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

2016 U.S. Department of Energy Race to Zero Student Design Competition Guide

August 2015

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FOREWORD

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 of their annual energy consumption.

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

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

- Inspire and develop the next generation of residential design and construction professionals with building science expertise.
- Advance and enhance building science curricula at universities.

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.

Sam Rashkin

U.S. Department of Energy

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

SUMMARY OF IMPORTANT DATES

The following dates are the important milestones for the competition:

- **September 3, 2015:** Registration opens and faculty leads can begin to send their Intent to Participate in the 2016 Race to Zero competition to racetozero@eere.doe.gov. Submitting an Intent to Participate ensures faculty leads are aware of competition communications and resources. Appendix A includes instructions for submission.
- **November 12, 2015:** The deadline by which all teams must register online.
    - Teams are encouraged to submit a three-page design concept, which is detailed in Appendix B. Submissions will be reviewed against the criteria outlined in Appendix B.
    - Each team pays a $200 fee at the time of registration.
- **November 19, 2015:** DOE will invite up to 40 registered teams to participate in the full competition. If fewer than 40 teams have submitted design concepts, the organizers may choose to accept additional teams who registered without them.
- **March 1, 2016:** The deadline by which student team members complete building science training online.
- **March 24, 2016:** The deadline by which invited teams must submit their project reports and RSVP to participate in the competition.
    - The project report requirements are provided in Appendix D.
    - To RSVP for competition participation, invited teams must complete security forms for all individuals who will attend onsite. At least one and up to four team members are expected to attend in person. The presentation must be given by students.
- **April 16–17, 2016:** Invited teams compete as they present to industry leaders at the National Renewable Energy Laboratory's main campus in Golden, Colorado.

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01

Participation

Participants in the Race to Zero have the opportunity to provide creative solutions to real-world issues in our nation's housing industry. Invited teams will complete the required submissions and attend the competition event where they will present their designs to a panel of expert jurors, compare their efforts with other teams, learn from presentations by thought leaders, and engage a variety of organizations about clean energy careers. The winning teams will be recognized at an awards ceremony, and the winning designs will be made available on the U.S. Department of Energy (DOE) Race to Zero website. The competition, awards event, and winners will all be promoted through a variety of media outreach efforts, which will provide participants and their universities an opportunity for national exposure. Universities that participate in the Race to Zero will be recognized as leading institutions that are producing job-ready young professionals with cutting-edge skills. Builders who collaborate with teams will gain national and local recognition and will have the opportunity to interact with knowledgeable future design and construction professionals.

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

The Race to Zero is designed to encourage student participation throughout an academic year that begins during the fall and ends in the spring with the project presentation and awards ceremony.

View Previous Year's Winners

Race to Zero Results: **http://energy.gov/eere/buildings/2015-results**

01

1.1 Task Overview

- Read this Race to Zero Guide and form a multidisciplinary team. The faculty lead submits an Intent to Participate indicated in the Summary of Important Dates. The Intent to Participate will ensure that teams receive all important information as it becomes available.
- DOE will invite up to 40 teams who have registered to participate in the full competition.
- All student team members must complete the DOE Building Science Training course either in person or online. This coursework will be provided at no cost to every team member.
- Teams are encouraged to review the winning teams' **submissions** from last year's competition to inform their efforts. Note that this year's rules and requirements have changed.
- Become familiar with this Race to Zero Guide and each subject area before beginning the project design process.
- Identify subject areas in which industry partnership is needed or wanted.
- Study the **DOE Zero Energy Ready Home** program requirements, including explanatory footnotes.
- Regularly consult the Race to Zero Student Design Competition **website,** your student team lead, and faculty lead for competition updates and announcements.
- Attend Race to Zero webinars for additional guidance.
- Submit all materials for evaluation by the deadlines.
- Submit your questions to **racetozero@eere.doe.gov**.

1.2 Developing a Team

Each team must be associated with a collegiate institution and registered by a faculty lead. The competition is open to all universities and degree institutions, including community colleges. International institutions are welcome to participate. Each team must have at least three students and a faculty lead with one student designated as the student team lead. Teams are encouraged to be multidisciplinary and to engage industry advisors such as local home builders, architects, and Home Energy Rating System (HERS) professionals who can help inform the students' decision-making process and provide reviews of the design materials. Multiple collegiate institution may combine to form a team. A college may submit only one team per design contest (Section 2).

1.3 Student Qualifications

Great teams are cross-functional. Student team members can be from any discipline and any level of collegiate schooling. Past teams have included students who majored in architecture, engineering, building science, construction management, marketing, management, landscape architecture, and other fields. All team members should have relevant education and training to meet project goals. Each student should be pursuing a degree and be currently enrolled in at least one class at a participating collegiate institution at the time of the project presentation.

1.4 Faculty Lead Role

The faculty lead, along with the student team lead, is responsible for communicating competition details from the Race to Zero organizers to the team members. The faculty lead is also required to provide confirmation of compliance on the building science training requirement for the students. The faculty lead is encouraged to closely engage with the students on the project.

