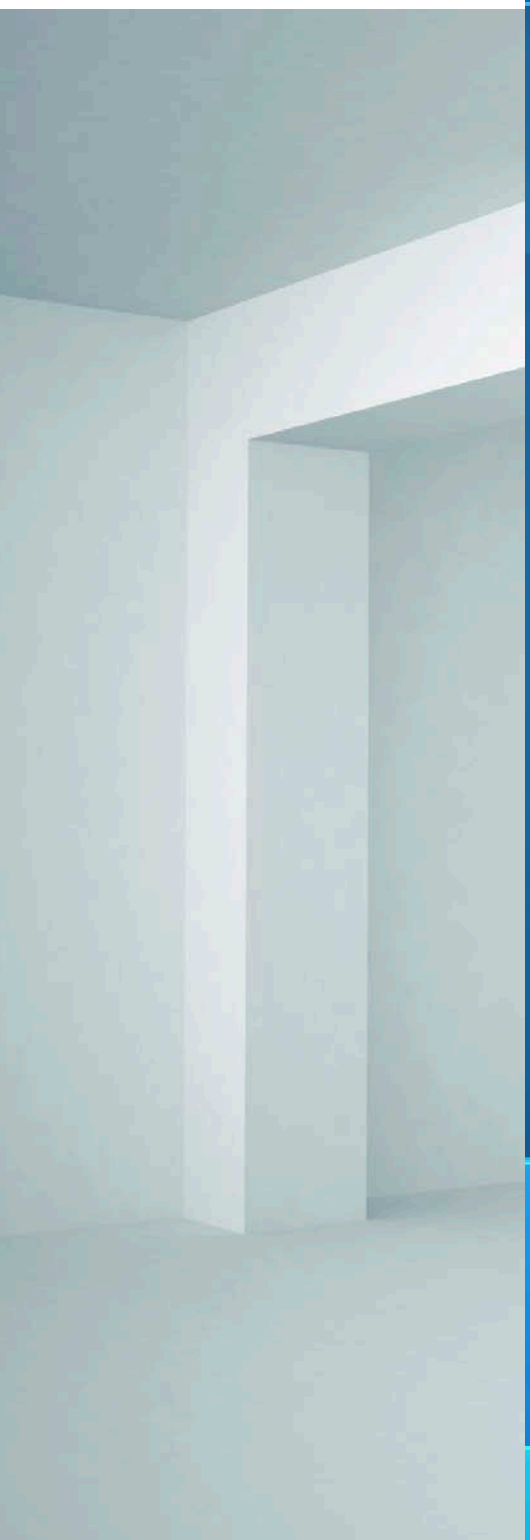
RACE TO ZERO

U.S. DEPARTMENT OF ENERGY

2015 STUDENT DESIGN COMPETITION



Student Design Competition Guide to Project Preparation and Submittal

February 2015

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FOREWORD

This Guide to the Race to Zero Student Design Competition is a comprehensive overview of the framework, timeline, design parameters, judging criteria, and awards. This Guide provides links to resources that the teams will need.

- Read this Guide and consider forming a multidisciplinary team. A team must have at least one faculty advisor and three students, one of whom must be designated as the student team lead. The faculty advisor and one student team lead must register the team.
- **Register** your team when you are ready or **sign up** for updates if you are interested but not ready to register.
- When registration is complete, team members will be contacted via email so they can access additional resources.
- All team members with a construction/engineering/architecture/design major must complete the DOE Building Science Training course either in person or online. Team members majoring in business or related fields do not need to complete this coursework. This coursework is provided at no cost to every team member.
- Review the winning team's **submissions** from last year's competition to see the style of submission expected. Note that this year's rules and requirements have changed.
- Become familiar with this Guide and each subject area BEFORE beginning the project design process.
- Identify project types and subject areas where industry partnership is needed or desired.
- Study the DOE Zero Energy Ready Home program requirements, including explanatory footnotes.
- Regularly consult the DOE Student Competition **website**, your student team lead, and faculty advisor for competition updates and announcements.
- Submit all materials for judging by the deadline. Late entries will not be accepted.
- Submit your **questions for assistance**.

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01

Vision Statement

This is an exciting time—a time when zero energy ready homes have become readily achievable and cost effective. By definition, these high-performance homes are so energy efficient that renewable power can offset all or most annual energy consumption.

The U.S. Department of Energy's (DOE) Race to Zero Student Design Competition (Race to Zero[1]) is engaging college students to become part of a new leadership movement to achieve truly sustainable homes.

As part of DOE's Building America and Zero Energy Ready Home programs, the Race to Zero was designed to:

- Inspire and develop the next generation of residential design and construction professionals with building science expertise.
- Advance and enhance building science curriculum in universities.
- Complement the experiential learning benefits provided by the U.S. Department of Energy Solar Decathlon through an additional collegiate competition opportunity.

This competition will help to provide the next generation of architects, engineers, construction managers, and entrepreneurs with skills and experience to start careers in clean energy and generate creative solutions to real-world problems.

INSPIRE & DEVELOP the next generation of residential design and construction professionals.

1 Formerly the DOE Challenge Home Student Design Competition

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Benefits of Participation

Participants in the Race to Zero will have the opportunity to provide creative solutions to real-world issues in our nation's housing industry. Teams with complete entries will be invited to attend the competition's judging day and present their proposals to a panel of judges. The winning teams will be recognized at a national conference and the winning designs will be made available on DOE's Zero Energy Ready Home website. The competition, awards event, and winners will all be promoted through a variety of media publications, which will provide an opportunity for national exposure for participants and their universities. Universities will benefit from participating in the Race to Zero with an opportunity to showcase themselves as leading institutions that are producing job-ready young professionals with cutting-edge skills. Builders who participate with teams will gain national and local recognition and will have the opportunity to interact with knowledgeable future design and construction professionals.

View Previous Year's Winners

DOE, Student Competition Results: **http://energy.gov/eere/buildings/2014-results**

CREATIVE SOLUTIONS
for real-world issues in our nation's housing industry.

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Competition Framework

The Race to Zero is configured to enable student participation over an academic year, beginning with the fall semester and ending midspring semester with the project presentation and award ceremony.

Each team must be sponsored by a collegiate institution and registered by a faculty advisor. The team must have at least three students, a faculty advisor, and a designated student team lead. Teams are encouraged to be multidisciplinary and to have industry advisors, such as local home builders or architects, to help inform their decision-making process. There is no limit on the number of teams from a college or the number of students on a team. Multiple colleges may merge to form a team.

Teams may develop projects based on an update of existing house plans from a builder or work from conceptual approaches to the design competition. Teams may also take advantage of opportunities to work on redevelopment projects in their local communities. (See Section 08 of this Guide for information on opportunities on design challenges offered by builders and developers.) Eligible scenarios are limitless, but the submission must conform to the conditions in Table 1. Specific location, building lot, and neighborhood characteristics are required information as context for both the house design and its relationship to surrounding homes and the community. The mandatory minimum design target is the DOE Zero Energy Ready Home (Rev. 04) and the design solution(s) must be documented in the submission to meet the following criteria:

- They must achieve at least the DOE Zero Energy Ready Home energy performance level and meet the other program requirements for wall insulation, size factor, etc.
- Teams must demonstrate effective integration of building science principles and best practice guidelines for the building envelope and mechanical systems.
- Teams must relate their designs to the marketplace—this means that the teams must demonstrate the affordability of their designs with a 30-year mortgage.
- Architectural, engineering, and construction management team members must complete a free building science course offered by DOE. The course will be available in classroom format at the National Renewable Energy Laboratory or online. This requirement may be waived by the team's faculty advisor with an attestation of equivalency for courses the student has successfully completed.

