Participatory Learning Through the Race to Zero Competition

The Fourth Residential Building Design and Construction Conference
February 28th, 2018, University Park

PHRC
(Pennsylvania Housing Research Center)

The Pennsylvania Housing Research Center (PHRC) serves the home building industry and the residents of Pennsylvania by improving the quality and affordability of housing through training, applied research, academic research, and technology transfer for PA builders, remodelers, land developers, engineers, architects, planners, code officials, and local government officials. The PHRC is housed in the Architectural and Civil & Environmental Engineering departments in the College of Engineering.

Sarah Klinetob Lowe has an M.S. in Architectural Engineering and ten years of broad work and research experiences within the residential construction industry, with technical focuses in residential energy retrofits and solar PV systems. She is currently the Housing Systems Specialist at PHRC after serving three years as the Budgets & Publications Coordinator.

EEHR
(Energy Efficient Housing Research Group)

The Energy Efficient Housing Research Group (EEHR) at Penn State is a multidisciplinary team of faculty, graduate, and undergraduate students dedicated to the investigation of energy efficient, affordable, and sustainable housing--from design & construction methods through performance optimization in order to inform better housing solutions and more resource conscious living. EEHR is housed in the Hamer Center for Community Design within the College of Arts & Architecture.

Chris Hazel graduated in May of 2017 with a Master of Architecture degree from Penn State. While there, he worked with Lisa Iulo in EEHR developing a net-zero energy ready home for State College, PA. He is currently a research technician at EEHR.

Race to Zero Competition

Student Education

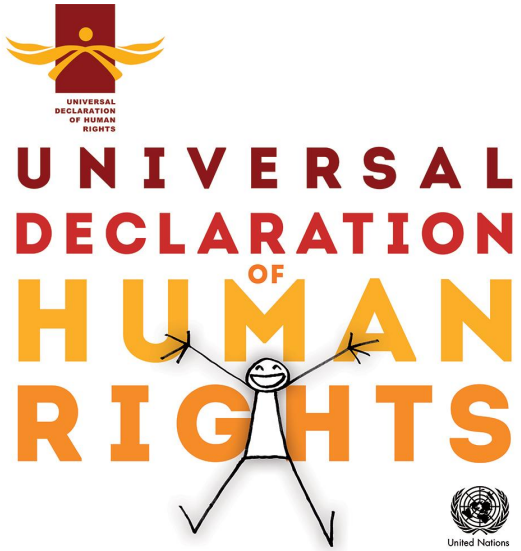
RACE TO ZERO
U.S. DEPARTMENT OF ENERGY
STUDENT DESIGN COMPETITION

Race to Zero Competition

Student Education

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

Community Engagement



(UDHR) Article 25 (1), 1948:

"Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, **housing** and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control."

“common standard of achievements for all peoples and all nations”

What is **Affordable Housing?**

The government says housing is “affordable” if a family spends **no more than 30%** of their income to live there.