The faculty lead provides support in many areas, including:

- Ensuring that all student team members complete the building science training. The faculty lead must ensure the team meets this requirement or provide a reason for the requirement to be waived (e.g., building science is part of the core curriculum). 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 familiarity with this Race to Zero Guide and additional guidance as appropriate.
- Ensuring the necessary information is provided for team members who will be onsite at the competition. The faculty lead should attend the competition in person if possible and should join the presentation remotely otherwise.

1.5 Project Requirements

For the 2016 Race to Zero, teams may develop projects based on updates of house plans from builders 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 to complete retrofit projects. Eligible scenarios are varied, and the submission must conform to the conditions in Section 2. The mandatory minimum design target is the **DOE Zero Energy Ready Home Requirements (Rev. 05),** and the design solution must be documented in the submission to meet the following criteria:

- The design must achieve at least the DOE Zero Energy Ready Home energy performance level and meet all program requirements.

01

- Teams must demonstrate the 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.
- All team members must complete a free building science course offered by DOE. The course will be available online. This requirement may be waived by the team's faculty lead with confirmation of equivalency for courses the student has successfully completed.

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

The final evaluation process will include an oral presentation by each invited team to a panel of jurors associated with one of four contests. Following the oral presentations, each jury panel will select the first- and second-place winners for its contest. Each contest first-place winner will then present their project to the other teams and a grand jury, which will then select a grand winner.

1.6 Industry Partnerships

Industry partnerships are encouraged to provide a market-ready perspective for proposed design solutions and for the selection and implementation of building systems. In this competition, "market ready" is understood to be a house design that can be constructed in today's housing market by typical trade contractors and offered for sale at reasonable cost of ownership in the neighborhood proposed for its location. Partnerships that are formed to support specific projects under consideration for construction should be clearly described in the project submission.

1.7 Resources

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

DOE, Zero Energy Ready Home National Program Requirements (Rev. 05):
http://energy.gov/sites/prod/files/2015/05/f22/DOE%20Zero%20Energy%20Ready%20Home%20National%20Program%20Requirements%20Rev05%20-%20Final_0.pdf

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

National Association of Homebuilders: **www.nahb.org/**

Air Conditioning Contractors of America: **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/**

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

02

Design Contests

The Race to Zero comprises four design contests. The competition organizers reserve the right to modify the contest categories in November based on registrations to ensure a balanced competition. Each collegiate institution may submit one entry per contest. Projects must conform to the contest constraints indicated below as measured using ANSI Z765-2003, which states that the finished square footage is the sum of finished areas measured at floor level to the exterior finished surface of the outside walls.

1. **Suburban Single-Family Detached House**
   a. Size: 1000–3000 ft^2
   b. Lot: 4000 ft^2 minimum
2. **Urban Single-Family Detached House**
   a. Size: 600 – 2500 ft^2
   b. Lot: 5000 ft^2 maximum
3. **Attached Housing (two- to six-unit duplex or townhouse style)**
   a. Size: 500–2500 ft^2
   b. Lot: 3000 ft^2 maximum per unit
4. **Small Multifamily (three or fewer stories above-grade)**
   a. Size: 350–2000 ft^2 per unit
   b. Lot: no minimum or maximum.

A dwelling unit, as defined by the 2012 International Energy Conservation Code (**http://publicecodes.cyberregs.com/icod/iecc/**), is a single unit that provides complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

In the project report, each team will define a specific location, building lot, and neighborhood characteristics as context for the house design and its relationship to surrounding homes and the community.

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Evaluation

Projects submitted to Race to Zero will demonstrate competency by applying best practice solutions and principles of building science. The teams will be assessed on their project report submissions, including the design and technical documentation, project plans, reports on required analyses, and the quality of their project presentations. 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 contest evaluation parameters and complete the requirements of the project report.

The student submissions will be scored by jurors in the following 10 parameters. Jurors will score each parameter of the contest on a scale of 0 to 10, which add up to the 100-point total.

Table 1. Evaluation Parameters

Evaluation Parameter	Available Points
1. Architectural Design	10
2. Interior Design	10
3. Energy Analysis	10
4. Constructability	10
5. Financial Analysis	10
6. Space Conditioning Selection and Design	10
7. Envelope Durability	10
8. Interior Air Quality (IAQ) and Appliances	10
9. Innovation	10
10. Presentation and Documentation Quality	10

ZERO ENERGY homes have become readily achievable and cost-effective.

03

3.1 Architectural Design

The Zero Energy Ready Home level of home performance will not achieve meaningful market acceptance unless it is integrated with architectural designs that meet or exceed consumer aesthetic and functional expectations.