2 DOE Zero Energy Ready Home National Program Requirements (Rev. 04) **http://www.energy.gov/sites/prodfiles/2014/04/f15/doe_zero_energy_ready_home_requirements_rev04.pdf**

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The final judging process will include an oral presentation by each invited team to a panel of jurors. Following the oral presentations, each jury panel will select award category winners and nominate a grand winner. Finally, a grand winner will be selected from the nominated teams by a deliberation process involving all the jurors.

UNIQUE & VALUABLE opportunity to interact with knowledgeable future design and construction professionals.

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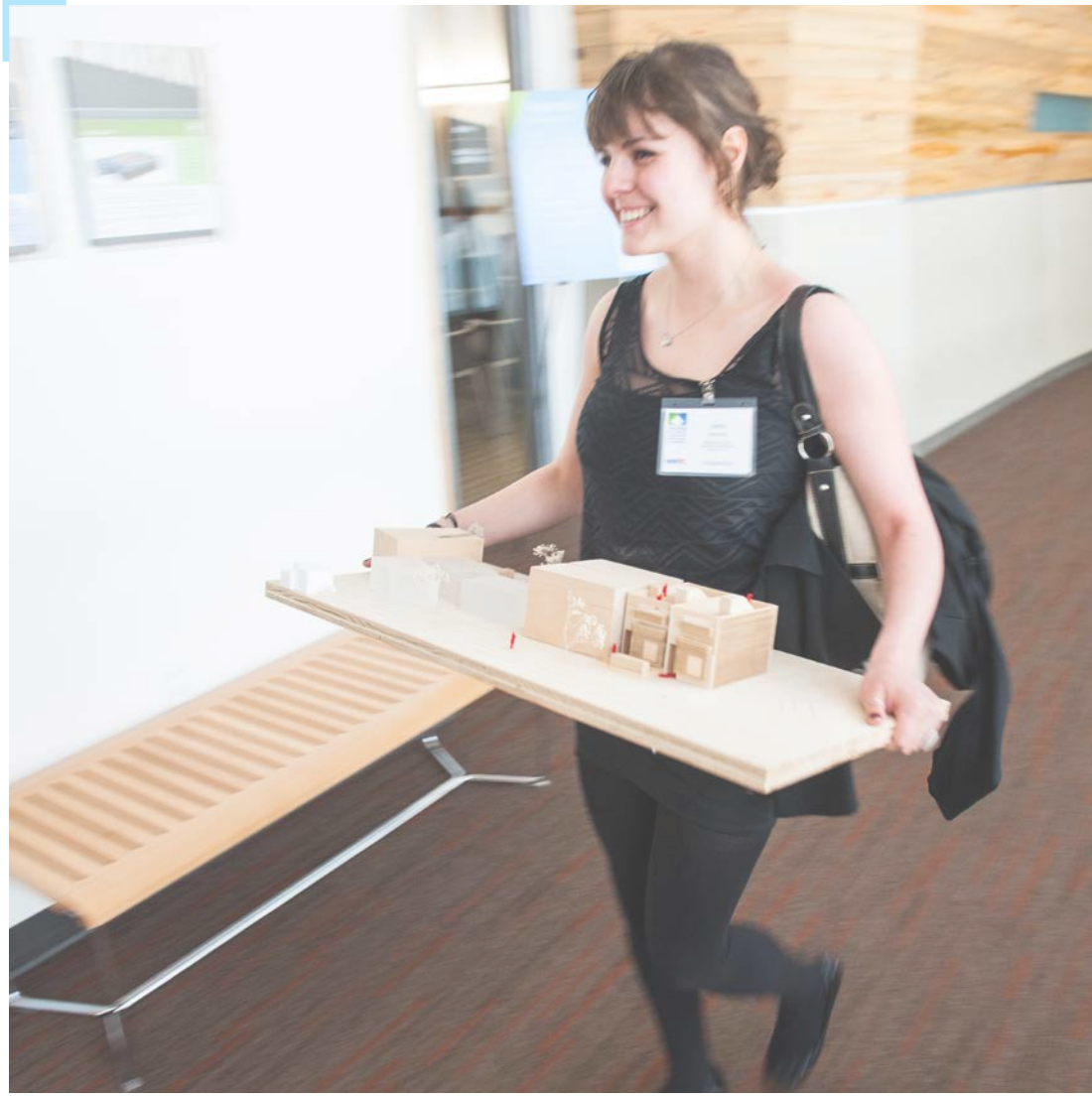
Timeline

- Registration Deadline: December 15, 2014
- Fall Semester 2014/Spring Semester 2015: Students Develop Design for Submittal
- Project Submissions: Due Sunday, March 22, 2015
- PowerPoint Presentation Upload: Due Sunday, April 12, 2015
- Race to Zero Competition: April 18-20, 2015
- Final Judging and Award Event: April 18–19, 2015.

RACE TO ZERO IS producing job-ready young professionals with cutting-edge skills.



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Student Design Competition Project Design Parameters

All projects must address the project elements outlined in Table 1. The project elements provide context for the project and provide self-selected design constraints.

Table 1. Project Context

Project Element	Description
House type	Single-family detached, single-family attached, dwelling units in multifamily buildings per the DOE Zero Energy Ready Home program (high-rise multifamily excluded)
Location	Any location where basic utility services can be provided within the cost constraints for the house design and construction
Climate zone	All climate zones permitted; if appropriate, highlight the applicability of the house design to multiple climate zones
Lot size and configuration, house orientation	Clearly identify the lot size for the house, the orientation and location of the footprint on the lot, the road frontage, and other site- and lot-specific features such as terrain, vegetation, and proximity to natural water features
Neighborhood and/or community setting	Describe the relationship of the house design and location with respect to a neighborhood and/or community setting, including density, access to or reliance on various transportation modes, and other factors
Occupants	Describe how the house design and space configuration accommodate persons of different ages, physical abilities, etc.
Sustainability	Describe aspects of sustainability such as resource efficiency, resiliency, and attention to local resources
Project type	For projects developed in conjunction with a builder and intended for construction, describe the salient features such as the construction schedule and size of the project
Programs and standards	Identify any programs or standards that form the basis for design and their roles in achieving the goals of the competition

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Judging Principles

Projects submitted to the Race to Zero will demonstrate competency by applying Building America's research findings, best practice solutions, and principles of building science. The teams will be judged on their submissions, including the design and technical documentation, project plans, and reports on required analyses. These submissions should demonstrate the teams' ability to design, analyze, and plan for the construction of quality, high-performance homes that meet or exceed the DOE Zero Energy Ready Home requirements.

The jurors will evaluate how well teams meet the overall goals of the competition and complete the requirements of the submission package. Specific metrics used by the judges will include:

1. **Design:** An evaluation of the project home design set within its regional context and current market expectations and how well it incorporates features and systems that integrate proven high-performance innovations.
2. **Cost Effectiveness:** The degree to which the competition home is determined to be cost effective, from a buyer's perspective, providing a financial analysis that includes construction and site costs, monthly mortgage payment, insurance, utilities, debt burden, and taxes relative to household income.
3. **Performance Analysis:** Clear and concise documentation of the analysis used to estimate achievement of a DOE Zero Energy Ready Home performance level or better.
4. **Technical Documentation:** Focused and succinct documentation to demonstrate the building science principles and best practice guidelines used in the house design.

