Water Event Schedules (publication)

This 2010 paper describes the development of an advanced spreadsheet tool that can generate a series of year-long hot water event schedules consistent with realistic probability distributions of start time, duration and flow rate variability, clustering, fixture assignment, vacation periods, and seasonality.

12. NREL PVWatts (online tool)

This tool estimates the energy production and cost of energy of grid-connected photovoltaic (PV) energy systems throughout the world. It allows homeowners, small building owners, installers and manufacturers to easily develop estimates of the performance of potential PV installations.

13. NORESCO REM/Rate (software tool)

REM/Rate™ and REM/Design™ desktop applications have been the industry standard for HERS® Ratings and home energy analysis/weatherization. Both programs are used within residential energy efficiency rebate programs. They provide valuable information about energy performance to electric and gas utility companies as well as their program implementers and evaluators who want to predict and assess new and existing single-family homes. IECC code compliance is also supported by REM software. A free 90-day trial is available.

14. Technical Feasibility Study for Zero Energy K-12 Schools (publication)

This study includes energy use intensity targets for all climate zones, a pathway for how to achieve these EUIs by climate zone, and case studies of actual K–12 school applications.

15. U.S. Environmental Protection Agency (EPA) Technical Reference: Source Energy (document)

This is a downloadable PDF of an ENERGY STAR document for commercial buildings (ENERGY STAR is a U.S. EPA partner).

16. EPA WaterSense

This website includes links to various WaterSense-labeled products for homes, yards, and businesses.

Engineering

1. Building Science Corporation Measure Guideline—Deep Energy Enclosure Retrofit for Interior Insulation of Masonry Walls (publication)

This 2015 Measure Guideline describes a deep energy enclosure retrofit (DEER) solution for insulating mass masonry buildings from the interior. It describes the retrofit assembly, technical details, and installation sequence for retrofitting masonry walls. Interior insulation of masonry retrofits has the potential to adversely affect the durability of the wall; this document includes a review of decision criteria pertinent to retrofitting masonry walls from the interior and the possible risk of freeze-thaw damage.

2. Connecticut Zero Energy Challenge

The CT Zero Energy Challenge is a design and build competition for single and multifamily homes built in Connecticut that awards cash prizes to its winners, while educating and demonstrating how to build super high-efficiency homes.

3. EPA Moisture Control Guidance for Building Design, Construction, and Maintenance

This 2013 document provides building professionals with practical guidance to control moisture in buildings during design, construction, and maintenance. The guidance includes audience specific moisture control guidance related to site drainage, foundations, walls, roof and ceiling assemblies, plumbing systems, and HVAC systems as well as methods for verifying the appropriate implementation of the discussed moisture control recommendations.

4. Oak Ridge National Laboratory Building Foundations Handbook—Basement Construction Details (publication)

This is Chapter 2 in the 2014 Foundation Design Handbook. The purpose of the handbook is to provide information that will enable designers, builders, and homeowners to understand foundation design problems and solutions.

Financial Feasibility & Affordability

1. Database of State Incentives for Renewables & Efficiency® (DSIRE)

DSIRE is the most comprehensive source of information on incentives and policies that support renewables and energy efficiency in the United States.

2. NREL National Residential Efficiency Measures Database

This database is a publicly available, centralized resource of residential building retrofit measures and costs for the U.S. building industry.

3. NREL BEopt™

The BEopt software provides capabilities to evaluate residential building designs and identify cost-optimal efficiency packages at various levels of whole-house energy savings along the path to zero net energy.

BEopt can be used to analyze both new construction and existing home retrofits, as well as single-family detached and multi-family buildings, through evaluation of single building designs, parametric sweeps, and cost-based optimizations.

Version 28.0.0 is available for download after registering for an account. The program is currently available for Windows operating system but can be used on other operating systems via virtual machines (e.g., Parallels) or via dual booting.

4. OpenEI Database

OpenEI is a trusted source of energy data, specifically for renewable energy and energy efficiency. Users can view, edit, add data, and download data for free.

5. RSMeans

A product line of The Gordian Group, RSMeans® is a supplier of construction cost information, providing accurate and up-to-date cost information that helps owners, developers, architects, engineers, contractors, and others to carefully and precisely project and control the cost of both new building construction and renovation projects. RSMeans keeps track of costs, along with a wide range of other key information, including productivity rates, crew composition, and contractors' overhead and profit rates.

