U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

2021 Design Challenge Rules

January 2021

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 Building
NREL	National Renewable Energy Laboratory
OB	Office Building
RT	Retail Building
RESNET	Residential Energy Services Network
SSF	Suburban Single-Family Housing
USF	Urban Single-Family Housing

Foreword—Why Solar Decathlon Design Challenge?

High-performance buildings include comprehensive building science, energy efficiency, optimized mechanical systems, indoor air quality, resilience, and water conservation. However, building occupants expect more, so it's imperative to integrate high-performance building solutions with great design. All of these attributes will ultimately determine whether buildings succeed or fail in terms of the human experience: affordability, comfort, health, durability, safety, and adequate resources.

Professional curricula across the United States and around the globe can do more to consistently provide architecture, engineering, and construction management students the skills needed to effectively integrate high-performance measures with design. In fact, emerging crises related to affordability, health, disaster risks, and water shortages are making these skills imperative. At the same time, degree programs are working to effectively integrate them into their curricula. Enter the U.S. Department of Energy (DOE) Solar Decathlon® Design Challenge.

Since 2014, the competition has focused on two critical goals: first, to integrate high performance with design in degree programs; and second, to inspire students to enter into sustainable building careers. Competition results during the past six years demonstrate substantial success toward these goals, including:

- More than 150% growth in the number of teams participating
- Feedback from Faculty Advisors suggesting more than 500% growth in the number of participating programs that have integrated the Design Challenge into their curricula
- Deep 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 equipping the next-generation building workforce with the skills and passion to create future-ready buildings.

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Solar Decathlon Design Challenge Competition Rules Authors: NREL's Rachel Romero, 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 during one or two academic semesters. Participants prepare creative solutions that address real-world issues in the building industry. Teams complete a design project, and finalists present their designs to a panel of industry expert jurors. Students compare their projects to those of other teams, learn from presentations by national thought leaders and collegiate peers, experience zero energy ready building design, and engage with a variety of organizations about careers related to high-performance buildings.

Finalist Teams are recognized at an Awards Ceremony, and project materials from winning teams are published on the Solar Decathlon webpage. 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. Select winners may receive further invitations to present at industry conferences following the Solar Decathlon Competition Event. 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 promising future design and construction professionals.

1 Summary of Important Dates

Please note the following key milestones for the 2021 Design Challenge:

- **July 2020:** The 2021 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 teams is the Project Site, an online platform for participating students to receive timely information from organizers, submit deliverables, and access necessary resources.
- **October 20, 2020, 5 p.m. Eastern Daylight Time (EDT):** All teams must submit their Team Application on the Project Site by this deadline. The Team Application must indicate which Division the team intends 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. Teams are required to identify a Faculty Lead, and strongly encouraged to also identify a student Team Lead if available.
- **December 1, 2020, 5 p.m. Eastern Standard Time (EST):** Teams are encouraged to submit an optional Project Pitch.
    - The optional Project Pitch should be submitted via the Project Site.
    - Submissions are evaluated against criteria indicated in this Rules document, and teams will receive feedback on project compliance.
- **January 29, 2021:** An updated version of the Solar Decathlon 2021 Design Challenge Rules is released.
- **February 16, 2021, 5 p.m. EST:** All teams must complete the Project Proposal, finalize 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.
    - The Project Proposal must be submitted via the Project Site.
    - Submissions are evaluated against criteria indicated in this Rules document. Based on the Project Proposal evaluation, up to 10 teams per Division are invited to participate in the Competition Event.
    - All participating teams are encouraged to complete their designs and the associated submissions regardless of finalist status.
- **March 30, 2021, 5 p.m. EDT:** Teams must submit their updated Project Summary, Design Narrative, and Team Photos.
    - The deliverables must be submitted via the Project Site.

- **April 6, 2021, 5 p.m. EDT:** Teams must submit their Presentation Recording.
- **April 13, 2021, 5 p.m. EDT:** Teams must submit their Presentation Slides, optional Project Media, and optional Film Submission. Presentations are not accepted after this date.
- **April 15–18, 2021:** Finalist Teams present to industry leaders at the Solar Decathlon Competition Event. Finalist and Participant Teams also take part in related competition events. Design Challenge winners are announced.
- **May 18, 2021:** The Faculty Report is due to the organizers at SDdesign@nrel.gov.

2 Design Challenge Description

2.1 Task Overview

- ☐ Read the Design Challenge Rules and form a multidisciplinary team.
- ☐ Study the resources provided in Appendix A.
- ☐ Review 2020 winning team presentations, past event photographs, and the Solar Decathlon website to inform efforts.
- ☐ Submit a Team Application and register all team members under one team on the Project Site, where competition updates and materials are posted regularly.
- ☐ Complete the on-demand Building Science Training online or provide confirmation from the team's Faculty Lead that equivalent training is part of the student's curriculum. The Building Science Training coursework is provided at no cost to every team member.
- ☐ Work with a Design Partner to develop project criteria (highly encouraged).
- ☐ Engage with industry to supplement existing knowledge and provide valued feedback on the design.
- ☐ Watch webinars posted to the Solar Decathlon YouTube.
- ☐ Attend Design Challenge Check-Ins as advertised on the Project Site for technical, design, and competition guidance. The recordings are posted to the Project Site if attendance is not possible.
- ☐ Consult the Solar Decathlon website and Project Site for updates and announcements.
- ☐ Ensure your project is compliant with the requirements listed in these Rules.
- ☐ Submit all materials well in advance of the deadlines.

For communications and questions, email the organizers at SDdesign@nrel.gov.

2.2 Forming a Team

The competition is open to all collegiate and degree-issuing institutions, including community and technical colleges. International institutions are welcome to participate. Teams should abide by the following criteria:

- Each team must be associated with a collegiate institution and include a Faculty Lead. Faculty may counsel multiple teams.
- Each team must have at least three students, with one student designated as the student Team Lead. There is no maximum number of student team members.
- 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 a team.
- 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.
- At least one student and one Faculty Advisor from each Finalist Team are required to participate in the Competition Event.