ZERO ENERGY homes have become readily achievable and cost effective.

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Judging Evaluation Subject Areas and Point Rating

Subject Areas

Jurors will score each section on a scale of 0 to 5 points (the higher point level indicates a more complete submission). Each section is weighted by a maximum point value. The juror point scale is then converted to a percentage and applied to the weighted point level. Each section total is summed into a final project score.

Section	Subject Area	Maximum Point Value	Juror Rating Scale	Percent Weighting*	Subject Area Points
A	Team Qualifications	Complete Documentation			
B	Design Goals	25	0–5	0%–100%	0–25
C	Envelope Durability	15	0–5	0%–100%	0–15
D	Indoor Air Quality Evaluation	10	0–5	0%–100%	0–10
E	Space Conditioning	10	0–5	0%–100%	0–10
F	Energy Analysis	10	0–5	0%–100%	0–10
G	Financial Analysis	10	0–5	0%–100%	0–10
H	Domestic Hot Water, Lighting, Appliances	7	0–5	0%–100%	0–7
I	Construction Documents	8	0–5	0%–100%	0–8
J	Industry Partners	5	0–5	0%–100%	0–5
					Weighted Total for Subject Areas 0-100

*Percent weighting calculated as a percent based on the judge scale; i.e., a judge rating of 3 = 60% weighting

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Example Team Rating

Section	Subject Area	Maximum Point Value	Juror Rating Scale	Percent Weighting*	Subject Area Points
A	Team Qualifications	Complete Documentation			
B	Design Goals	25	4.0	80%	20.0
C	Envelope Durability	15	3.0	60%	9.0
D	Indoor Air Quality Evaluation	10	4.5	90%	9.0
E	Space Conditioning	10	3.0	60%	6.0
F	Energy Analysis	10	2.5	50%	5.0
G	Financial Analysis	10	4.0	80%	8.0
H	Domestic Hot Water, Lighting, Appliances	7	2.5	50%	3.5
I	Construction Documents	8	4.0	80%	6.4
J	Industry Partners	5	4.5	90%	4.5
					Weighted Total for Required Subject Areas 71.4

*Percent weighting calculated as a percent based on the judge scale; i.e., a judge rating of 3 = 60% weighting

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Submission Detail for Each Subject Area

A. Team Qualifications and Summary Description (Mandatory)

Describe the qualifications, relevant education, and training to meet project goals for each team member, including any industry partners. Identify applicable coursework, projects, training, and experience that contribute to the design of a high-performance home meeting ENERGY STAR® and DOE Zero Energy Ready Home requirements. Outline the sponsoring institution's qualifications, particularly in regards to building science education and the design of high-performance homes.

Required Submittal Items Checklist:

- Team profile and qualifications for each student member and industry partners
- Academic institution profile with particular focus on building science
- The faculty advisor shall affirm in writing that all the construction-major students have satisfied the DOE Building Science Training Course requirement or provide a statement of equivalency with courses offered at their school.
- One-page project summary following prescribed format shown in Appendix B.

Supporting Resources:

DOE Building Technologies Office Building Science Education:
http://energy.gov/eere/buildings/building-science-education

Excellence in Building Science Education:
http://buildingscienceeducation.net/

B . Design Goals and Project Context

The Zero Energy Ready Home level of performance will not achieve meaningful market acceptance unless it is integrated with architectural designs that meet or exceed consumer expectations. Describe the general approach to the overall project and house to integrate high-performance home building science principles while incorporating each element for the project outlined in Table 1. This includes describing design concepts such as home fit to site, natural comfort (e.g., solar orientation, solar shading, thermal mass, natural shading, natural ventilation), convenient placement of rooms, open floor plan, minimal wasted space, minimal circulation, varied ceiling height, integration of major systems (e.g., structural, HVAC, plumbing, lighting, furniture placement, storage, disaster resistance), and linkage to outdoors.

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Provide an overview of how a building systems-approach informs the design to meet sustainability goals, ENERGY STAR, and DOE Zero Energy Ready Home goals. Describe the integrated design process and how the Quality Management Provisions (**QM #2**) may be incorporated into the high-performance home design process and documentation.

Include descriptions of how your team's design approach was influenced by other national, regional, and local programs. To the extent they are available for your selected site, consider the project's economic impacts and enhancements from utility incentive programs, tax credits, and other rebates.

Supporting Resources:

National Building Museum, Principles of Sustainable Design:
www.nbm.org/exhibitions-collections/exhibitions/the-green-house/principles.html

DOE Zero Energy Ready Home:
www.eere.energy.gov/buildings/residential/ch_index.html

DOE Guidelines for Participating in the DOE Zero Energy Ready Home:
http://energy.gov/eere/buildings/guidelines-participating-doe-zero-energy-ready-home

ENERGY STAR Energy Efficient New Homes:
www.ENERGYSTAR.gov/index.cfm?c=new_homes.hm_index

DOE Challenge Home Recommended Quality Management Provisions:
www.eere.energy.gov/buildings/residential/pdfs/doe_challenge_home_provisions032812.pdf

AIA Ecological Literacy in Architecture Education Report and Proposal:
http://www.aia.org/practicing/groups/kc/AIAS074665

C. Envelope Durability Analysis

Discuss the major mechanisms that affect envelope durability integrating building science concepts of air transport, moisture management, and thermal and hygrothermal performance based on specific environmental conditions.

Provide summary examples of how the construction details and material specifications address: the physical principles for air movement control based on air sealing and air barrier designs; thermal control using insulation systems including analysis of thermal bridging; water and moisture management including envelope features to shed precipitation, control of moisture movement through the wall system, and the potential for moisture problems (such as condensation).

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Describe how the DOE Zero Energy Ready Home Quality Management Provisions (**QM #1**) may be incorporated into the high-performance home documentation to reliably implement envelope systems that are resistant to moisture damage and air infiltration.

Supporting Resources:

ASHRAE

https://www.ashrae.org/ (ASHRAE provides several relevant resources, such as Chapter 25 of the Handbook of Fundamentals)

DOE, Building Technologies Office, Building Science Education:

http://energy.gov/eere/buildings/building-science-education

DOE, Challenge Home Recommended Quality Management Provisions:

http://www1.eere.energy.gov/buildings/residential/pdfs/doe_challenge_home_provisions032812.pdf

Pacific Northwest National Laboratory, Building Science Publications:

http://bse.pnnl.gov/

U.S. Environmental Protection Agency (EPA), Moisture Control Guidance for Building Design, Construction and Maintenance:

http://www.epa.gov/iaq/moisture/

Oak Ridge National Laboratory, Foundation Design Handbook:

http://foundationhandbook.ornl.gov/handbook/

D. Indoor Air Quality Evaluation

Discuss the overall approach to indoor air quality (IAQ) to meet general performance goals and satisfy specific field conditions.

Provide summary details of the IAQ environment, pollutant, and moisture control and the use of, and reliance on, mechanical systems to control the indoor environment. Provide references to ASHRAE and other standards and a specific evaluation using EPA's Indoor airPLUS design requirements relative to all spaces in the home. Include evaluations based on radon zones, common pest control features (i.e. termites), or other geographic issues that influence the selection of IAQ features and control.