Resilience

1. DisasterSafety.org

This website is a resource regarding how disasters affect homes and business and the solutions to mitigate against the impacts from events. It also includes information on the different risks found in each state.

2. FORTIFIED Home

FORTIFIED Home™ is a set of engineering and building standards designed to help strengthen new and existing homes through system-specific building upgrades to minimum building code requirements that will reduce damage from specific natural hazards.

3. FORTIFIED Commercial

FORTIFIED Commercial™ is a voluntary, superior construction standard and designation program designed by the Insurance Institute for Business and Home Safety to make new commercial buildings stronger against severe weather, including hurricanes and high winds/high winds and hail.

Architecture

1. Architecture 2030

Architecture 2030 is a nonprofit organization whose mission is to rapidly transform the global built environment away from being the major contributor of greenhouse gas emissions.

2. Efficient Windows Collaborative

This site provides unbiased information on the benefits of energy-efficient windows, descriptions of how they work, and recommendations for their selection and use.

3. ENERGY STAR® Certified New Homes

ENERGY STAR is the government-backed symbol for energy efficiency, providing simple, credible, and unbiased information that consumers and businesses rely on to make well-informed decisions. Thousands of industrial, commercial, utility, state, and local organizations—including more than 40% of the Fortune 500®—rely on their partnership with the U.S. Environmental Protection Agency to deliver cost-saving energy efficiency solutions. Ninety percent of American households recognize the ENERGY STAR, making it one of the most widely recognized consumer symbols in the nation. Together, since 1992, ENERGY STAR and its partners have helped save American families and businesses more than $450 billion and over 3.5 trillion kilowatt-hours of electricity while also achieving broad emissions reductions—all through voluntary action.

4. EPA Moisture Control Guidance for Building Design, Construction, and Maintenance

This 2013 document provides building professionals with practical guidance to control moisture in buildings during design, construction, and maintenance. The guidance includes audience specific moisture control guidance related to site drainage, foundations, walls, roof and ceiling assemblies, plumbing systems, and HVAC systems as well as methods for verifying the appropriate implementation of the discussed moisture control recommendations. The Appendix A in this document, the Pen Test, is particularly helpful.

5. High Performance Enclosures (publication)

This is a 2012 publication for purchase that provides guidance for architects and building enclosure engineers working to meet the growing need for buildings that have significantly lower operational energy consumption.

6. Leadership in Energy and Environmental Design (LEED) V4
This is the website to view LEED credit descriptions and values for various project aspects such as innovation, energy and atmosphere, and regional priority. A downloadable scorecard is also available.

7. New Building Institute Five Steps to Net Zero Energy (document)

This 2017 introduction guide includes information on how architects and engineers can help clients upgrade their existing buildings to be zero net energy through a Deep Energy Retrofit combined with renewable energy sources.

8. National Institute of Building Sciences—Whole Building Design Guide

Gateway to up-to-date information on integrated whole building design techniques and technologies.

9. Oak Ridge National Laboratory—Foundation Design Handbook

The purpose of the 2014 handbook is to provide information that will enable designers, builders, and homeowners to understand foundation design problems and solutions.

10. Pacific Northwest National Laboratory—Building Science Publications

This is a searchable database of Pacific Northwest National Laboratory publications.

11. WELL Building Standard

The WELL Building Standard, by the International WELL Building Institute, is a cutting-edge standard that focuses exclusively on the ways that buildings, and everything in them, can improve comfort, drive better choices, and generally enhance, not compromise, health and wellness.

12. WUFI

WUFI is a menu-driven PC program that allows realistic calculation of the transient coupled one-dimensional heat and moisture transport in multilayer building components exposed to natural weather. Software download is available for purchase.

Operations

1. ENERGY STAR® Energy-Efficient New Homes

This website describes the features and benefits of an ENERGY STAR certified home, along with benefits for homeowners and information on how integrated systems and features (such as a complete thermal enclosure system; efficient lighting and appliances; and high-efficiency heating and cooling) make a difference.

2. ENERGY STAR Renewable Energy Ready Homes (RERH)

The U.S. Environmental Protection Agency (EPA) developed the RERH specifications to educate builders on how to assess and equip new homes with a set of features that make it easier and less expensive for homeowners to install solar energy systems after the home is constructed. The website includes links to the Solar Photovoltaic (PV) Specification, Checklist, and Guide; RERH Solar PV Checklist; and RERH Solar Site Assessment Tool.