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 collegiate institution. 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. In addition, students must meet the following:

- Although collegiate institutions may have more than one team, students are limited to one team for the competition year of the Design Challenge.
- Each student must be pursuing a degree and enrolled in at least one class between the Team Application deadline and the Competition Event.

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. 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.
- Making sure that all student team members complete the Building Science Training 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 participating in the Competition Event.

2.5 Design Partners

Teams are strongly encouraged (but not required) to engage a Design Partner in their project. Design Partners are organizations that have a planned construction, major retrofit project, or new construction project in their building portfolio and would like to work with a team to develop a zero energy ready design option for the project. For example, a school district that is planning a major retrofit to an existing school could be a Design Partner and work with a team to receive a basic zero energy ready design and cost analysis for the retrofit.

Design Partners should provide teams with basic project information and requirements. The partner should be willing to provide up to 30 hours of engagement with the team over the course of the competition for design programming, iterative schematics, and feedback. A representative from each Design Partner organization may participate in the Competition Event. Teams should

secure their own Design Partner; a limited number of Design Partner opportunities will be posted on the Solar Decathlon website.

2.6 Industry Engagement

Engagement with industry professionals is expected to provide real-world perspective on proposed solutions and to provide guidance for selecting and integrating building systems into the design. Successful teams often engage with several 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.

3 Design Challenge Project Requirements

Designs should represent a high-performance building so energy efficient that a renewable energy system can be expected to 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 practices for the building enclosure and mechanical systems.

Designs should meet the following specifications:

- Teams may develop an original design, improve or conceive of a new design for a Design Partner, or chose to retrofit or modernize an existing building.
- Projects must be substantially different from any submitted to DOE competitions in the past. If a school has multiple teams competing in the Solar Decathlon across the Design and Build Challenges, each team must have distinct designs.
- 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 expected 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 required; a submission with both metric units and English units is acceptable. If metric units are used, state English units first, followed by metric equivalents in parentheses. Example: 125 feet (ft) (38.1 meters [m]).[1]

3.1 Design Challenge Divisions

Teams participating in the Design Challenge compete in one of seven Divisions. In all Divisions, maximizing both energy performance and building design are critical to success. Building science decisions significantly impact 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.

Design teams must abide by the following:

- Each collegiate institution may submit up to seven applications, but may ***not*** have more than one team in any Division.
- Only one design per team may be submitted to the organizers for the Project Proposal and Design Portfolio. If more than one is submitted, the organizers will review only the last-received design 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.

[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.

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, 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 Housing (SSF)

The parameters for the Suburban Single-Family Housing (SSF) Division are below.

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 Housing (USF)

The parameters for the Urban Single-Family Housing (USF) Division are below.

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 are below.

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 Building (MM)

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

1. Minimum of eight dwelling units; building is up to five 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 are below. An ES is defined as a complete educational facility for students in kindergarten through fifth grade, and 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 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.

Retail Building (RT)

The parameters for the Retail (RT) Building Division are below. An RT is defined as a building or a portion of a building where merchandise is sold to customers. The space will include full fit and finish for a defined client(s), including support functions such as mechanical and electrical spaces and circulation.

1. Building size: 7,500 ft^2 (697 m^2) to 250,000 ft^2 (23,226 m^2)
2. Lot size: no minimum or maximum
3. In addition to the retail area, the following spaces must be included:
    i. Point of sale
    ii. Stock room(s)
    iii. Support office(s)
    iv. Restroom
    v. Break room(s) with kitchenette.
4. The source EUI target before renewables must be less than that shown in Section 3.2.

3.2 Evaluating Building Energy Performance

Energy analysis is invaluable for predicting energy performance and evaluating trade-offs to achieve energy goals. Energy analysis can be conducted using a variety of software programs. Tools and resources for these calculations are provided in Appendix A as well as through the Project Site.

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. RESNET-accredited programs, REM/*Rate,* and Ekotrope are provided to teams at no charge after completing the Team Application; however, using them 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 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 Buildings, Office Buildings, and Retail Buildings are shown in Table 1. These EUI values include all building loads, including plug loads; heating, ventilating, and 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.

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

Table 1. Source Energy[3] Use Intensity Targets for Elementary Schools,[4] Mixed-Use Multifamily Buildings with a Commercial Retail or Office Space,[5] Office Buildings,[6] and Retail Buildings.[7]

Climate Zone	Elementary School Source EUI (kBtu/ft²·yr)	Mixed-Use Multifamily[8] Source EUI (kBtu/ft²·yr)	Office Building Source EUI (kBtu/ft²·yr)	Retail Building Source EUI (kBtu/ft²·yr)
0A	69	80	80	104
0B	71	96	96	101
1A	66	81	81	100
1B	67	89	89	100
2A	64	77	77	89
2B	60	79	79	87
3A	57	74	74	83
3B	58	73	73	84
3C	53	55	55	72
4A	56	75	75	79
4B	55	71	71	81
4C	52	60	60	73
5A	57	80	80	79
5B	56	79	79	80
5C	50	61	61	72
6A	63	96	96	89
6B	58	86	86	84
7	66	88	88	92
8	71	100	100	106

[3] For the methodology for 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] For retail that requires specialty lighting, an allowance of 15 kBtu/ft² is allowed. The specialty lighting must be justified as critical to the retail operation. For retail that requires refrigerated cases, an allowance of 3,500 kBtu per linear foot of refrigerated cases is allowed in ASHRAE Climate Zone 3 and below, and 4,500 kBtu per linear foot of refrigerated cases in ASHRAE Climate Zone 4 and above.
[8] 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, Office Buildings, and Retail 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 Competition Event Details

Based on the quality of the Project Proposals submitted in February 2021, up to 10 Design Challenge Finalist Teams in each Division will be invited to compete at the Competition Event, occurring virtually in April 2021. Finalist Teams will deliver an 8-minute Project Presentation live to the Division Jurors, with an additional 15 minutes for questions. If your team is selected as the first-place team in your Division, your team will also deliver an 8-minute presentation live to the Grand Jurors during the Awards Ceremony. No time is reserved for questions during the Awards Ceremony.