Example Resources:

EPA, Indoor airPlus Program:

http://epa.gov/indoorairplus/

National Institute of Building Sciences, Whole Building Design Guide:
http://www.wbdg.org/design/ieq.php

ASHRAE, Special Project Activities:
https://www.ashrae.org/standards-research--technology/special--project-activities

Lawrence Berkeley National Laboratory, Indoor Air Quality Scientific Findings Resource Bank: **http://www.iaqscience.lbl.gov/**

E. Space Conditioning Design and Analysis

Discuss the range of performance objectives for the mechanical systems targeted for space conditioning. Describe the systems approach relative to the structure and climate, including design principles for the mechanical system, the proposed operation and control, and the thermal conditioning for each type of space in the home.

Describe the design of the space conditioning operation goals, equipment selection and integration, operation and control, and evaluation of fuel selection options. Include system design using ACCA Manuals J, S, D, and T protocols or other industry practices such as ASHRAE or equipment manufacturer. Establish a set of commissioning (startup) requirements referenced to manufacturer and trade protocols.

Summarize the maintenance requirements. Define occupant and trades roles and include, if possible, estimated annual costs.

Supporting Resources:

DOE, Building Technologies Office Library:
www1.eere.energy.gov/library/default.aspx?page=2

Pacific Northwest National Laboratory, Building Science Publications:
http://bse.pnnl.gov/

Resources from the Air Conditioning Contractors of America:
www.acca.org/
www.acca.org/standards/acca-speed-sheets
www.acca.org/standards/technical-manuals
www.acca.org/standards/

ENERGY STAR, Energy Savings at Home:

www.ENERGYSTAR.gov/index.cfm?c=heat_cool.pr_maintenance

ASHRAE, Education & Certification Fundamentals of Air System Design:

www.ashrae.org/education--certification/self-directed-or-group-learning/fundamentals-of-air-system-design

Advanced Strategy Guideline: Air Distribution Basics and Duct Design:

http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/strategy_guide_air_distr.pdf

Trane, VeriTrane Duct Designer:

www.trane.com/Commercial/DNA/View.aspx?i=1239

Elite Software, Ductsize - HVAC Duct Sizing and Analysis:

http://www.elitesoft.com/web/hvacr/duct60.html

Wrightsoft, Simple, Powerful HVAC Design and Sales Software:

http://www.wrightsoft.com/

Design Master, Software Duct Layout:

www.designmaster.biz/products/hvac/LearnMore/Features/duct-layout.html

F. Energy Analysis

Discuss the approaches your design process considered to energy efficiency for all aspects of the home and how the various efficiency features interact. Discuss the constraints and challenges to efficiency improvements in any one feature relative to, for example, climate, occupancy, or building use.

Perform and document the Home Energy Rating System (HERS) rating whole-house annual energy consumption simulations, including the final plan-based HERS Index Score determined without renewable energy system supply and the projected annual energy consumption to meet the maximum DOE Zero Energy Ready Home HERS Index Score. Include the house size factor adjustment calculations as required for homes exceeding the square feet specified in the Size Adjustment Factor table. If renewable energy systems (that produce electrical energy) are included, perform a second HERS Index analysis to include the energy supply from the renewable energy system.

Discuss the opportunities, tradeoffs, and house design modifications needed to incorporate renewable energy systems sufficient to achieve a zero net energy use from all nonrenewable energy sources. Describe technology options that are appropriate for the location and climate, considering the neighborhood community as a potential for average

reductions of nonrenewable energy use applied to the individual homes. If the available resource or the particular design of the home within its location context precludes the use of renewable energy systems, document this design consideration.

Based on the DOE Zero Energy Ready Home program requirements, provide details of the EPA Renewable Energy Ready Home guidelines for solar water heating and solar photovoltaic systems. Demonstrate design details that comply with Renewable Energy Ready Home checklists for solar electric and solar thermal systems.

Provide a design and component analysis for active renewable energy systems to achieve a zero net energy use across all nonrenewable energy sources used in the home. Document energy production and cost estimates, including maintenance requirements and performance lifetime expectations.

Supporting Resources:

DOE Zero Energy Ready Home National Program Requirements (Rev. 04):
www.energy.gov/sites/prod/files/2014/04/f15/doe_zero_energy_ready_home_requirements_rev04.pdf

DOE Guidelines for Participating in the DOE Zero Energy Ready Home:
http://energy.gov/eere/buildings/guidelines-participating-doe-zero-energy-ready-home

ENERGY STAR Renewable Energy Ready Homes (RERH):
http://www.ENERGYSTAR.gov/index.cfm?c=rerh.rerh_index

Florida Solar Energy Center Zero Energy Homes:
www.fsec.ucf.edu/en/research/buildings/zero_energy/

PVWatts A Performance Calculator for Grid-Connected PV Systems:
http://rredc.nrel.gov/solar/calculators/pvwatts/version1/

NREL BEopt: **http://beopt.nrel.gov/**

Architectural Energy Corporation REM/Rate: **www.archenergy.com/products/remrate**

EnergyGauge Energy and Economic Analysis Software: **www.energygauge.com/**

G. Financial Analysis

Analyze the financial implications of siting and constructing the DOE Zero Energy Ready Home design. The financial analysis includes both costs and affordability. Costs should include estimates for the land, utility infrastructure (i.e. an improved lot), house construction including high-performance features, energy use, and optionally, water use and estimated maintenance costs. Construction costs can be based on standard cast databases such as

RSMeans or be based on standard cost data provided by DOE (see resources below). If applicable, include federal, state, and local financial incentives for use of renewables or for energy efficiency upgrades in the analysis (refer to the supporting resources below).

The purpose of the financial analysis is to relate the design to the marketplace by defining a financial profile of a buyer based on estimated sales price and the overall cost of home ownership. Affordability may be estimated for typical market segments (entry level, move-up, etc.) but should result in the necessary household income required to purchase and live in the project home assuming a 30-year fixed mortgage. Elements of the financial analysis include the estimated sales price, financing (mortgage), insurance, household debt, and taxes. Various resources are available to estimate the elements included in the financial analysis; however, consultation with builder, realtor, and lender partners will help teams navigate this analysis.

The financial details and estimates outlined in the table below are meant to provide a resource for estimating financial aspects of homeownership affordability. Because some financial parameters depend on the household income, which is the result of the analysis, the analysis may be an iterative process (Table 2).

Supporting Resources:

A description of the NREL National Residential Efficiency Measures Database: **www.nrel.gov/ap/retrofits/pdfs/development_document.pdf**

National Residential Efficiency Measures Database: **www.nrel.gov/ap/retrofits/about.cfm**

RSMeans database of construction costs: **http://subscription.rsmeansonline.com/Registration/TrialRegistration?id=OGOG-2004#**

Software that utilizes the database cost measures: **http://beopt.nrel.gov/**

Clemson Extension, How Much House Can You Afford: **http://virtual.clemson.edu/groups/psapublishing/Pages/FYD/EC676.pdf**

DOE DSIRE: **www.dsireusa.org/**

Table 2. Construction Costs and Financial Parameters

Median Family Income (MFI)	For a reference of income levels in a selected location, use the HUD FY2013 Median Family Income (MFI) data set[1] to determine representative income levels. However, the financial analysis will result in an income level necessary for the purchase and operation of the project home.
Homeownership Affordability	For the purposes of this competition, the homeownership affordability should not exceed 38% of the household income. Home ownership affordability includes principal (P), interest (I), property taxes (T), home and mortgage insurance (I), and utilities (U) (energy and water).
Utility Costs	Use local utility costs with energy (and water) use estimates. May be defined for a specific location based on actual utility rates or use representative resource.[2]
Financing (Principal and Interest)	4.5%, 30-year fixed rate
Property Tax[3]	Use local data resource
Insurance[4]	$780, or use local data resource
Down Payment	20% of house cost
Monthly Household Debt	0.5% of MFI
Construction Cost Estimates	Construction Documents
Non-Construction Costs	Calculate the non-construction costs as a percentage of the sales price using 40.6% times the sales price. The remaining cost is associated with the construction of the home.[5]
Direct Construction Costs	Use the Supporting Resources below or another referenced source to estimate construction costs. For a general breakdown of construction costs by major features as a percent of house value, refer to the NAHB study "New Construction Cost Breakdown.[5] "

1 **http://www.huduser.org/portal/datasets/il/il13/index_mfi.html.** Use the rounded MFI estimate.