3. ENERGY STAR Efficient Lighting and Appliances

This website includes a fact sheet (PDF) for energy-efficient lighting and appliances.

4. Green Globes

Green Globes is an online assessment protocol, rating system, and guide for green building design, operation, and management. It is interactive, flexible, and affordable, and it provides market recognition of a building's environmental attributes through third-party assessment. A free 30-day trial is available.

5. Grid-Interactive Efficient Buildings Factsheet

The U.S. Department of Energy's Building Technologies Office envisions a future in which buildings operate dynamically with the grid to make electricity more affordable and integrate distributed energy resources while meeting the needs of building occupants.

6. Lighting Design Lab

The Lighting Design Lab focuses on the commercial and industrial markets and offers lighting technology services and resources to electric utilities, energy efficiency organizations, and trade professionals. Resources available on the website include lighting guides, energy codes, incentive programs and workshops.

7. Lighting Design Lab Footcandle Light Guide

Footcandles are the most common unit of measure used by lighting professionals to calculate light levels in businesses and outdoor spaces. A footcandle is defined as the illuminance on a one square foot surface from a uniform source of light. The Illuminating Engineering Society recommends the following footcandle levels to ensure adequate illumination and safety for occupants. This website has a guideline for common areas to assist in achieving appropriate light levels with the greatest energy efficiency.

8. Lighting Research Center Energy Efficient Residential Lighting

This site provides information on quality, energy-efficient lighting for residences for an audience that includes homeowners, contractors, retailers, architects, and lighting design students. This website includes the Builders Guide to Home Lighting and an Economic Worksheet.

9. Residential Energy Services Network (RESNET): Lighting, Appliance and Miscellaneous Energy Usage Profile Amendments

The RESNET website is a one-stop solution to learn about the energy audit and rating processes.

Market Potential

1. Green Building: Principles and Practices in Residential Construction (Go Green with Renewable Energy Resources).

This is a downloadable book, published in 2012, that is a guide to green building residential construction.

2. LEED Guide to Certification: Homes

This is a step-by-step guide to obtain LEED certification for your project (downloadable PDF available).

3. National Association of REALTORS (NAR)

NAR is America's largest trade association, representing 1.3 million members, including NAR's institutes, societies, and councils. NAR is involved in all aspects of the residential and commercial real estate industries.

4. Sustainable Residential Interiors, 2nd edition.

This book, published in 2014, is available for purchase as an ebook or hardcover. It addresses cutting-edge processes, strategies, and principles for sustainable residential interiors.

Comfort & Environmental Quality

1. Air Conditioning Contractors of America (ACCA)

ACCA is a nonprofit association with a membership that includes more than 60,000 professionals and 4,000 businesses in the indoor environment and energy services community. ACCA works together to promote professional contracting, energy efficiency, and healthy, comfortable indoor environments.

2. ACCA Spreadsheets, Technical Manuals, Standards & Codes

ACCA develops the industry standards for heating, ventilation, air conditioning, and building performance. Under the auspices of the American National Standards Institute (ANSI), the ACCA works across the industry in a consensus-based process to create meaningful standards that raise the bar for contracting. Resources are available for members.

3. Design Master—Duct and Diffuser Layout

Design Master HVAC makes it easier for a designer or engineer to lay out their ductwork in AutoCAD. The website offers a free demonstration and a 30-day trial.

4. Elite Software Ductsize—HVAC Duct Sizing and Analysis

Ductsize allows creation of a complete duct system from start to finish and gives control over every aspect of the design. The program can size all the ducts (using three different sizing methods), enter sizes to analyze an existing design, or any combination of the two, where you specify the duct sizes through tight areas where there is little room for ductwork, and let the program calculate the sizes everywhere else. A demo is available, though pricing depends on the program.

5. ENERGY STAR® Heat and Cool Efficiently, Maintenance Checklist

This is a checklist for maintaining heating and cooling equipment.

6. Energy Savings Plus Health: Indoor Air Quality Guidelines for School Building Upgrades

This 2014 guide (PDF) is written primarily for school facility managers, energy managers, risk managers, building operators and school administrators to help them collaboratively manage the relationships between energy efficiency upgrade activities and indoor air quality in schools.