3.1.1 Criteria

The jury will evaluate each submission according to the following criteria:

- Quality of the architectural design and project aesthetics.
- The general success of the team's approach to integrate high-performance home and building science principles within an architecturally appealing design.
- The design's responsiveness to the site; natural comfort (e.g., solar orientation, solar shading, thermal mass, natural shading, natural ventilation); functionality; careful integration of major systems (e.g., structural, heating, ventilation, and air conditioning [HVAC]; plumbing; lighting; furniture placement; storage; disaster resistance); and connection to the outdoors.
- The team's integrated design process and how well the DOE Zero Energy Ready Home Recommended Quality Management Provisions (QM #2) (http://energy.gov/eere/buildings/downloads/doe-challenge-home-recommended-quality-management-provisions) were incorporated into the high-performance home design process and documentation.
- How well the design approach responded to relevant national, regional, and local programs and knowledge.
- Effective design and specification of materials, products, and design elements.

3.1.2 Resources

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

DOE, Zero Energy Ready Home:
http://energy.gov/eere/buildings/zero-energy-ready-home

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, Zero Energy Ready Home Recommended Quality Management Provisions:
http://energy.gov/eere/buildings/downloads/doe-challenge-home-recommended-quality-management-provisions

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

3.2 Interior Design

Creative and technical solutions are applied within a structure to achieve a successful interior environment. These solutions must be functional, enhance the quality of life and culture of the occupants, and be aesthetically attractive. The interior design should complement the exterior architecture. Consideration for the environmental sustainability of materials is encouraged in interior design.

3.2.1 Criteria

The jury will evaluate each submission according to the following criteria:

- The design's functionality, attractiveness, and enhancement of the occupants' quality of life
- Extent to which the interior design complements the exterior architecture
- Environmental sustainability of materials used for finishes, furniture, and other items within the house
- Appropriateness, effectiveness, and attractiveness of the home's floorplan to the intended occupants, their furniture, and other belongings
- Marketability of the design to the intended target market
- Approach to meeting sustainability goals, ENERGY STAR®, and DOE Zero Energy Ready Home goals
- Aspects of sustainability, such as resource efficiency, resiliency, and attention to local resources.

3.2.2 Resources

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

DOE, Zero Energy Ready Home:
http://energy.gov/eere/buildings/zero-energy-ready-home

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

Leadership in Energy & Environmental Design (LEED), Interior Design and Construction
www.usgbc.org/articles/getting-know-leed-interior-design-and-construction-idc

LEED, Guide to Certification: Homes
www.usgbc.org/cert-guide/homes

Kruger, A., and Seville, C. *Green Building: Principles and Practices in Residential Construction (Go Green with Renewable Energy Resources)*, Cengage Learning, Independency, KY, 2012.

AIA. *The Environmental Resource Guide, Wiley, Hoboken, NJ, 1*999.

3.3 Energy Analysis

The basis of high-performance homes is grounded in energy analysis. Early energy analysis demonstrates how the various efficiency features interact for whole-house energy reductions.

A Zero Energy Ready Home is a high-performance home so energy efficient that a renewable energy system can offset all or most of its annual energy consumption. The program builds on the comprehensive building science requirements of ENERGY STAR Certified Homes Version 3 (www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_v3_guidelines), along with proven Building America innovations and best practices.

The building industry uses the HERS Index to measure the energy efficiency of residences. The index provides a score in which the lower the number, the more energy efficient the home. Homes are compared against a benchmark home based on the 2006 International Energy Conservation Code to determine the score. HERS can be calculated through any accredited HERS software.

REM/Rate™ Software is used by organizations which conduct HERS Ratings. The software calculates heating, cooling, hot water, lighting, and appliance energy loads, consumption and costs for new and existing single and multi-family homes. The REM/Rate program is expected to be provided to teams at no charge after registration but is not required to be used.

The BEopt™ (Building Energy Optimization) 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 energy.

3.3.1 Criteria

The jury will evaluate each submission according to the following criteria:

- The team's consideration of energy efficiency for all aspects of the home and how the various efficiency features interact with each other
- The quality of the HERS whole-house annual energy consumption simulations
- The final plan-based HERS Index Score calculated with and without a renewable energy system

- The projected annual energy consumption of the designed home
- The opportunities, tradeoffs, and house design modifications needed to incorporate renewable energy systems sufficient to achieve zero energy use and offset nonrenewable energy sources
- The appropriateness of the technology options chosen for the location and climate
- Design and component analyses for active renewable energy systems that are necessary to achieve zero energy use across all nonrenewable energy sources used in the home.

3.3.2 Resources

DOE, Zero Energy Ready Home National Program Requirements (Rev. 05):
http://energy.gov/sites/prod/files/2015/05/f22/DOE%20Zero%20Energy%20Ready%20Home%20National%20Program%20Requirements%20Rev05%20-%20Final_0.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:
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/

NREL, PVWatts A Performance Calculator for Grid-Connected PV Systems:
pvwatts.nrel.gov

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

Noresco, REM/Rate:
http://www.remrate.com

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

3.4 Constructability

Construction details are important for clear and precise communication to the trades and others who are responsible for reviewing or implementing the design, as well as for technical analysis of the design. Well-drafted details in the drawings clarify design elements and help ensure a team's design and strategy are successfully implemented.