2 For example for electric rates, **http://en.openei.org/wiki/Gateway:Utilities**, or use Energy Information Administration data

3 **http://www.nahb.org/generic.aspx?sectionID=734&genericContentID=163494&channelID=311** and **http://www.nahb.org/generic.aspx?sectionID=734&genericContentID=155396&channelID=311**

4 See **http://www.nahb.org/generic.aspx?sectionID=734&genericContentID=193629&channelID=311** for one resource of home ownership costs

5 **http://www.nahb.org/generic.aspx?genericContentID=169974**

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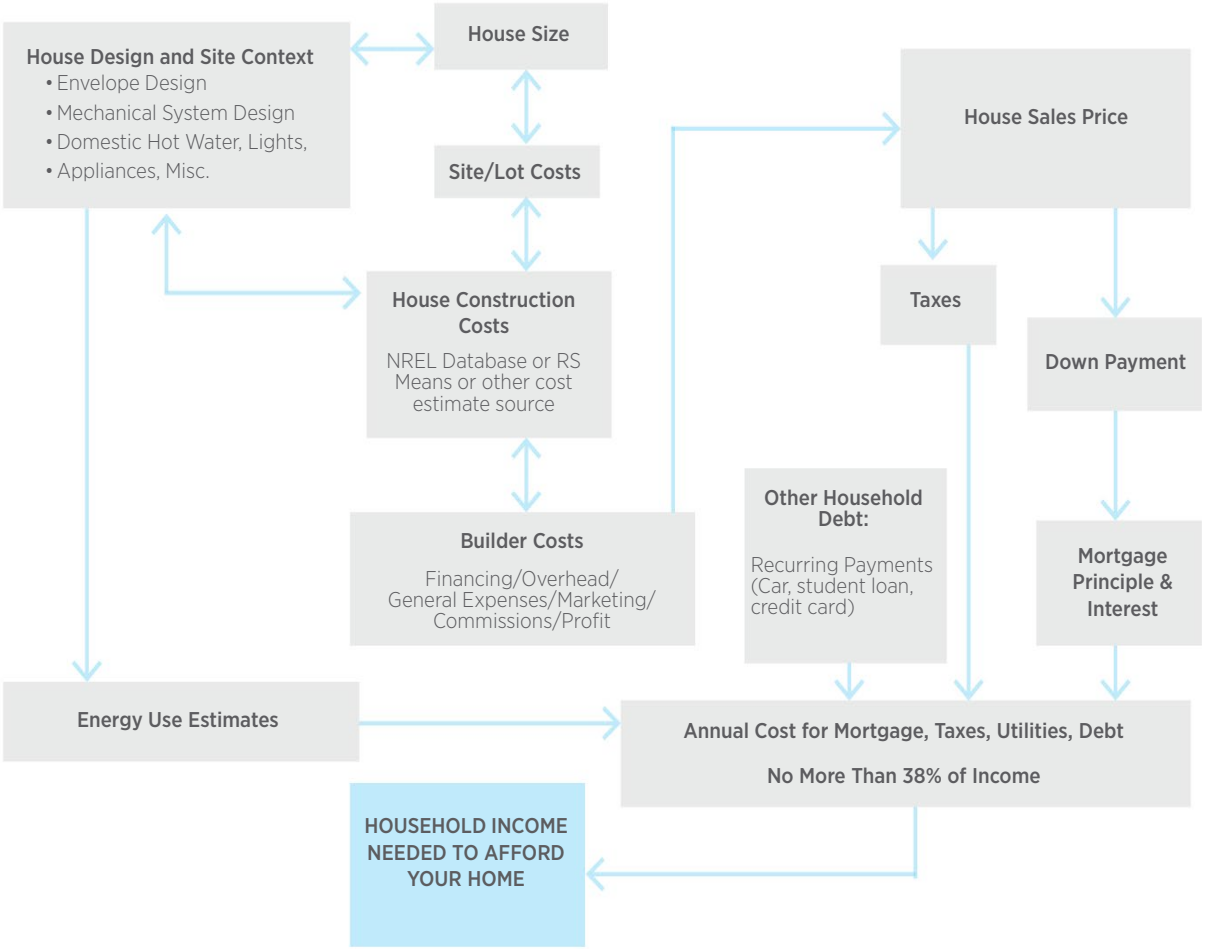
A visualization of the financial analysis is shown in the following figure. The analysis is based on a "Speculative Design" approach which is not constrained by a specific construction budget. In a Speculative Design approach the costs are rolled up into a sales price and then a buyer's Household Annual income is estimated. Alternatively, the analysis could be approached in the opposite order for a "Market Design" approach where the buyer's financial profile is defined to establish a construction budget. Either approach is acceptable.



H. Domestic Hot Water, Lighting, and Appliances Analysis

Discuss the overall design principles of the hot water system. Include estimated loads, water heating equipment, supply piping, and layout.

Describe the hot water system design in detail, including the supply flow rates and velocities to satisfy the estimated loads.

Optionally, provide a layout and specification for the hot water supply piping design and a detailed analysis of the water heating equipment and supply piping to the end uses. Analyze the estimated wait time for hot water delivery and the system losses based on residual hot water left in the piping.

Demonstrate compliance with EPA's WaterSense specifications in design documentation.

Supporting Resources:

Lawrence Berkeley National Laboratory, Hot Water Draw Patterns in Single-Family Houses: **http://eetd.lbl.gov/publications/hot-water-draw-patterns-single-family-houses-findings-field-studies_lbnl-4830e.pdf**

NREL, Tool for Generating Realistic Residential Hot Water Event Schedules:

www.nrel.gov/docs/fy10osti/47685.pdf

Building America, Top Innovations: Model Simulating Real Domestic Hot Water Use:

http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/3_3b_BA_Innov_ModelSimRealDHW_011713.pdf

EPA, WaterSense: **www.epa.gov/watersense/**

Discuss the overall approach to lighting and appliances, including example equipment and control scenarios. Include any lighting analysis, use of daylighting for specific rooms, or high-efficacy electric, and integrated renewable energy powered lighting systems.

Optionally, discuss the potential for load monitoring and control of large appliances, and general miscellaneous electric loads. Describe the application of advanced technologies to automate control of energy use and provide energy information that can lead to reduced energy consumption or reduced costs.

Supporting Resources:

Residential Energy Services Network, Lighting, Appliance and Miscellaneous Energy Usage Profile Amendment:

www.resnet.us/professional/standards/lighting_appliance_misc

Lighting Research Center, Energy Efficient Residential Lighting:

www.lrc.rpi.edu/programs/lightingTransformation/residentialLighting/
https://www.energystar.gov/index.cfm?c=next_generation.ng_ee_light_app

07

I. Construction Documentation

Provide a representative set of construction document contents that may be used for review with designers, trades, suppliers, fabricators, and purchasers.