This event provides a rich experience for participants to engage in networking opportunities and attend other team and professional presentations. Attendance at the Competition Event is based on the following criteria:

- At least one student and one Faculty Advisor from each Finalist Team are required to participate in the Competition Event.
- Each team may have a maximum of five student team members present to juries. Additional team members may participate virtually in the Division Presentation Q&A.
- Faculty Advisors may not participate in the team's presentation or Q&A.

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 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.

This competition values innovation and creative approaches in design areas, including: scaled adoption of prefabricated design, energy efficiency, energy production, grid integration, building operations, and overall functionality and appeal.

Effective designs incorporate innovations that are likely to be embraced by the construction industry and consumers on a large scale. Enabling the construction and building design industries to adopt modern technology, manufacturing techniques, automation, or mass customization may allow innovation to have a greater impact on building energy consumption. Teams are encouraged to find solutions that make use of new or existing technologies as well as other creative features to improve building operations and desirability.

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. Architecture
2. Engineering
3. Market Analysis
4. Durability and Resilience
5. Embodied Environmental Impact
6. Integrated Performance
7. Occupant Experience
8. Comfort and Environmental Quality
9. Energy Performance
10. Presentation

4.1 Architecture

Contest Intent

This Contest evaluates the building's architecture for creativity, overall integration of systems, and ability to deliver outstanding aesthetics and functionality.

Architecture marries aesthetics with sound building science, energy efficiency, natural ventilation, energy production, and resilience. Cutting-edge energy-efficient buildings are better positioned to achieve meaningful market acceptance if integrated into architectural designs that creatively meet or exceed aesthetic and functional expectations of both industry and consumers.

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.

4.2 Engineering

Contest Intent

This Contest evaluates the effective design of high-performance engineering systems, technologies, and techniques through the use of energy efficiency and renewable energy.

Effective designs for buildings systems incorporate careful considerations of structural performance, occupant comfort, environmental conditions, and regulatory constraints. Heating, cooling, water, and ventilation system types and design should reflect different technology and integration options, including analysis of implications for energy and environmental performance, up-front and long-term costs, and reliability. Opportunities for water efficiency should be reflected in smart engineering solutions for domestic hot water delivery and landscaping irrigation as well as plumbing fixtures and landscaping choices. Energy consumption and production is evaluated against specific site constraints and designed accordingly.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Overall approach to solving engineering challenges and integrating solutions in design

- Sound selection and design of all building components (foundation, wall systems, roof) to address building science control layers
- Lighting system selection and design for energy-efficient ambient, task, and mood lighting fully integrated with natural light
- Plumbing system layout for efficient hot water delivery to minimize wait time, losses, and wasted water
- Selection of water conservation fixtures, estimated loads, supply piping, rainwater or gray water systems, and landscaping systems for minimizing water use.

4.3 Market Analysis

Contest Intent

This Contest evaluates the building's appeal, affordability, and attainability to its stated target market; this includes the likelihood of adoption by intended occupants and the construction industry for impactful, cost-effective design.

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 productivity of building industries. A successful design should also include high-quality construction documentation.

Financial analysis should include estimated costs of construction, 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 and overall affordability. The cost of construction, as well as the extent to which the design would cost more than a code-compliant building, should be carefully considered and justified.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Execution of market analysis, including affordability and the integration of key findings in the design
- Use of design solutions that meet current market expectations for owner experience
- Application of market-ready construction materials and their cost-effectiveness in the design
- Life cycle cost comparison between a minimally code-compliant building and the proposed design
- Financial feasibility analysis in the target market as presented to the consumer
- Operational and maintenance cost estimate.

4.4 Durability and Resilience

Contest Intent

This Contest evaluates the building's long-term ability to endure local environmental conditions and anticipate, withstand, respond to, and recover from disruptions.

Durability reflects the ability of the building envelope to maintain long-term performance despite routine environmental conditions. Resilient design enables the building to maintain critical operations during disruptions and quickly restore normal operations. The benefits of investing in highly efficient buildings are compounded by also investing in resilient design. Teams must demonstrate how their buildings effectively address all of these challenges.

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
- 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 in 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 Embodied Environmental Impact

Contest Intent

This Contest evaluates the full life cycle of a building, from cradle to grave.

"Circular economy" for a building refers to an economic system in which buildings are designed with a focus on minimizing environmental impact from material extraction and manufacturing to transportation, construction, and use, while also considering "Re-X"—reclamation, refurbishment, repair, reuse, recycle, etc.—of materials throughout the building's life cycle. Within the sphere of a circular economy, various measurements and calculations are used to quantify the environmental impacts that are embodied in the building at each life cycle stage. As buildings become more resource efficient during occupancy, the environmental impact during this stage decreases. Consequently, the other life cycle stages—such as material production, manufacturing, construction processes, and end of life—become larger contributors to a building's total environmental impact and, therefore, become more important to address. The building industry must go beyond the occupancy stage to address these impacts in all life cycle stages.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Life cycle assessment of the building's embodied environmental impacts, showing assumptions (e.g., intended service life, functional requirements) for the assessment of each life cycle stage
- Design decisions and material selections with regard to circularity and embodied environmental impacts
- Discussion of trade-offs between up-front/embodied environmental impacts (e.g., energy, greenhouse gas emissions) and operational environmental impacts.

4.6 Integrated Performance

Contest Intent

This Contest evaluates how effectively the whole building performance is optimized through passive and active strategies across multiple building disciplines.

An integrated design utilizes architectural and engineering elements that complement each other to help the building achieve optimal performance. For example, a building that is properly oriented will more effectively capture passive heating, cooling, ventilation, and lighting. Without one design element (e.g., building orientation), additional energy-consuming systems are required to provide the dependent design element for interior conditions (e.g., mechanical HVAC). In a truly integrated design, when any element is altered or removed from the building, energy consumption of the overall building could increase.

Design Challenge Criteria

The jury evaluates teams on each of the following:

- Systems approach to integrating architecture and engineering relative to the building envelope and climate
- Effective use of passive design strategies to meet heating, cooling, ventilation, and lighting needs
- Integrated, interdisciplinary solutions that enhance synergies among building subsystems
- Space-conditioning system integration within the building's structural system
- Optimized installation of renewable energy systems to ensure technical feasibility of the application
- Discussion of lighting system effectiveness, including daylighting and electric lighting to provide ambient, task, and mood lighting.