3.4.1 Criteria

The jury will evaluate each submission according to the following criteria:

- How effectively the drawings and associated documentation communicate the team's design and would enable successful construction and implementation by industry professionals
- The quality and completeness of the construction document content that may be used for review with designers, trades, suppliers, fabricators, code reviewers, and purchasers
- The proactive design and detailed approach to prevent common problems in construction, which often occur at transitions or discontinuities in control layers (e.g., water, air, thermal, vapor)
- Level at which the design is constructible
- Level at which typical construction practices are considered as part of the design process.

3.4.2 Resources

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

U.S. Environmental Protection Agency (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

3.5 Financial Analysis

The purpose of the financial analysis is to relate the design to the marketplace by estimating the overall cost of home ownership for the team's unique design. Elements of the financial analysis include the estimated sales price, financing (mortgage), insurance, household debt, taxes, monthly utility costs, and maintenance costs.

3.5.1 Criteria

The jury will evaluate each submission according to the following criteria:

- Quality of the construction cost analysis completed
- Integration of the utility cost estimate calculated for the energy analysis
- Quality of the maintenance cost estimate analysis completed
- Affordability of the design for the targeted market segment(s) (e.g., entry level, move-up), including the necessary household income required to purchase and live in the project home assuming a 30-year fixed mortgage.
- Construction costs analysis based on standard cost databases such as RSMeans or standard cost data provided by DOE, including federal, state, and local financial incentives for use of renewables or for energy efficiency upgrades in the analysis.

3.5.2 Resources

Teams are expected to complete the organizer-provided financial analysis form and provide explanations for all numbers entered. The form is expected to be posted by October 2015. The following table is to be used as a resource for completing the finanical analysis.

Table 2. Construction Costs and Financial Values

Value	Description
Median Family Income	Each team should indicate the U.S. Department of Housing and Urban Development's fiscal year 2014 median family income data set[1] for its home's location to determine representative income levels.
Home Ownership Affordability	For this competition, the home ownership affordability should not exceed 38% of the household income. Home ownership affordability includes principal, interest, property taxes, home and mortgage insurance, and utilities (energy and water). Based on a team's specific design, team members will calculate the required household income to afford the home.
Utility Costs	Use local utility costs with energy (and water) use estimates. This may be defined for a specific location based on actual utility rates or a representative resource.[2]
Financing (Principal and Interest)	4.5%, 30-year fixed rate
Property Tax	1.15%
Insurance[3]	$952 annually[3]
Down Payment	20% of house cost
Monthly Household Debt	0.5% of area median family income
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.
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."

1 **www.huduser.org/portal/datasets/il/il14/index_mfi.html.** Use the rounded MFI estimate.

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

3 **http://www.valuepenguin.com/average-cost-of-homeowners-insurance.**

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#**

NREL, software that uses 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**

Database of State Incentives for Renewables & Efficiency: **www.dsireusa.org/**

3.6 Space-Conditioning Selection and Design

The space-conditioning system is designed to maintain uniform comfort conditions via temperature control, humidity control, air movement, and a successful distribution system design. Space conditioning can be provided via different means and depends on climate conditions and building envelope construction.

Successful space-conditioning selection and design involve choosing the appropriate technology and evaluating the system performance, installed cost, reliability, operations and maintenance costs, and environmental performance.

3.6.1 Criteria

The jury will evaluate each submission according to the following criteria:

- The team's approach to choosing and meeting performance objectives for the mechanical systems that are targeted for space conditioning
- 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
- The design of the space-conditioning operation goals, equipment selection and integration, operation and control, and evaluation of fuel selection options
- Whether the system design meets the requirements of Air Conditioning Contractors of America Manuals J, S, D, and T protocols or other industry practices such as ASHRAE or equipment manufacturer specifications
- Consideration of the maintenance requirements, working to minimize overall costs
- Reasonableness of assumptions and technical justifications for prototype equipment that may not be commercially available.

3.6.2 Resources

DOE, Building Technologies Publication and Product Library:
http://www.eere.energy.gov/library/default.aspx?page=2

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

Air Conditioning Contractors of America, Resources:
www.acca.org/

www.acca.org/standards/speedsheets

www.acca.org/standards/technical-manuals

www.acca.org/standards/

ENERGY STAR, Heat and Cool Efficiently, Maintenance Checklist:
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:
www.eere.energy.gov/buildings/publications/pdfs/building_america/strategy_guide_air_distr.pdf

Trane, VariTrane Duct Designer:
www.trane.com/Commercial/DNA/View.aspx?i=1239

Elite Software, Ductsize - HVAC Duct Sizing and Analysis:
www.elitesoft.com/web/hvacr/duct60.html

Wrightsoft, Simple, Powerful HVAC Design and Sales Software:
www.wrightsoft.com/

Design Master, Duct Layout:
www.designmaster.biz/products/hvac/LearnMore/Features/duct-layout.html

3.7 Envelope Durability

The building envelope separates the living environment from the outdoor environment and provides the enclosure for all the systems in the home. The building envelope includes the foundation, walls, attic, and roof.