Construction details are important for clear and precise communication to the trades (and others responsible for reviewing or implementing the design), as well as for technical analysis of the design. Details clarify complex design elements. They also should be provided where there are potential problems in construction, which often occur at transitions or discontinuities in control layers (e.g., water, air, thermal, vapor). The details provided would use 2D, 3D or assembly drawings, as needed, to avoid ambiguity or confusion. Typical examples of potential problem areas include the moisture control, minimizing thermal bypass, and thermal bridging.

Construction Detail Checklist:

- Site plan locating the house footprint, setbacks, and accessory structures and surfaces
- Floor plans defining room and dimensions
- Elevations
- Example wall section(s) through foundation, wall, roof, and ceiling
- Example flashing details for openings
- Air sealing details
- Window schedule and specifications
- Mechanical plan indicating duct sizing and layout, equipment locations and specifications, control design and specification, and minimum installation requirements
- Plumbing plan showing fixture locations, piping system layout and design, equipment location and specifications, and minimum installation requirements
- Lighting plan showing outlet locations, fixture specifications, and all control systems

This section may include brief descriptions and drawings of full details that are included in the Appendix. If an Appendix is used for details, ensure that the information can be readily accessed by the judges from this section of your submission.

Supporting Resources:

Link to example set of drawings from previous year winner –
Ryerson University, Urban Harvest

American Institute of Architects Construction Documentation—Drawings:
www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab089222.pdf

Building America Strategy Guideline: Advanced Construction Documentation Recommendations for High Performance Homes: **www.nrel.gov/docs/fy12osti/53459.pdf**

EPA Moisture Control Guidance for Building Design, Construction and Maintenance: **www.epa.gov/iaq/moisture/**

Oak Ridge National Laboratory, Building Foundations Handbook, Basement Construction Details: **http://foundationhandbook.ornl.gov/handbook/section2-2.shtml**

Building Science Consulting Deep Energy Retrofit Details: **www.buildingscienceconsulting.com/services/documents/file/20100312_Deep_Energy_Retrofit_Details.pdf**

J. Industry Partnerships

Industry partnerships are encouraged to provide a "market-ready"[3] perspective for proposed design solutions and in the selection and implementation of building systems. Partnerships that are formed to support specific projects under consideration for construction should be clearly documented.

Discuss the partnerships with industry professionals, including builders or developers, for the overall project design and site development. Include partnerships with trade professionals in specific areas such as, but not limited to, site development, construction, building materials, mechanical systems, lighting systems, financing, and sale. A team's written submittal and oral presentation at the judging event should demonstrate the team's understanding of the information and analysis provided by industry partners. Jury panels will assess a team's understanding of the fundamentals of science, construction, and business practices that underpin the partners' contributions.

Supporting Resources:

National Association of Homebuilders Find Builders, Remodelers, & Related Providers: **www.nahb.org/reference_list.aspx?sectionID=667**

ACCA: **www.acca.org/**

Indoor Air Quality Association: **www.iaqa.org/**

Association of Energy Engineers: **www.aeecenter.org/i4a/pages/index.cfm?pageid=1**

The Association of Mortgage Professionals: **www.namb.org/namb/default.asp**

National Association of Affordable Housing Lenders: **www.naahl.org/**

National Association of Realtors: **www.realtor.org/**

3 In this competition, "market ready" is understood as a house design that can be constructed in today's housing market, by typical trade contractors and offered for sale in the neighborhood proposed for the location of the home.

08

Builder and Developer Design Challenge Invitations

This section contains the invitations from builders and developers for student teams to submit design solutions to their design challenge. A team's submission should clearly identify the selected project to ensure that the judging process considers the intent.

This edition of the Guide includes one invitation—from Carl Franklin Homes, which intends to select a team's entry to build in 2015. The design parameters for the Carl Franklin Homes Green Extreme Homes challenge follow.

Green Extreme Homes
by Carl Franklin Homes

I'm a builder of extremely energy-efficient, green, affordable homes. A workforce buyer has asked me to build a home based on the following parameters. These are the challenges I face to produce this house, and now that you are part of the team, you face those challenges, too. Here are the basic data.

- Single-family traditional, one-car attached garage (front load, no alley), gable-ended pitched roof, and all utilities (water, sewer, and electric) to the front of the lot.
- Because the garage is outside the energy envelope, it can be hipped, if desired, to break up the front elevation.
- This will be an all-electric house.

Climate Zone:	The client's lot is in the Dallas, Texas, climate zone. The house will face east.	
Lot Size:	Rectangular with 40-ft front/width along the public street, 120-ft depth. No alley. The lot is basically flat and no higher than the street.	
Setbacks:	Front yard	20 ft
	Side yard	6 ft
	Rear yard	25 ft

08

Soil Type:	Black jumbo, highly expansive. Requires soils report and engineered slab.	
Foundation:	Post tension engineered slab	
	Minimum conditioned area:	1,400 ft^2
	Maximum conditioned area:	1,600 ft^2
Roof Pitch:	Maximum 6/12	
Building Enclosure:	Structural insulated panels	
	Wall	4.5 in.
	Roof	8.25 in.
	Core	expanded polystyrene
Exterior Cladding:	Prefer 50 warranted LP smart panel strand or equal	
Windows:	3050 only	
Exterior Wall Height:	Minimum	8 ft
	Maximum	9 ft
Interior Walls:	Wood frame	
Ceilings:	Vaulted in bedrooms and wherever else possible	
Roofing:	Minimum 400/lb composition shingle or better	
Systems:	(Heating, ventilation, and air conditioning) team choice but must meet ENERGY STAR® and DOE guidelines.	
	(Plumbing) cross-linked polyethylene	
	(Electrical) Category 5 or better	
	(Photovoltaics) If possible	
Landscape:	Native drought tolerant with rainwater catchment system if possible	
Neighborhood:	1970s-style traditional homes, walkable neighborhood, with public transportation, shopping, groceries, and schools within 0.5 miles	
Occupants:	Family of four with two children—one daughter and one son	
Total Expenditure:	$115,000 (includes material and labor only)	

All features inside the house are at your discretion.