4.7 Occupant Experience

Contest Intent

This Contest evaluates how the building optimizes occupants' quality of life while also meeting the energy performance goals of the design.

Technologies and appliances should be thoughtfully selected and integrated into the overall design. This includes strategies for efficiency, comfort, health, and safety that address operational expectations of consumers.

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

4.8 Comfort and Environmental Quality

Contest Intent

This Contest evaluates the building's capability to deliver intended comfort and indoor environmental quality.

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 exterior noise infiltration. 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:

- 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-building ventilation and strategies for spot ventilation (e.g., controlling moisture in bathrooms as well as moisture and particles from cooking in kitchens) and filtration (e.g., high-capture filters)
- Acoustical design strategies for controlling unwanted interior and exterior noise.

4.9 Energy Performance

Contest Intent

This Contest evaluates reduction of whole-building energy consumption, ability to generate clean energy that is needed on-site, and interaction with local grid operations.

Effective whole-building energy analysis and decision-making is the foundation for energy performance. Energy performance incorporates energy consumption, clean energy generation, and the capability of the building to provide grid services.

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
- 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.

4.10 Presentation

Contest Intent

Successful evaluation of each Contest depends on the team's ability to accurately and effectively convey its design and approach to energy performance to relevant audiences.

In order to inspire future professionals, incumbent industry leaders, and the public at-large to pursue energy efficiency and renewable energy opportunities, the value proposition must be clearly conveyed, both verbally and visually.

A smart design on its own is insufficient. Presentation quality can dramatically affect consumer perception and the likelihood of innovation being adopted. As such, each jury evaluates not just the criteria of the individual Contest but also the team's presentation of the design solution.

Design Challenge Criteria

The jury evaluates teams on each of the following:

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

5 Design Challenge Evaluation Process

The evaluation process of the competition is multifaceted and includes several submissions.

5.1 Optional Project Pitch

The optional Project Pitch is an opportunity to submit preliminary information about your project and receive early competition feedback. The organizers provide feedback on the following:

- Compliance with Division definition
- Submission formatting compliance.

It is understood that the Project Pitch might be considerations, aspirations, or otherwise tentative and subject to change in future submissions. The organizers will not provide feedback on the quality of the design itself.

5.2 Project Proposal to Select Finalist Teams

Based on the deliverables submitted for the Project Proposal, 10 Finalist Teams from each Division are selected to participate in the Competition Event. These Finalist Teams are selected based on the following:

- One panel of reviewers (each with 1–3 industry experts) convenes for each Division. Each reviewer evaluates all Project Proposals within their assigned Division.
- The reviewers assess the team's preliminary designs.
    - Reviewer feedback represents their professional guidance. This feedback is based on the unique expertise and opinion of the reviewer and should not be used as a justification for a final design to conflict with the Rules.
- Organizers individually evaluate the Project Proposals according to the following criteria:
    - Effectiveness of Project Summary in conveying the salient points of the project
    - Description of target market and building occupant characteristics
    - Discussion of how target market impacts the design constraints
    - Description of local climate
    - Discussion of the building science issues in the selected climate that impact the design
    - Discussion of building code constraints or standards that impact the design
    - Discussion of design goals
    - Quality of team's plan for completing the design and submitting the final Design Portfolio
    - Compliance with Division definitions
    - Compliance with submission formatting

    - Other factors, such as geographic locations and technology choices, that help optimize competition diversity and fairness.
- Up to 10 Finalist Teams are selected by organizers in each Division based on reviewer evaluation.
- Reviewers develop written feedback that is shared with the teams via the Project Site within two weeks of Project Proposal deadline.

5.3 Design Portfolio to Select Winners

The Design Portfolio provides sufficient design information for the jurors to score each team and select winners. The process is as follows:

- Division Juries (each with 3–5 industry experts) assess the team designs.
- One jury convenes for each of the Divisions. Each juror reviews all Design Portfolios within their assigned Division.
- Division Jurors individually determine preliminary evaluation results based on the Design Portfolio.
- Preliminary team evaluation results are modified by the jurors based on the live Division Presentations and associated question-and-answer period during the Competition Event.
- Division Juror panels select first-place, second-place, and third-place award winners in each Division based on the extent to which the design demonstrates the following attributes:
    - Understanding and application of building science
    - Excellence in design intent of the competition
    - Excellence in the Contest criteria subject areas.
- Each first-place team delivers a live presentation at the Awards Ceremony for evaluation by the Grand Jury, which chooses a Commercial Grand Winner and Residential Grand Winner according to the process described in Section 5.5.
- Division Jurors develop written feedback for the teams that is shared with the teams via the Project Site within two weeks of the Competition Event's conclusion.

5.4 Evaluation Rating Scale

The following scale is used to evaluate the submissions:

Table 4. Evaluation Scale

Design Challenge Scale for Evaluation	
1	MISSES EXPECTATIONS: Missing all items; no explanation of how the design addresses the criteria
2	APPROACHES EXPECTATIONS: Missing some items; minimal explanation of how the design addresses the criteria
3	MEETS EXPECTATIONS: All minimum requirements met; basic explanation of how the design addresses the criteria
4	EXCEEDS EXPECTATIONS: All minimum requirements met; detailed demonstration of applying the design solution to address the criteria
5	ECLIPSES EXPECTATIONS: All minimum requirements met; distinguished excellence in the explanations describing how the design exceeds the criteria

5.5 Grand Jury Award

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

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 of the design are evaluated against the following:

- Level of inspiration
- Appeal to the target market, community, and occupants
- Architectural design aesthetics and functionality
- Responsiveness of design to building science factors
- Financial feasibility
- Constructability
- Innovation
- Presentation quality within specified 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.

5.6 Bonus Awards for Creativity

Bonus awards are given to teams 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 may recognize:

- Terrific Team Spirit
- Spectacular Team Virtual Background
- Impressive First-Time Team
- Superb Social Media Engagement
- Fantastic Team Photo
- Outstanding Team Showcase Award
- Excellence in Industry Engagement
- Notable Engagement at Competition Event
- First Complete Design Narrative Submitted
- Unique Team Name
- Director's Award
- Fantastic Film Submission.