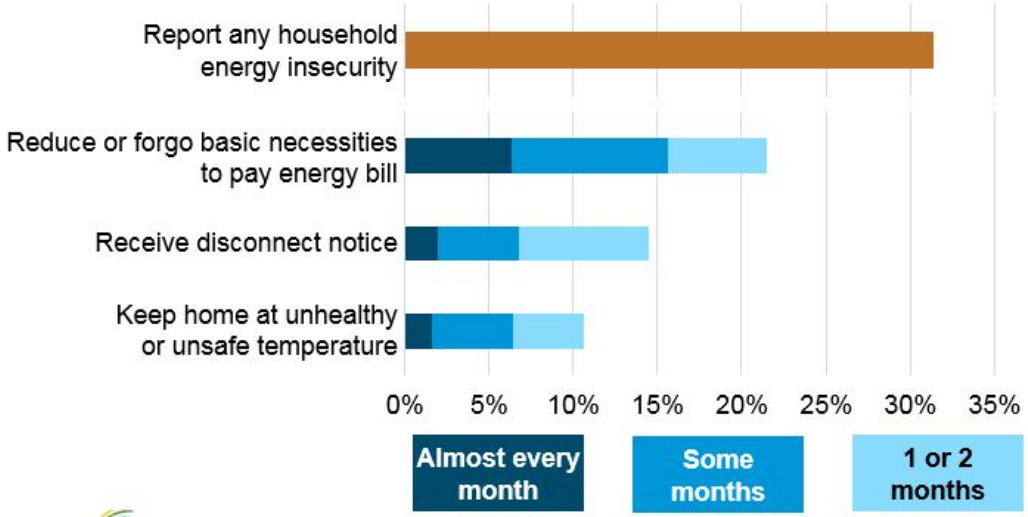
Pennsylvania Housing Research Center (Producer). (2016). *Affordable Housing Initiatives in Pennsylvania: Land Trusts* [Video webinar]. Retrieved from http://www.phrc.psu.edu/Industry-Education/webinar-details.aspx?ArticleID=8d91a4517550464cbfe4fbbce

‹ CONSUMPTION & EFFICIENCY

RESIDENTIAL ENERGY CONSUMPTION SURVEY (RECS)

Households experiencing household energy insecure situations, 2015

percent of households



eia Source: U.S. Energy Information Administration, Residential Energy Consumption Survey 2015