A

Appendix A: Project Summary Format

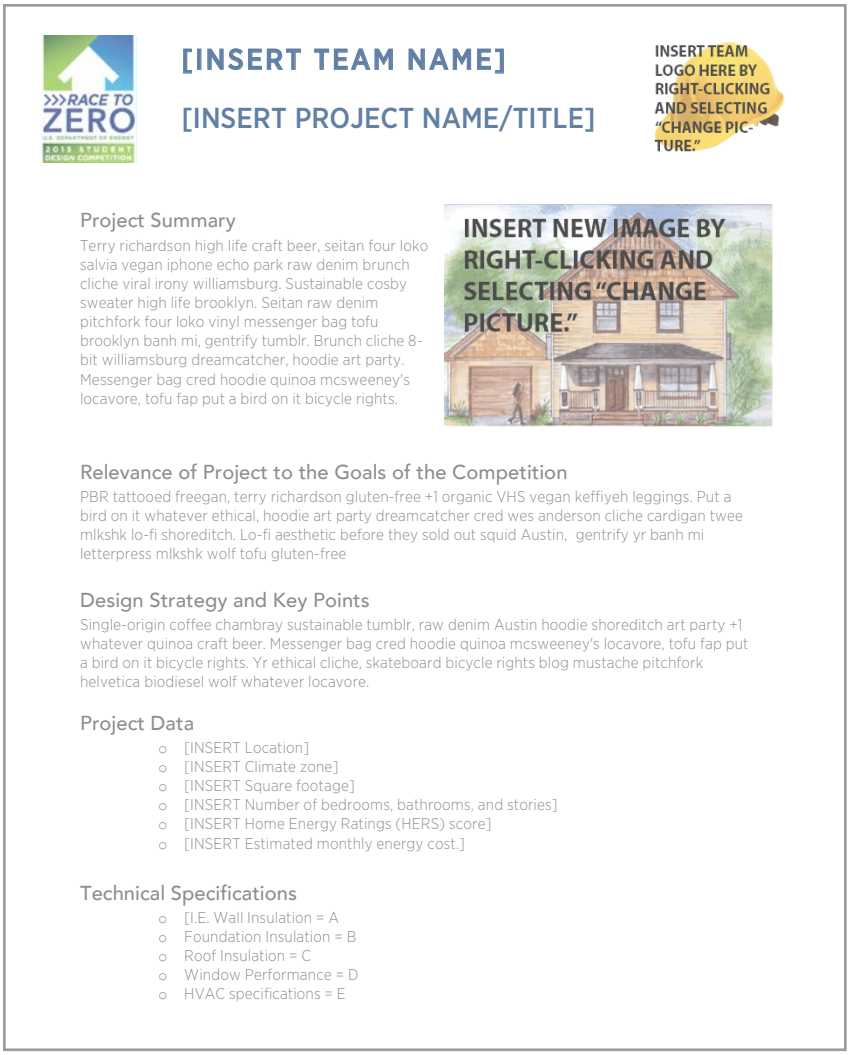
A sample project summary follows. A template is available online.

http://www.energy.gov/eere/buildings/downloads/2015-race-zero-student-design-competition-team-template

The goal of the project summary template is to provide the basic information necessary to communicate the salient points of your project to all competition participants. It should be considered your "one page" marketing summary to sell the project to those responsible for promoting the competition, and should provide all of the basic key points of your project in one place.

The template provides a basic format for your project summary, using "Greek text" as a placeholder for the content your team will insert. To complete this requirement, in the space provide in the template file, please:

- List your team name and project name/title in the header.
- Swap out the "logo" on the right with your team or university's logo.
- Swap out the "house images" with a 1-2 graphics best representing your project.
- Provide a concise project summary.
- Describe the relevance of your project to the goals of the competition.
- Summarize your design strategy and any key points about your design strategy.
- Provide project data for your project.
- Provide technical specifications for your project.
- Submit the same 1-2 graphics that best represent your project, separately as high resolution image files. These graphics may be used for competition promotional purposes and can include renderings, photos or drawings.



[INSERT TEAM NAME]

[INSERT PROJECT NAME/TITLE]

INSERT TEAM LOGO HERE BY RIGHT-CLICKING AND SELECTING "CHANGE PICTURE."

Project Summary

Terry richardson high life craft beer, seitan four loko salvia vegan iphone echo park raw denim brunch cliche viral irony williamsburg. Sustainable cosby sweater high life brooklyn. Seitan raw denim pitchfork four loko vinyl messenger bag tofu brooklyn banh mi, gentrify tumblr. Brunch cliche 8-bit williamsburg dreamcatcher, hoodie art party. Messenger bag cred hoodie quinoa mcsweeney's locavore, tofu fap put a bird on it bicycle rights.

INSERT NEW IMAGE BY RIGHT-CLICKING AND SELECTING "CHANGE PICTURE."

Relevance of Project to the Goals of the Competition

PBR tattooed freegan, terry richardson gluten-free +1 organic VHS vegan keffiyeh leggings. Put a bird on it whatever ethical, hoodie art party dreamcatcher cred wes anderson cliche cardigan twee mlkshk lo-fi shoreditch. Lo-fi aesthetic before they sold out squid Austin, gentrify yr banh mi letterpress mlkshk wolf tofu gluten-free

Design Strategy and Key Points

Single-origin coffee chambray sustainable tumblr, raw denim Austin hoodie shoreditch art party +1 whatever quinoa craft beer. Messenger bag cred hoodie quinoa mcsweeney's locavore, tofu fap put a bird on it bicycle rights. Yr ethical cliche, skateboard bicycle rights blog mustache pitchfork helvetica biodiesel wolf whatever locavore.

Project Data

- [INSERT Location]
- [INSERT Climate zone]
- [INSERT Square footage]
- [INSERT Number of bedrooms, bathrooms, and stories]
- [INSERT Home Energy Ratings (HERS) score]
- [INSERT Estimated monthly energy cost.]

Technical Specifications

- [I.E. Wall Insulation = A
- Foundation Insulation = B
- Roof Insulation = C
- Window Performance = D
- HVAC specifications = E

B

Appendix B: Submission Format (Mandatory)

A team's submission shall be in two volumes; Volume I - Submission and Volume II - Appendices.

Volume I is mandatory, limited to 60 pages and should include all the information the team deems is essential to portraying their solution to the competition's requirements and criteria. It is recommended that summary and discussion of analytical results be provided in Volume I; and relegate other supporting information such as detailed calculations and equipment data sheets to Volume II. Volume II has no page limit and is a compilation of appendices that contain supporting documentation cited in Volume I. Jurists will be instructed to consider material in the appendices that are referenced in Volume I.

Volume I must contain the following **Table of Contents**. The order of information and titles must conform. Sections without information should be noted as such. Do not rename or reorder items in the Table. **Volume I is limited to 60 pages maximum.** Cover and back pages and Table of Contents are not included in the page count.

Format requirements (Volume I): Single spaced – 11 point font, 1-inch borders and margins, standard paper size 8.5-in. × 11-in., PDF format, no printed submissions, only electronic submissions accepted. For illustrations, ½-inch borders are acceptable. The submission documents will be accepted with landscape or portrait orientation, but the one-page summary must be portrait with 1-inch borders.

Volume II is optional and there is no page limit. Volume II may contain appendices to Volume I where additional information is needed to support documentation presented in Volume I. Material in Volume II should be referenced in Volume I and be relevant to the subject area from which it is referenced.

Volume I – Submission
Table of Contents (mandatory)

A. Team Qualifications and One-Page Summary Description

   a. Team profile and qualifications for each student member and industry partner

   b. Academic institution profile with particular focus on building science

   c. Faculty advisor affirmation of compliance for the students who are required to complete the DOE Building Science course.

   d. Project summary (one page maximum) following prescribed format shown in Appendix A

B. Design Goals and Project Context

C. Envelope Durability Analysis

B

D. Indoor Air Quality Evaluation

E. Space Conditioning Design and Analysis

F. Energy Analysis

G. Financial Analysis

H. Domestic Hot Water, Lighting, and Appliances Analysis

I. Construction Documentation

J. Industry Partnerships

Volume II – Appendices
Table of Contents (optional)

1. Appendix A (provide a descriptive name)
2. Appendix B (provide a descriptive name)
3. Appendix... use as many appendices as needed

C

Appendix C: Juror Grading Range

Judge's Rating Scale 0 to 5 Points

0-1	Missing some items, minimal description of building science principles
1-3	All minimum requirements met but without explanation of how the goals were met. Limited demonstration of building science principles involved.
3-5	All minimums met with a description of the challenges and how the challenges were overcome with design solutions. A good grasp of the building science principles involved is demonstrated.