6 Design Challenge Deliverables

Throughout the Design Challenge, teams must submit deliverables necessary for evaluating their progress and design. The deliverables, file naming conventions, and due dates are below.

Table 5. Summary of Deliverables, File Naming Conventions, and Due Dates

Deliverable	Required Content	File Name	Due Date	Submit To
Project Pitch (optional)				
Project Summary	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_SUMMARY_[SUBMISSION DATE (YYYY-MM-DD)].pdf	Dec. 1, 2020, 5 p.m. EST	Project Site
Project Proposal				
Updated Project Summary	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_SUMMARY_[SUBMISSION DATE (YYYY-MM-DD)].pdf	Feb. 16, 2021, 5 p.m. EST	Project Site
Design Concept	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_CONCEPT_[SUBMISSION DATE (YYYY-MM-DD)].pdf	Feb. 16, 2021, 5 p.m. EST	Project Site
Design Portfolio				
Updated Project Summary	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_SUMMARY_[SUBMISSION DATE (YYYY-MM-DD)].pdf	March 30, 2021, 5 p.m. EDT	Project Site
Design Narrative	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_NARRATIVE_[SUBMISSION DATE (YYYY-MM-DD)].pdf	March 30, 2021, 5 p.m. EDT	Project Site
Supplemental Documentation (optional)	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_SUP_[SUBMISSION DATE (YYYY-MM-DD)].pdf	March 30, 2021, 5 p.m. EDT	Project Site
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 30, 2021, 5 p.m. EDT	Project Site
Presentation Recording	.mov, mp4 or PPTX	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_RECORDING_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	April 6, 2021, 5 p.m. EDT	Box
Presentation Slides	PDF and/or PPTX	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_ PRESDIV_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	April 13, 2021, 5 p.m. EDT	Box
Additional Submissions				

Deliverable	Required Content	File Name	Due Date	Submit To
Short Film (optional)	.mov or mp4	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_FILM_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]	April 13, 2021, 5 p.m. EDT	Box
Faculty Report	Single, bookmarked PDF	DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_FACULTY_[SUBMISSION DATE (YYYY-MM-DD)].pdf	May 18, 2021, 5 p.m. EDT	SDdesign@nrel.gov

Note that a "bookmarked" PDF means the file has each major header bookmarked for easy viewing. This makes it easier for the jurors and reviewers to move around within lengthy and technical deliverables. For an example of what that looks like, view the bookmarks for this Rules document PDF. Guidance for creating a bookmarked PDF is provided on the Project Site.

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

6.1 Project Pitch Submission Instructions (Optional)

The optional Project Pitch communicates the initial plan of the design project to the organizers, and it is submitted via the Project Site.

The Project Pitch is an opportunity for each team to submit a preliminary Project Summary, which will be revised for subsequent submissions. The Project Summary is one piece of the Project Pitch submission, with the other major piece being the information completed in the Project Site form. The Project Summary provides a high-level description of the project with key takeaways, and introduces the team and collegiate institution. Teams submit the Project Summary as a stand-alone document, developed via the Project Summary template. Past Project Summaries can be viewed on the history web page, and an example is provided on the Project Site. Teams are highly recommended to submit a Project Pitch—to practice submitting deliverables through the Project Site as well as for early feedback from the organizers—although this submission is not required.

It is understood that for the Project Pitch, the details might be considerations, aspirations, or otherwise tentative and subject to change in future submissions. This submission will not impact future evaluation of the team's project.

Project Summary 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: 2
☐	File type: Single, bookmarked PDF
☐	File size: Less than 10 MB
☐	File name: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_SUMMARY_[SUBMISSION DATE in format of YYYY-MM-DD].pdf

Project Summary Content Requirements

Project Summary
☐ 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. Architecture 2. Engineering 3. Market Analysis 4. Durability and Resilience 5. Embodied Environmental Impact 6. Integrated Performance 7. Occupant Experience 8. Comfort and Environmental Quality 9. Energy Performance 10. Presentation.

6.2 Project Proposal Submission Instructions

The Project Proposal comprises an updated Project Summary and a 5-page Design Concept document. These deliverables provide an interim submission to demonstrate the team's progress and likelihood of a complete design and submission of the Design Portfolio. If a team conducts an internal competition and creates multiple projects, only one Project Proposal per team can be submitted and reviewed for acceptance as a Finalist Team. Teams submit the Project Proposal via the Project Site.

Note that teams also submit a further refined Design Concept as part of the Design Portfolio.

Project Summary and Design Concept 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: • Project Summary: 2 pages • Design Concept: No more than 5 pages; the cover, back pages, and table of contents are not included in this count.
☐	File type: Single, bookmarked PDF
☐	File name: • Project Summary: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_SUMMARY_[SUBMISSION DATE in format of YYYY-MM-DD].pdf • Design Concept: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_CONCEPT_[SUBMISSION DATE in format of YYYY-MM-DD].pdf

Project Summary Content Requirements

Project Summary
☐ 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. Architecture 2. Engineering 3. Market Analysis 4. Durability and Resilience 5. Embodied Environmental Impact 6. Integrated Performance 7. Occupant Experience 8. Comfort and Environmental Quality 9. Energy Performance 10. Presentation.

Design Concept Content Requirements

Front Matter (Not included in page count)
☐ Cover (list collegiate institution, team name, and Division name)
☐ Table of Contents
☐ List of Tables and/or List of Figures (as applicable)
Target Market and Design Constraints Description (1–3 pages)
☐ Describe the neighborhood and/or community setting, including density, access to, and reliance on various transportation modes
☐ Summarize the lot location, size, shape, orientation, and relationship to road(s)
☐ Summarize the intended occupants and their characteristics
☐ Describe how the building's community setting, lot location, and occupant characteristics impact the design constraints
☐ Describe the local climate

☐	Summarize the building science considerations—as influenced by the local climate—that impact the building envelope construction to ensure building durability
☐	Describe how existing codes, standards, and programs influence the building's design and achieve competition goals
Design Goals (1 page)	
☐	Summarize the goals the team considered when creating and developing the design.
☐	Summarize the building systems anticipated for the design.
Plans for Completing Design Portfolio (1 page)	
☐	Provide a timeline of team's next steps for completion of competition deliverables.