AMERICAN HOUSING SURVEY 2015 RESULTS // ENERGY BURDEN

Energy Costs

Median monthly costs for…

$133 FUEL OIL

$53 GAS

$29 OTHER FUEL

$104 ELECTRICITY

Energy Overview

Type of fuel used

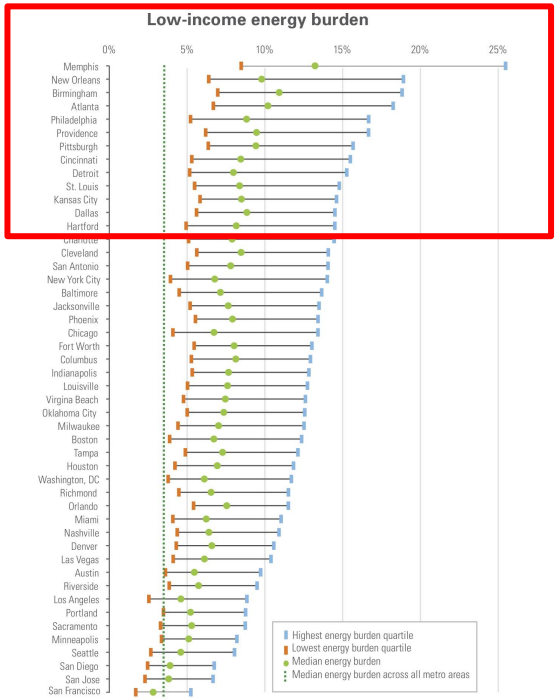
99.9% Electricity

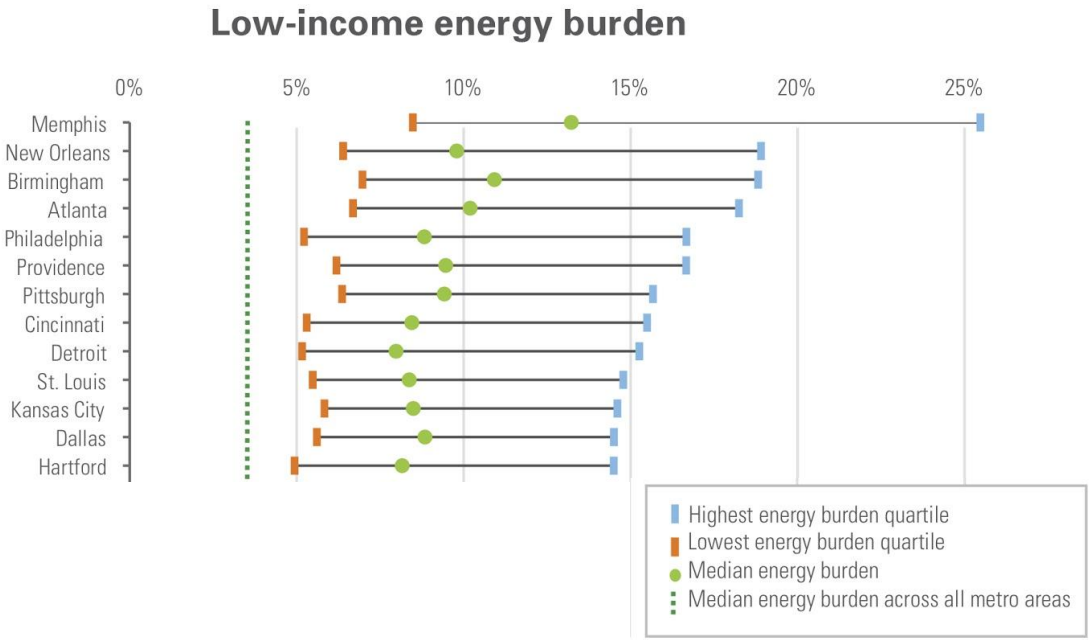
67.9% Gas

6.4% Fuel Oil

4th RBDCC | Why Energy-Efficient Housing Research Matters

FIGURE 4. Low-income (≤80% AMI) household energy burdens for the median, highest energy burden quartile, and lowest energy burden quartile households for each metro area. The orange bars represent the beginning of the quartile of low-income households with the lowest energy burden. The blue bars represent the beginning of the quartile of low-income households with the highest energy burden. These data include both single- and multifamily low-income households.





Dreihobl, Ariel & Ross, Lauren. **Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities**. ACEEE. April 2016.

4th RBDCC | Why Energy-Efficient Housing Research Matters

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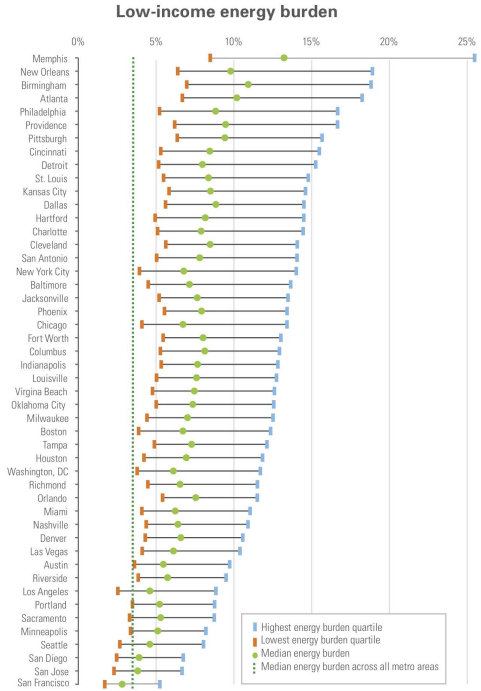