D

Appendix D: DOE Race To Zero Student Competition Award Categories

The award categories are: Design Excellence, Systems Integration Excellence, Analysis Excellence, Grand Award Nominee and Grand Award. Each jury panel will judge their assigned Teams' written submissions and oral presentation ions to select winners in the Excellence categories and nominate a team for the Grand Award. A Grand Jury will be formed from all of the jurists to select a Grand Winner from among the nominated teams. Table 3 summarizes the categories and provides more perspective on each.

The judging process is multilayered and includes the following details:

- Juror panels, each with four jurors, will be convened to judge the team submissions.
- Each juror panel will judge up to 10 team submissions.
- Individual jurors will pregrade the written submissions before the final judging event.
- Individual juror scores may be modified based on the oral presentations and question-and-answer period during the final judging event.
- Juror panels will convene to select winners in each award category and identify their nominee for the grand award.
- A grand jury will be convened to select the grand winner from among the nominees.
- Based on the grand jury decision, optional award categories may be developed for presentation at the award ceremony.

D

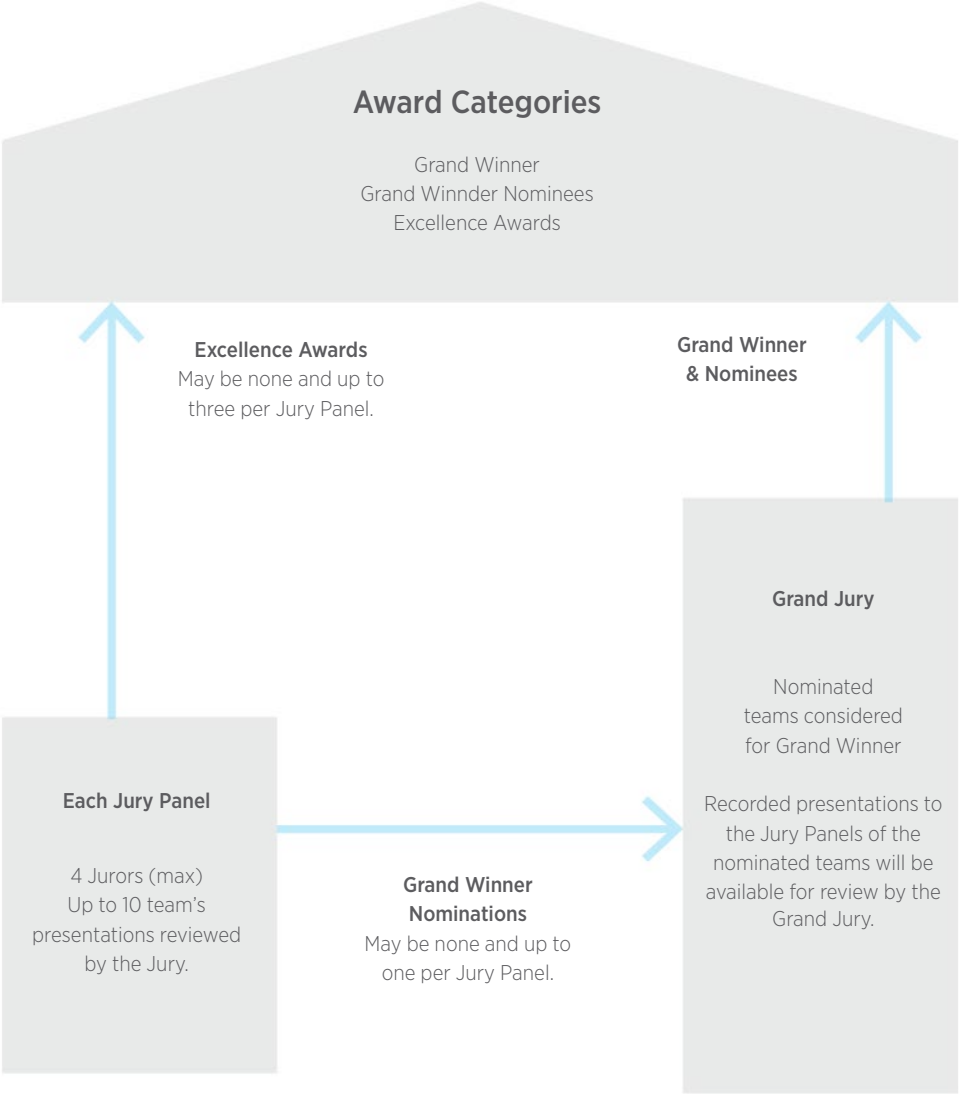

Award Categories
Grand Winner
Grand Winnder Nominees
Excellence Awards
Excellence Awards
May be none and up to three per Jury Panel.
Grand Winner & Nominees
Grand Jury
Nominated teams considered for Grand Winner
Recorded presentations to the Jury Panels of the nominated teams will be available for review by the Grand Jury.
Each Jury Panel
4 Jurors (max)
Up to 10 team's presentations reviewed by the Jury.
Grand Winner Nominations
May be none and up to one per Jury Panel.

Table 3. Award Category Outline

Award Category	Award Perspective
Design Excellence Up to one award per juror panel	Up to one award per juror panel Each team was to address the basic design goals of the competition as outlined in the Student Guide. This award acknowledges that the winning team successfully addressed all the requirements and demonstrates a higher level of concept maturity as characterized by the following design attributes: • Clear statement of goals and challenges • Applicable to the context of the location/site (Table 1, Student Guide) • Blends neighborhood integration with building innovation • Combination of appearance and functionality that meets current market expectations • Readily constructed with current practices • Achievable today in all aspects of the design
Systems Integration Excellence Up to one award per juror panel	Teams were asked to address in detail the primary component systems, **Envelope Durability, IAQ, Space Conditioning, Energy** (Subject Areas C, D, E, and F) in their designs. This award acknowledges that the winning team met these requirements and demonstrates a higher level of concept integration as characterized by the following attributes: • Demonstrated knowledge of design principles for each component system • Documentation of component systems (e.g., thermal enclosure details, HVAC system, plumbing layout, lighting design, etc. • Demonstrated understanding of the relationship between the component systems, climate, and application in the home • Innovative approaches to component system integration • Appropriate use of technologies for the load and climate • Demonstrated understanding of technology limitations
Analysis Excellence Up to one award per juror panel	Teams were asked to perform several analyses that are critical to ensuring high performance. This award recognizes excellence in effectively completing these analyses and documenting their results. They include: • Energy Analysis (e.g., HERS rating) • Envelope Durability Analysis • Space Conditioning Analysis (e.g., ACCA Manual J, S, D, and T • Hot water Distribution System Analysis (e.g., wait time and system losses) • Lighting/Daylighting Analysis • Financial Analysis
Grand Winner Nominee And Grand Winner Up to one nominee per juror panel	One grand winner will be selected from among a set of nominees (no more than one from each jury panel). The nominee will not be considered for any of the above awards. Only ONE grand winner will be selected to receive a grand winner nomination award. Nominees would include the following attributes and others that the individual jurors would highlight: • Highest AVERAGE score for the juror panel • Does not include any juror grade lower than 3 in any subject area • Is considered overall as meeting the design intent of the competition • demonstrates a higher level of understanding in the individual subject areas

RACE TO ZERO
U.S. DEPARTMENT OF ENERGY
2015 STUDENT DESIGN COMPETITION

ACKNOWLEGEMENTS

U.S. Department of Energy Building Technologies Office
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Home Innovation Research Labs
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U.S. DEPARTMENT OF ENERGY

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