6.3 Design Portfolio Submission Instructions

The Design Portfolio demonstrates the culmination of all the team's design work, and provides the final materials needed to evaluate the project. The Design Portfolio must include:

1. Project Summary (updated)
2. Design Narrative
3. Three Project Images
4. Presentation Recording (20 minutes)
5. Slides for the live presentation.

In addition, teams have the option to submit Supplemental Documentation. The Design Narrative and Presentation Recording will be reviewed by jurors and used to determine preliminary scores prior to the Competition Event. The submission instructions for the Design Portfolio deliverables are as follows.

6.3.1 Project Summary

Teams must submit the Project Summary via the Project Site. The Project Summary should be updated as needed to reflect the final parameters of the design. It must follow the requirements below:

Project Summary 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: 2
☐	File type: Single, bookmarked PDF
☐	File size: Less than 10 MB
☐	File name: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_SUMMARY_[SUBMISSION DATE in format of YYYY-MM-DD].pdf

Project Summary Content Requirements

Project Summary	
☐	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. Architecture 2. Engineering 3. Market Analysis 4. Durability and Resilience 5. Embodied Environmental Impact 6. Integrated Performance 7. Occupant Experience 8. Comfort and Environmental Quality 9. Energy Performance 10. Presentation.

6.3.2 Design Narrative

Teams must submit the Design Narrative via the Project Site. This deliverable comprises an updated Design Concept as well as construction details and Contest narratives. The Design Narrative is limited to 60 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 Design Narrative. 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.

Design Narrative 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)
☐	Borders: 0.5-in. (12.7-mm) minimum, except for tables, figures, and images
☐	File type: Single, bookmarked PDF
☐	Limit content to no more than 60 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: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_NARRATIVE_[SUBMISSION DATE in format of YYYY-MM-DD].pdf

Design Narrative 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: Design Constraints and Goals (up to 4 pages)	
☐	Design Constraints Description, including timeline, budget, community setting, climate, building science considerations, codes, occupant characteristics, etc. (1–3 pages)
☐	Design Goals, including rating systems, energy targets, occupant experience, operational cost, etc. (1 page)
Section 2: Contest narratives, including relevant images and figures (up to 27 pages)	
☐	1. Architecture
☐	2. Engineering
☐	3. Market Analysis
☐	4. Durability and Resilience
☐	5. Embodied Environmental Impact
☐	6. Integrated Performance
☐	7. Occupant Experience
☐	8. Comfort and Environmental Quality
☐	9. Energy Performance.

Appendices	
☐	A. Design renderings **(up to 5 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

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

☐	i. Electrical and lighting plans and schedules,[10] including installed lighting (watt/ft^2 or watt/m^2) levels, control systems, and renewable systems
☐	C. Energy performance (HERS Index rating and/or EUI target) **(up to 4 pages)**
☐	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.
☐	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.

6.3.3 Supplemental Documentation

Teams submit Supplemental Documentation via the Project Site. Supplemental Documentation is optional and may not be more than 100 pages. This document 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. Jurors have a limited amount of time to review the entire submission. They might not read the Supplemental Documentation in detail or at all, and they are not expected to open any hyperlinks contained within.

Supplemental Documentation 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)
☐	Borders: 0.5-in. (12.7-mm) minimum, except for tables, figures, and images
☐	File type: Single, bookmarked PDF
☐	Limit content to no more than 100 pages
☐	Number pages
☐	File name: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_SUP_[SUBMISSION DATE in format of YYYY-MM-DD].pdf

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

6.3.4 Presentation Recording

Each team must submit a Presentation Recording summarizing their Design Portfolio via a Box link provided on the Project Site. The recording may be a maximum of 20 minutes. The base expectation is for teams to present slides with an audio narration; however, teams may be creative in how they chose to develop their Presentation Recording.

The jurors will review these recordings prior to the Competition Event. The recordings provide an opportunity to highlight design aspects that the team does not have time to discuss during the shorter presentation given live during the Competition Event. The Presentation Recordings from the winning teams will be shared via the Solar Decathlon YouTube following the Competition Event.

Presentation Recording Format Requirements

☐	Length: 20 minutes or less
☐	File type: .pptx, .mov, or .mp4
☐	File name: DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_RECORDING_[SUBMISSION DATE in format of YYYY-MM-DD].[EXTENSION]

Presentation Recording Content Requirements

☐	Cover Slide (list collegiate institution, team name, and Division name)
☐	Design Constraints and Goals
☐	Contest Narratives
☐	Energy Analysis
☐	Design Renderings

6.3.5 Project Images

Each team must submit three project images: two (2) images that best represent the project, such as renderings, drawings, photographs of scale models, or other team-generated content, and one (1) image of your team. These images must be submitted via the Project Site. Organizers use images to recognize individual team performance, to integrate into event materials, or for outreach, as appropriate.

Project Images Format Requirements

☐	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 in format of YYYY-MM-DD].[EXTENSION] • DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_PHOTO2_[SUBMISSION DATE in format of YYYY-MM-DD].[EXTENSION] • DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_TEAMPHOTO_[SUBMISSION DATE in format of YYYY-MM-DD].[EXTENSION]

6.3.6 Presentation Slides Submission Instructions

Each team develops one presentation for the competition event. The Presentation Slides are submitted via a Box link provided on the Project Site.

Presentation Slides 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.
☐	Maximum file size: • 100 MB.
☐	File name: • DC_[DIVISION]_[SHORT COLLEGIATE INSTITUTION NAME]_PRESDIV_[SUBMISSION DATE in format of YYYY-MM-DD].[EXTENSION]

6.4 Project Media Materials (Optional)

Each team may develop additional optional materials that showcase their design and response to Contest criteria. A session during the Competition Event will display the materials to teams, industry partners, and sponsors. Materials do not need to be submitted prior to the session.

6.5 Film Submission Instructions (Optional)

Teams can submit an optional short film, 3 minutes or less, to highlight how their design impacts the target market and/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 a Box link provided on the Project Site.