3.7.1 Criteria

The jury will evaluate each submission according to the following criteria:

- The design's consideration of major mechanisms that affect envelope durability and integrate the building science concepts of air transport, moisture management, and thermal and hygrothermal performance based on specific environmental conditions
- The level with which 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 that are properly installed without gaps, voids, compression, and thermal bridging; comprehensive water and moisture management including flashing details, water barriers, and capillary breaks to control bulk moisture; control of moisture movement through the wall system; and considerations for other potential moisture problems (e.g., condensation)
- How well the team documented their envelope durability solutions in their plans and construction details.

3.7.2 Resources

EEBA Moisture Control Handbook
http://web.ornl.gov/sci/roofs+walls/facts/moisture/Moisturehandbook.pdf

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

Building America, Solution Center Resources
https://basc.pnnl.gov/

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

DOE, Zero Energy Ready Home Recommended Quality Management Provisions:
http://energy.gov/eere/buildings/downloads/doe-challenge-home-recommended-quality-management-provisions

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

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

Alliance to Save Energy: Efficient Windows Collaborative: **www.efficientwindows.org**

Oak Ridge National Laboratory, Foundation Design Handbook:
http://foundationhandbook.ornl.gov/handbook/

National Institute of Building Sciences, Whole Building Design Guide:
www.wbdg.org/resources/resbuildingenclosure.php

WUFI:
http://web.ornl.gov/sci/buildings/tools/wufi/

3.8 Indoor Air Quality and Appliances

IAQ can significantly impact the health and comfort of occupants. Many factors, including ventilation rates and methods, contamination control, and effective filtration, can affect IAQ.

The occupants should be provided with an appropriately sized, water-efficient, and energy-efficient domestic water system.

Thoughtful selection of lighting and appliances can significantly affect the overall home energy use and enhance the home's ability to offset energy consumption with renewable energy. This is typically achieved with ENERGY STAR certified or better fixtures and appliances throughout the home.

3.8.1 Criteria

The jury will evaluate the team's approach to addressing each criterion as follows:

- Indoor Air Quality
  - The overall approach to IAQ to meet performance goals and satisfy specific field conditions
  - Details of the IAQ contaminant control, ventilation, and filtration solutions used to control the indoor environment
- Domestic Water Systems
  - Selection of water conservation fixtures throughout the home
  - The overall design principles of the hot water system, including estimated loads, water heating equipment, supply piping, and layout to minimize wait time, losses, and wasted water

- Lighting and Appliances
  - The overall approach to lighting and appliances, including specified equipment and control scenarios
  - Analysis of artificial lighting and daylighting for specific rooms
  - The potential for load monitoring and control of large appliances and general miscellaneous electric loads
  - The application of advanced technologies to automate the control of energy use and provide energy information that can reduce energy consumption and costs.

3.8.2 Resources

EPA, Indoor airPlus Program:
http://epa.gov/indoorairplus/

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

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

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

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

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://energy.gov/sites/prod/files/2014/01/f6/3_3b_BA_Innov_ModelSimRealDHW_011713.pdf

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

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/

ENERGY STAR, Energy–efficient Lighting and Appliances
www.energystar.gov/index.cfm?c=next_generation.ng_ee_light_app

3.9 Innovation

The residential building industry can often be slow to adopt the latest building science knowledge, technologies, and practices. Unique and innovative approaches to smart building design and construction that improve the status quo are necessary to transform the nation's energy future. This parameter seeks to award points to teams that take an innovative and beneficial approach to addressing residential architecture and reaching the goals of the Zero Energy Ready Home while still addressing suitability for mainstream builders. The jury will evaluate innovation across the entire design and within each scoring parameter.

3.9.1 Criteria

The jury will evaluate each submission according to the following criteria:

- Overall approach to the design competition with regard to integration of innovations that improve the design solution
- Unique integration of building science principles in ways that are achievable, beneficial, cost-effective, and functional
- Smart consideration and development of unique design parameters in the submission
- Collaboration with industry partners to evaluate and provide feedback on innovations that are integrated into the design for the team's Zero Energy Ready Home.

"'Different' and 'new' is relatively easy. Doing something that's genuinely better is very hard."

– Jony Ive

3.9.2 Resources

Building America, Bringing Building Innovations to Market:
http://energy.gov/eere/buildings/building-america-bringing-building-innovations-market

Building America, Top Innovations:
http://energy.gov/eere/buildings/building-america-top-innovations

DOE, Housing Innovation Awards:
www.energy.gov/eere/buildings/housing-innovation-awards

National Institute of Building Sciences, Innovation Conference Proceedings
www.nibs.org/?page=conference2015

U.S. Department of Housing and Urban Development, The Diffusion of Innovation in the Residential Building Industry
www.huduser.org/portal//Publications/PDF/Diffusion_Report.pdf

3.10 Presentation and Documentation Quality

Presentation quality often determines how the client receives and implements work and how effectively innovation spreads. Clear, complete, and consistent documentation will clearly convey the goals of the team and its home design. Presentations should tell the story of the project without verbose language or cluttered slides. Planning ahead for spoken presentations, coordinating deliverables, and focusing on the visual representation of complex data can increase audience interest and commitment to the ideas undertaken.