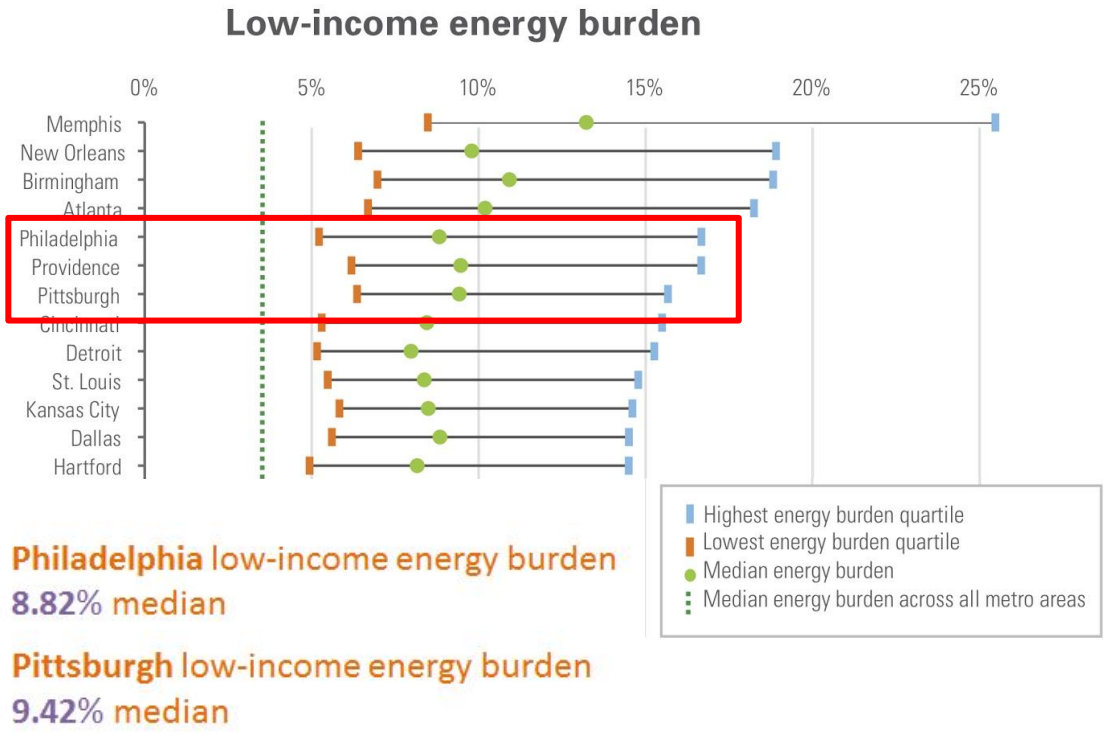

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MorningStar Home
Solar Decathlon - 2007

MorningStar Montana - 2007
American Indian Housing Initiative

Natural Fusion
Solar Decathlon - 2009

GridStar Home - 2012

UCHA EEHP - 2012

GreenBuild
Race to Zero - 2015

U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

MorningStar Home
Solar Decathlon - 2007

MorningStar Montana - 2007
American Indian Housing Initiative

Natural Fusion
Solar Decathlon - 2009

U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

"Market Viability" & "Market Potential"

2009 Team: **University of Darmstadt**
Overall: **1st Place**
Market Viability: **5th Place**
Size: **~800 sq. ft**
Cost: **$$$$ ($650,000-$850,000)**

Cost per Square Foot: ~$1,062.50

2017 Team: **Swiss Team**
Overall: **1st Place**
Market Potential: **11th Place (last)**
Size: **~700 sqft, living space (1940 sqft, total)**
Cost: **$$$$ (~ $833,000)**

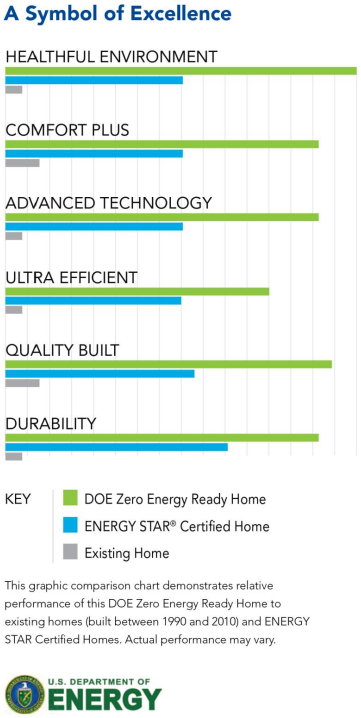
Cost per Square Foot: ~$1,190 (L), ~$429 (T)

Homes to the Power of **ZERO**

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

What is the DOE Zero Energy Ready Home™ Label?
It is a Symbol of Excellence for energy savings, comfort, health, quality, and durability met by a select group of leading builders meeting U.S. Department of Energy Guidelines.