Film Format Requirements

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

Film Content Requirements

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

6.6 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 email to SDdesign@nrel.gov.

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 in format of YYYY-MM-DD].pdf

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

Competition Event
The period when teams are presenting to juries and related activities

Contest
Like the Olympic decathlon, the Contests evaluate the building for creativity, overall integration of systems, and ability to deliver outstanding aesthetics, efficiency, and functionality

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

Design Concept
A 5-page maximum Design Challenge deliverable as part of the Project Proposal; this is an interim submission that demonstrates a team's progress toward completing the Design Portfolio

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

Design Narrative
A 56-page maximum Design Challenge deliverable that is part of the 60-page Design Portfolio; the Design Narrative provides a complete submission to be reviewed by jurors in advance of the competition

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 dwelling unit 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. For more information, see the 2018 International Energy Conservation Code.

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

Finalist Teams
Teams selected to present their final design to Division Jurors at the Competition Event

Floor Area
The floor area of the building is the sum of the floor areas of the spaces within the building, including basements.[11] The floor area is measured from the exterior faces of the exterior walls or from the centerline of walls separating buildings. For more information see ANSI Z765-2003 and ASHRAE 90.1-2019.

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 Partner
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

[11] Floor area is sometimes referred to as the finished floor area or gross floor area.

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

Participant Team
A team that is not selected to present to Division Jurors, but allowed to participate in the Competition Event to present Project Media

Project Pitch
An optional deliverable that communicates the salient points of the projects to all competition participants

Project Media
An optional deliverable that showcases a team's design and response to Contest criteria

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

Project Summary
A 2-page, high-level description of the project with key takeaways and introductions of the team and collegiate institution; a preliminary Project Summary can be submitted through the optional Project Proposal, and updated in later deliverables

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; this document is the "Rules document"

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 that works 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. 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. 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 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

  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, collegiate 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

- 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.

- The U.S. Department of Energy Solar Decathlon 2017
- The U.S. Department of Energy Solar Decathlon 2015
- The U.S. Department of Energy Solar Decathlon 2013
- The U.S. Department of Energy Solar Decathlon 2011
- The U.S. Department of Energy Solar Decathlon 2009
- The U.S. Department of Energy Solar Decathlon 2007
- The U.S. Department of Energy Solar Decathlon 2005
- The U.S. Department of Energy Solar Decathlon 2002

Each individual team page on the Solar Decathlon website includes links to download a range of the following: 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.

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. 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. Recorded Seminar (Vimeo).

- Exploring Efficient Design for a Mass Timber Office: The Nail Laminated Timber Solution

  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. 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. 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. 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. Recorded Seminar (Vimeo).

Resources by Contest

Architecture

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- National Institute of Building Sciences—Whole Building Design Guide

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

- 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.

- Pacific Northwest National Laboratory—Building Science Publications

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

- 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.

- 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.

Engineering

- 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.

- 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.

- 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.

- 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.

Market Analysis

- 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.

- 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.

- 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 multifamily buildings, through evaluation of single building designs, parametric sweeps, and cost-based optimizations.

- 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.

- RSMeans

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.

- 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.

- LEED Guide to Certification: Homes

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

- 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.

Durability and Resilience

- 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.

- 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.

- 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.

- Federal Emergency Management Agency (FEMA) Risk Management: Building Science

The U.S. Federal Emergency Management Agency (FEMA) offers resources for risk management through building science to address resiliency in the face of natural hazards. Resources include publications on the effects of wildfires, earthquakes, hurricanes, and other natural hazards on building infrastructure and guidance for mitigating the associated risks.

Embodied Environmental Impact

- Design for the Circular Economy: Cradle to Cradle Certification

This website provides information on Cradle to Cradle Certification as well as resources for Circular Design, including material selection guidance, videos, podcasts, and case studies.

- Material Flow Tracking system

This research presents a model of materials present in the Swiss residential building stock and predicts future flow of materials on an individual building basis. Capturing this information supports strategies for reducing environmental impact of buildings based on informed material choice.

- Katerra LCA study for Modular

The Carbon Leadership Forum provides a report on their life cycle assessment of cross laminated timber in the Katerra Catalyst Building. The report outlines opportunities for reducing environmental impact and enhancing efficiency in mass timber construction of mid-rise structures.

- Using Life Cycle Assessment Methods To Guide Architectural Decision-Making For Sustainable Prefabricated Modular Buildings

This research provides a case-study of using life cycle assessment modeling to inform sustainable design decisions for prefabricated modular buildings. Findings emphasize the importance of minimizing operational energy impacts.

Integrated Performance

- Whole Building Design Guide

The Whole Building Design Guide (WBDG) presents the philosophy of the integrated design approach and design objectives for whole building design. WBDG also includes guides for building envelope design.

- Integration at its Finest: Success in High-Performance Building Design and Project Delivery in the Federal Sector

This research report by Renee Cheng, AIA, Professor at the University of Minnesota School of Architecture, highlights the successes the integrated design approach for high-performance building design in the Federal Sector.

Occupant Experience

- 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.

- 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.

- ENERGY STAR Efficient Lighting and Appliances

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

- 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.

- 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.

- 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.

- 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. This website has a guideline for common areas to assist in achieving appropriate light levels with the greatest energy efficiency.

- 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.

- 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.

Comfort and Environmental Quality

- 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.

- 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.

- 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.

- 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.

- ENERGY STAR® Heat and Cool Efficiently, Maintenance Checklist

This is a checklist for maintaining heating and cooling equipment.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

Energy Performance

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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 multifamily 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.

- 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). Refer to the Software Document on the Project Site for full instructions.

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

- Ripple (software tool)

Ripple is a web-based tool developed by Slipstream that allows for basic energy modeling for commercial building types. Some large residential building types, such as multifamily residential, are also included. The platform provides a user-friendly introduction to whole-building energy modeling that is suitable for all level of users. The tool provides the opportunity to model how various improvement measures can impact overall energy performance and cost compared to a baseline. Refer to the Software Document on the Project Site for full instructions on how to access Ripple.

- 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.

- 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.

- 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.

- 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.

- 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).