3.10.1 Criteria

The jury will evaluate each presentation according to the following criteria:

- Overall completion of project deliverables
- Overall presentation documentation quality
- Overall spoken presentation quality
- Overall quality for submission
- Overall quality for presentation.

3.10.2 Resources

Ignite Presentations
http://igniteshow.com/

TED talks
www.ted.com/talks

DOE-hosted presentations
www.youtube.com/user/USdepartmentofenergy

3.11 Evaluation Rating Scale

Juror Rating Scale 0 to 10 Points

0–1	Missing all items and no explanation of how the design addresses the critera
1–3	Missing some items and minimal explanation of how the design addresses the criteria
3–5	All minimum requirements met, but withminimal explanation of how the design addresses the criteria
6–8	All minimums requirements met with a full description of how the design addresses the criteria
9–10	All minimum requirements met with distinguished excellence in describing how the design exceeds the criteria

3.12 Evaluation Process

The evaluation process is multilayered and includes the following details:

- Juror panels, each with three to five jurors, will be convened to assess the team designs.
- Each juror panel will assess up to 10 team designs in each of the four design contests.
- Individual jurors will pregrade the project reports before the project presentations.
- Individual juror scores will be modified based on the project presentations and question-and-answer period during the final evaluation event.
- Jurors will assign an integer value between 0 and 10 for each parameter and add them up to total score for each team.
- Juror panels will select first and second place award winners in each contest based on the following attributes and others that the individual jurors will highlight:
    - Highest AVERAGE score for the juror panel
    - Does not include any juror grade lower than 5 in any subject area
    - Is considered overall as meeting the design intent of the competition
    - Demonstrates an excellent level of understanding in the individual subject areas

- The four contest first-place award winners will then deliver a 10-minute presentation at the awards dinner.

3.13 Competition Awards

The two categories of awards are Contest Award and Grand Award. Each jury panel will assess its assigned teams' project reports and project presentations to select winners within the contest and choose first and second place Contest Award winners. A grand jury will select a Grand Winner from among the four first-place Contest Award winning teams based solely on the 10-minute presentations given at the awards dinner.

A

Appendix A: Intent to Participate Submittal Instructions

Interested collegiate institution faculty leads are asked to send their Intent to Participate to racetozero@eere.doe.gov.

The Intent to Participate email should contain the following:

1. Name, title, email address, and phone number of team faculty lead.
2. Identify the one or multiple collegiate institutions that compose the team by listing the school formal name(s), preferred short-form name(s), and website homepage URL(s).
3. Anticipated design contest for competition entry. A faculty lead may indicate that multiple teams will participate under his or her guidance, but each school can only have one team per contest.
4. Summary statement of previous involvement with Race to Zero (if any).
5. Summary of plans to incorporate Race to Zero into building science curriculum, if any. For example, students will participate in the Race to Zero as a collegiate course project for academic credit, independent study credit, thesis, extracurricular activity, etc. Include degree program name(s) and level(s) (such as associate, undergraduate, and/or graduate) of anticipated student participants.
6. Indicate interest (Yes/No) to be further contacted about collaboration opportunities with DOE's Guidelines for Building Science Education efforts.

   The DOE Guidelines for Building Science Education (**www.pnnl.gov/main/publications/external/technical_reports/PNNL-24143.pdf**) are a set of job-specific checklists intended to be used by partnering training organizations, universities, and certification bodies to self-certify that their programs include these important aspects of building science in their curriculum. Partners of DOE's Guidelines for Building Science Education will be highlighted on related websites and may receive awards from DOE for their efforts in this area.

   Initial feedback from potential partnering professors has been that easy-to-access, interactive, and accurate content is difficult to come by, especially in terms of the specific modules described in the Guidelines. To address this issue, DOE is developing an online database of building science teaching resources that also supports the job-specific checklists in the Guidelines.

   If you are interested in playing an advisory role, partnering with this effort, or just sharing some of your curriculum for this new building science database, please indicate your interest.

B

Appendix B: Design Concept Submittal Instructions

Teams are encouraged to submit design concepts with the following requirements:

Format requirements:

- Packaged into single bookmarked PDF
- 8.5-in × 11-in ANSI A sheet size
- 3-page maximum.

Content requirements:

1. Project summary: preliminary version, one page as detailed in Appendix C
2. Name(s) of the one or multiple collegiate institutions that comprise the team
3. Names of the student team members with academic majors and degree levels; identify the student team leader
4. Contest category (see Section 2 Design Contests)
5. Project approach
6. Summary of industry partners and expected form of support
7. Potential structural and mechanical systems to be pursued
8. Floorplan, exterior renderings, or interior renderings (optional).

Evaluation Criteria:

- Demonstrate the formation of a team.
- Demonstrate the formulation of a project approach.
- Demonstrate a design strategy.
- Include the required content.
- Other factors, such as geographic and technology diversity, will be considered for the benefit of the program.