7. EPA Indoor airPLUS Program

Indoor airPLUS is a voluntary partnership and labeling program that helps new home builders improve the quality of indoor air by requiring construction practices and product specifications that minimize exposure to airborne pollutants and contaminants. Resources available on the website include publications and resources along with podcasts and webinars.

8. Indoor Air Quality Association (IAQA)

IAQA is dedicated to bringing practitioners together to prevent and solve indoor environmental problems for the benefit of consumers and the public. Their website has membership information along with resources and access to training.

9. Lawrence Berkeley National Laboratory—Indoor Air Quality Scientific Findings Resource Bank

The Indoor Air Quality (IAQ) Scientific Findings Resource Bank (IAQ-SFRB) serves as a resource for public health professionals, building professionals, and others who seek scientific information about the effects of IAQ on people's health or work performance.

10. Protecting IAQ During School Energy Efficiency Retrofit Projects with Energy Savings Plus Health Guidelines

This is an EPA website with links to various documents, resources, and training related to reducing energy costs in schools.

11. Trane® VariTrane™ Duct Designer (software)

VariTrane Duct Designer streamlines duct design and improves calculation precision, helping optimize designs while obtaining a minimum pressure system. VariTrane Duct Designer enables organization of the layout structure of a duct system and provides detailed engineering information on a section-by-section basis making revisions and updates easier.

The software is based on engineering data and procedures outlined in the ASHRAE Fundamentals Handbook. It includes tested data from ASHRAE Fitting database and from United McGill to provide the most accurate modeling possible. A free 30-day trial is available.

12. Ventilation Guide (publication)

This 2011 publication by Armin Rudd is available for purchase. It presents a variety of recommendations for improving indoor air quality in residential buildings through controlled mechanical ventilation. These recommendations are intended to illustrate principles of best practice.

13. Wrightsoft®, HVAC Design and Sales Software

This is a comprehensive start-to-finish HVAC tool available for desktop or mobile solutions. Permanent and subscription packages are available for purchase.

Innovation

1. National Energy Educational Development Project (NEED)

The NEED Project began more than 35 years ago as a one-day celebration of energy education when National Energy Education Day was recognized by a Joint Congressional Resolution. In the same year, President Jimmy Carter issued a Presidential Proclamation stressing the need for comprehensive energy education in schools, a reduction of dependence of fossil fuels, and increasing use of renewable energy technologies and energy efficiency. Since its founding, NEED has kept its Kids Teaching Kids philosophy as a fundamental principle of NEED programming—encouraging students to explore, experiment, and engage, and encouraging teachers to embrace student leadership in the classroom. NEED trains and assists teachers in harnessing the energy of the classroom—the energy of students.

Course catalog and workshop calendar are available.

2. National Institute of Building Sciences Innovation Conference Proceedings

Speaker presentations are available for download from 2015. Sign-in is required.

3. U.S. Department of Housing and Urban Development—The Diffusion of Innovation in the Residential Building Industry (publication)

This 2004 publication is a report in direct support of ongoing efforts to understand the home building industry's means and methods.

Presentation

1. Solar Decathlon 2019 Design Challenge (Team Presentations)

View the presentations (PDFs) of the 2019 winning team presentations and 2019 results

2. Race to Zero Student Design Competition (Team Presentations)

View the presentations (PDFs) of the 2018, 2017, and 2016 winning team presentations and 2018, 2017, and 2016 results.

3. DOE-Hosted Presentations

This YouTube channel includes video presentations on various topics.

4. Ignite® Presentations

Ignite Talks are 5-minute video presentations on various topics. Ignite's mission is "Everyone Speaks," and the group believes that public speaking builds confidence in individuals and that events like Ignite build community. Their goal is to make it possible for anyone, anywhere, to learn to present their ideas and their stories.

5. PG&E Zero Net Energy Program

Pacific Gas and Electric's (PG&E) ZNE outreach activities include workshops and educational series. Workshops help design professionals learn about creating ZNE buildings and are offered through PG&E's Training Centers. PG&E also holds speaker forums and presentations on key ZNE topics for building professionals and residential customers.

6. TED Talks

This website includes video presentations on various topics. TED is a nonprofit devoted to spreading ideas, usually in the form of short, powerful talks (18 minutes or less).