- EPA WaterSense

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

Presentation

- Solar Decathlon 2020 Design Challenge (Team Presentations)
- Solar Decathlon 2019 Design Challenge (Team Presentations)

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

- 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.

- DOE-Hosted Presentations

This YouTube channel includes video presentations on various topics.

- 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.

- 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.

- 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).

- National Energy Educational Development Project (NEED)

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.

- National Institute of Building Sciences Innovation Conference Proceedings

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

- 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.

Additional Resources

Passive House

- PHIUS+

PHIUS is a non-profit organization dedicated to making high-performance passive buildings the mainstream standard. PHIUS provides training and certification programs for building professionals, conducts high-performance building research, and certifies passive buildings. PHIUS offers software and resources to assist building designers in incorporating passive design strategies, including the WUFI® Passive energy modeling software available for download at no charge.

- International Passive House Association (iPHA)

iPHA is a global network of Passive House stakeholders including architects, planners, scientists, suppliers, manufacturers, contractors, and property developers. It works to promote the Passive House Standard and foster a greater public understanding of its significance. IPHA provides Passive House Guidelines and contributes to additional passive design resources, including Passipedia: The Passive House Resource.

- Passipedia: The Passive House Resource

Passipedia is a web-based collection of resources related to the passive house design concepts curated by the Passive House Institute (PHI). Resources cover a range of topics for both residential and non-residential passive design strategies, including building envelope, mechanical systems, and applying passive strategies in different climates.

Design for Disassembly/Deconstruction

- Design for Disassembly – Themes and Principles

The disassembly of buildings to recover materials and components for future reuse is not widely practiced in the modern construction industry. This guide covers a range of themes and offers a set of principles, or guidelines, for design for disassembly that can be applied to a project in order to facilitate and encourage greater rates of reuse and recycling in the future.

See more of Dr. Philip Crowther's works for additional resources on design for disassembly and deconstruction.

- EPA Study on Methods and Success Stories for Designing for Disassembly and Deconstruction

This series of fact sheets developed by EPA highlights innovative approaches, results, and environmental and economic benefits emerging from innovative pilot projects that test ideas and strategies for improved environmental and public health results. Specifically, fact sheets cover topics on design for disassembly in the built environment; deconstruction for urban revitalization; and design for reuse.

Industrialized Construction

- Modular Construction—Process to Product

This research by McKinsey & Company quantifies benefits and challenges of modular construction and its potential for widespread and sustainable impact. Specifically, it covers cost-saving benefits, market impacts, and various approaches to modular construction.

- Modular Advantage by Modular Building Institute

This edition of Modular Advantage includes highlighted success stories and case studies of modular and offsite construction in industry. Topics include the future of offsite construction, construction savings and advantages, relocatable buildings, and innovative instances of modular design.

- Mass MODX

This resource by the Northeastern School of Architecture includes clear discussions with graphics and insights on a variety of topics concerning modular design, including modular ecologies, the modular factory and method of production, urban instances of modular design, modular dimensions, modular coalitions, and other indicators and initiatives.

- Off-site School in UK

Offsite Hub is an online information center for offsite construction based in the UK. The project gallery contains numerous case studies on offsite construction projects for both residential and commercial, including schools and retail, sectors.

- Design for Modular Construction by AIA

This materials practice guide by the American Institute of Architects is an introduction for architects entering the realm of modular construction design. It outlines the modular approach in detail, highlighting both benefits and barriers of modular construction. The guide also includes additional resources for prefab and modular architecture.

Advanced Manufacturing Tools for Buildings

Subtractive Manufacturing for Buildings

- Integrated Design and Manufacturing [IDM] Framework for the Modular Construction Industry

This research by Virginia Tech investigates the connection between design and manufacturing design phases for modular single-family homes. It also proposes strategies for improving this relationship through an integrated design and manufacturing (IDM) framework.

- WikiHouse

WikiHouse is a digitally-manufactured building system that aims to simplify design, manufacturing, and assembly of high-performance homes. CNC-fabrication of modular WikiHouse components can be performed on site, eliminating the cost for a prefabrication facility. Simple assembly of components further enhances the speed and practicality of the WikiHouse process. The WikiHouse Guide outlines the technology and process in full.

- Blueprint Robotics

Blueprint Robotics utilizes an integrated engineering approach and robotics to manufacture custom wall, floor, and roof elements for building projects. Designs are sent to the Blueprint Robotics facility, where robotics are used to quickly construct building elements, that are shipped to and assembled on the building site.

- Swedish Production Line for Construction

Lindbäcks Bygg, a Swedish modular timber-frame home manufacturer, is highlighted for its revolutionary assembly line approach to successful production. Training workers and streamlining processes through worker feedback are two ways in which Lindbäcks is able to maximize efficiency without sacrificing quality.

- Fabricating the Modern Dwelling

A prefab house designed and built by MIT architect Larry Sass uses mass-customized and standardized components that require no nails, screws, or glue for assembly. The structure is assembled with entirely friction-fit components.

- Digital Fabrication

The Design Fabrication Group MIT highlights a digital fabrication project in which planar modeling is used to break a building design into components that connect with interlocking joints. This method increases affordability by reducing on-site construction costs, making it a possible solution for affordable housing construction.

Additive Manufacturing for Buildings

- Hypes and Limitations of 3D printing in construction

This article provides an overview of the 3D-printing with concrete in the building sector and the progress of this technology. Benefits and limitations are highlighted, including examples of successful implementation of 3D-printed concrete structures.

- Contour Crafting

Contour Crafting Corp uses robotics to construct detached houses to multi-story and -unit structures through 3D-printing with concrete.

Process Optimization

- Digital Twin for construction

A digital twin is digital representation of the real-world object. In the case of construction, a digital twin can be used to monitor construction and make changes real-time, document progress, and streamline production methods. It also provides opportunities for automated process and safety monitoring, resource planning and logistics, quality assessment, and optimization of equipment usage.

- Solar Home Factory: Industry Best Practices

The Solar Village in Geneva, NY, is a fully solar-powered community designed by the Solar Home Factory. Their design includes prefabricated off-grid homes, community buildings, electrical vehicle checkout system, community gardens, and a 1.5-megawatt Solar Farm with battery back-up.