C

Appendix C: Project Summary Submittal Instructions

The Project Summary is a one-page document that provides the basic information necessary to communicate the salient points of your project to all competition participants. It should be considered a "one-page" marketing summary to sell the project to those who are responsible for promoting the competition, and it should provide the key points of your project in one place.

A template is available online **(http://www.energy.gov/eere/buildings/downloads/race-zero-student-design-competition-team-template**) for the project summary. It uses "Greek text" as a placeholder for the content your team will insert. To complete this requirement, please do the following in the space provided in the template file:

- List your team name and project name/title in the header.
- Swap out the "logo" in the upper right corner with your team or collegiate institution's logo.
- Swap out the "house images" with one or two graphics that best represent your project.
- Provide a concise project summary including a brief identification of the target market.
- Describe the relevance of your project to the goals of the competition.
- Summarize your design strategy and any key points about your design strategy.
- List the project data.
- Provide technical specifications for your project.
- Maintain 1-inch side margins and portrait orientation.

Past project summary submissions can be viewed on the Race to Zero website (**http://energy.gov/eere/buildings/2015-results**).

D

Appendix D: Project Report Submittal Instructions

A team's project report submittal shall be in two volumes: Volume I—Project Report and Volume II—Supporting Documentation. Both submissions are required.

Each team needs to submit the one or two graphics that best represent its project separately as high-resolution image files. These graphics may be used for competition promotional purposes and can include renderings, photos, or drawings.

Volume I is limited to 40 pages and should include all the information the team deems essential to portraying its solution to the competition's requirements and criteria. A summary and discussion of analytical results should be provided in Volume I—Project Report; other supporting information such as detailed calculations and equipment data sheets should be relegated to Volume II—Supporting Documentation. Volume II has no page limit and is a compilation of supporting documentation. Citations may be in the team's chosen format but should be consistent throughout the submission.

Format Requirements

- Volume 1. No more than 40 pages. The cover, back pages, and table of contents are not included in the page count. For convenience of the reviewers, please number the pages. Front matter can have page numbers using Roman numerals (e.g., i, ii...iv).
- Volume II. No page limit. Please number the pages.
- Single-spaced, 11-point font for body text (diagrams may have smaller fonts).
- Standard paper size 8.5-in. × 11-in, ANSI A.
- Packaged into single bookmarked PDF.
- ½-inch minimum borders, except for tables, figures, and images.

Content Requirements

Volume I—Project Report

Table of Contents

List of Tables

List of Figures

D

Project Summary (1 page)

Follow the prescribed format shown in Appendix C

Team Qualifications (1 to 3 pages)

Team profile and qualifications for each student member and industry partner

Academic institution profile with particular focus on building science

The faculty lead shall affirm in writing that all the construction-major students have satisfied the DOE Building Science Training Course requirement; alternatively, provide a statement of equivalency with courses offered at their school.

Industry Partnerships (1 to 2 pages)

Summary of partnerships with industry professionals, including builders or developers, for the overall project design and site development

Summary of partnerships with trade professionals in specific areas such as site development, construction, building materials, mechanical systems, lighting systems, financing, and sales.

Design Constraints Description (1 to 3 pages)

Summarize the lot size, shape, orientation, climate, and relationship to road(s).

Summarize the intended occupants and their characteristics.

Identify any programs or standards that form the basis for design and their roles in achieving the goals of the competition.

Describe the neighborhood and/or community setting, including density, access to, and reliance on various transportation modes.

Design Goals (1 page)

Summarize the goals the team considered when creating and developing the design.

Evaluation Parameters Narratives, Images, and Figures (1 to 30 pages)

1. Architectural Design
2. Interior Design
3. Constructability
4. Financial Analysis

D

5. Energy Analysis
6. Space Conditioning
7. Envelope Durability
8. Indoor Air Quality (IAQ) and Appliances
9. Innovation

Volume II—Supporting Documentation

Table of Contents

1. Design Renderings
   a. Exterior
   b. Interior
   c. Floorplan with furnishings
2. Construction Drawings
   a. Site plan
   b. Dimensioned floorplan(s)
   c. Building elevations (all)
   d. Building sections
   e. Interior details, including a required furniture layout and option details on finishes, cabinetry, and other fixtures
   f. Wall, floor, and roof sections
   g. Window and door details (including flashing), schedule, and specifications
   h. Air sealing details
   i. Mechanical plans and schedules, indicating duct sizing and layout, equipment locations and specifications, control design and specification, and minimum installation requirements
   j. Plumbing plans and schedules, including fixture locations, piping system layout and design, equipment location and specifications, and minimum installation requirements
   k. Electrical and lighting plans and schedules, including outlet locations, fixture specifications, control systems, and photovoltaic systems
   l. Construction schedule and size of the project

D

3. Energy Analysis

   a. HERS Rating Documentation

      i. Include the house size adjustment factor calculations as required for homes exceeding the square feet specified in the Size Adjustment Factor table.

      ii. Perform a HERS Index analysis to include the energy supply with and without the renewable energy system.

4. HVAC Commissioning requirements referenced to manufacturer and trade protocols

5. Financial Analysis, using provided template and appropriate references

6. Optional additional documentation to support team design goals and submission

E

Appendix E: Project Presentation Submittal Instructions

Each team shall develop two presentations. The first will be a 25-minute presentation of the submission to give to the jurors in person at the event; an additional 10 minutes must be reserved for questions.

The second presentation will be a 10-minute version. This shorter presentation is in preparation for winning the contest category. Winners of the contest category will then give their 10-minute presentations to a grand jury at the closing dinner for all the competition participants.

Teams are not required to include their project presentation in the project report.

F

Appendix F: Project Poster Submittal Instructions

Each team shall develop a project poster that showcases the team's design and response to contest parameters.

- Content should, at a minimum, include in the project summary content.
- A team may include additional information, graphics, and images as desired.
- Size to be 3' wide by 2' tall maximum.
- Submitted as a PDF. Teams should print the poster and bring to the competition.

G

Appendix G: Frequently Asked Questions

Some of the technical frequently asked questions from the 2015 competition follow.

Question:

Does the building have to be furnished (couches, beds, televisions, etc.)?

Answer:

Yes, the rendered floorplan must show furniture, but the dimensioned floorplan does not need to show furnishings. A good design must consider how the occupants will live in the home; that includes furniture. This will help move the housing market away from a total square footage to an effective square footage metric. Moreover, furnishings provide a better visual presentation and help jurors better understand scale and functionality of the design.

Question:

Is air conditioning a necessity in the home if LEED requirements for comfortability are met without it?

Answer:

The Race to Zero Guide does not specify rules or limits on this. Because air conditioning (comfort cooling) provides dehumidification, your team should assess that need as well. That said, a house might not require space heating or cooling if it is located in paradise (climatically).

Question:

Should we use metric units or English units?

Answer:

English units are preferred. Most of the jurors are oriented to English units, not SI or metric. However, a submission with metric units would be accepted.

Question:

I have two questions about the Renewable Energy Ready Home Photovoltaic Checklist.

1. One aspect is dedicating a "4×4 plywood backing for mounting the inverter and balance of system components." If we are using a micro inverter system would we still need to dedicate this space? Our photovoltaic subpanel is located outside the house along with the air conditioning disconnect/meter.

2. Another aspect of the Renewable Energy Ready Home Checklist states "designate and install circuit breaker for use by the photovoltaic system in the electrical service panel." For our project (on paper), what would you recommend as the best way to indicate that we have dedicated a 70-amp dual pole breaker in the electrical service panel?

G

Answer:

The answer is based in "what is practical, functional, and meets the intent of the provision."

1. The intent for solar ready is to allocate space for necessary components, so if the collegiate team has considered this criterion the intent is fulfilled. It would not make sense to allocate more space than necessary to accommodate the selected equipment by arbitrarily following the checklist for a 4-ft ×4-ft mounting board.

2. Electrical components should be delineated on the electrical plan and schedule (listing) of components. A notation on the checklist would help the jurors locate the information; the electrical plans should also have sufficient detail for purchasing (specifications) and installation.

Question:

We have a question about the competition guide as it relates to which zero energy calculation method to use. We are familiar with ZNE Site, ZNE Source, ZNE TDV (being Californians), and many others, so we're just trying to determine whether we need to choose the way we calculate reaching "zero." I am not too familiar with REM/Rate so perhaps the answer lies within the way this software calculates it? A follow-up question: is the use of REM/Rate a requirement for the competition versus another energy modeling program?

Answer:

REM/Rate calculates a HERS Index score, which includes building energy consumption and renewable sources … an index of zero is "net zero" and a negative index indicates net positive (more generation than consumption) and the larger the index number indicates lower energy efficiency. The competition guide requires reporting HERS Index scores with and without renewables so the jurors can assess the two independently.

Question:

Our team is wondering how detailed we should be in our demonstration of following the Zero Energy Ready Home guidelines. For instance, one section includes the ENERGY STAR Qualified Homes checklists (which include many subsections). What level of detail is desired? Would we have to specify that we would seal and caulk around bathtubs, for instance, or could we check this off with the understanding that this is required? Essentially, we're just wondering how to fit the demonstration of compliance into our report without going overboard.

G

Answer:

Think of your collegiate institution's team as part of a builder's operation. One of the challenges there is managing and implementing design intent ... if checklists from multiple programs (assume the builder has adopted ENERGY STAR, Indoor airPlus, WaterSense, and green certification programs) are part of quality control and compliance inspection. How would you (the builder's management team) implement these? Obviously it has to be built into scopes of work for trade contractors, and likely part of the bid package for the trades that define the pricing and ultimately the instructions to the trade contractors' crews. Your challenge in the Race to Zero competition is to demonstrate how to manage the process. What could the team put in place that organizes the requirements so they can be handed off with the expectation that the design intent can be fulfilled? There are many ways to approach this, such as by providing model scopes of work, providing a list of requirements (specifications) to the builder's purchasing department that addresses the items of concern, assembling it into a form for next-level "implementation" meeting and handoff, etc.

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

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