What is a Zero Energy Ready Home?
It is a high-performance home so energy efficient, all or most annual energy consumption can be offset with renewable energy. In other words, it is the Home of the Future.



DOE Zero Energy Ready Home point-of-sale fact sheet:
https://energy.gov/sites/prod/files/2014/08/f18/DOE%20POS.pdf

- **ENERGY STAR for Homes Baseline**
- **Sound Building Science**
- **Renewable ready (Solar PV)**
  - **Orientation, shading, roof design, conduit**
- **Affordable for target Median Family Income**

DOE Race to Zero Goals

- Building Science
- Market Transformation
- Industry Connections/Partnerships to advance the industry
- Educating the next generation of home builders

U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

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

Debt-to-Income Ratio
= 38% MFI *(including utilities)*

Cost per Square Foot: ~$125.00

4th RBDCC | Race to Zero - Educational Goals

- Building Science
- Market Transformation
- Industry Connections/Partnerships to advance the industry
- Educating the next generation of home builders

- Community Connected design
- Integrative Design
- Affordable housing
- High-Performance Building Research
- Interdisciplinary Collaboration
- Educating the general student body
- Industry-Student partnerships

Image Credit: 2017 Race to Zero Competition

2014

Columbia County Housing Authority & LaSalle Street Homes

2015

State College Community Land Trust & GreenBuild

2016

Union County Housing Authority & Penn Commons

2017

Centre County Housing & Land Trust, Ferguson Township, & Turnberry Traditional Town Development

2018

S&A HOMES This is Home

S&A Homes (Production Builder)

2014 2015 2016 2017 2018

S&A HOMES This is Home.

Components of the Community Partnership

- **Single Point of Contact**
- **Specific site / development**

- Site visit
- Engage in 2+ design charrettes
- Explicit expectations

- Additional engagement (presentations, meetings, etc.)

2014 2015 2016 2017 2018

S&A HOMES
This is Home

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2014 2015 2016 2017 2018

S&A HOMES This is Home.

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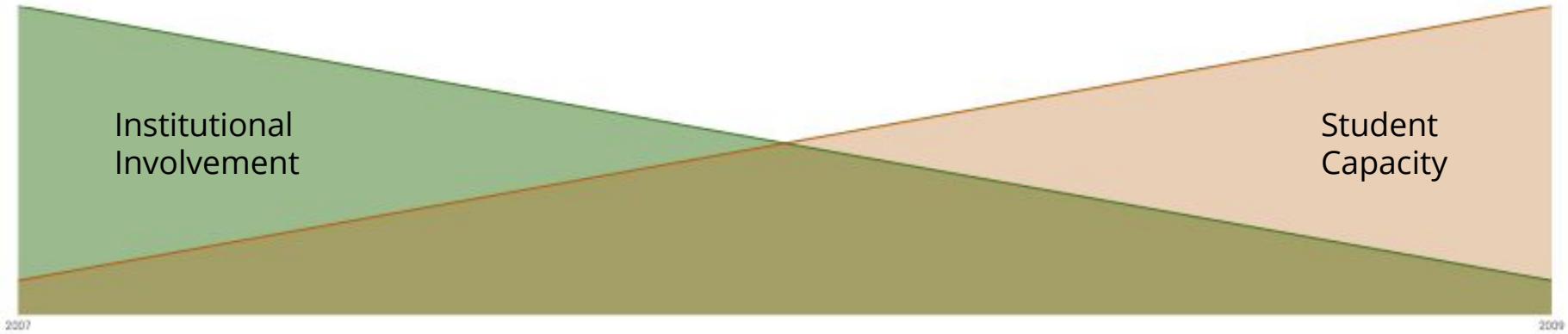
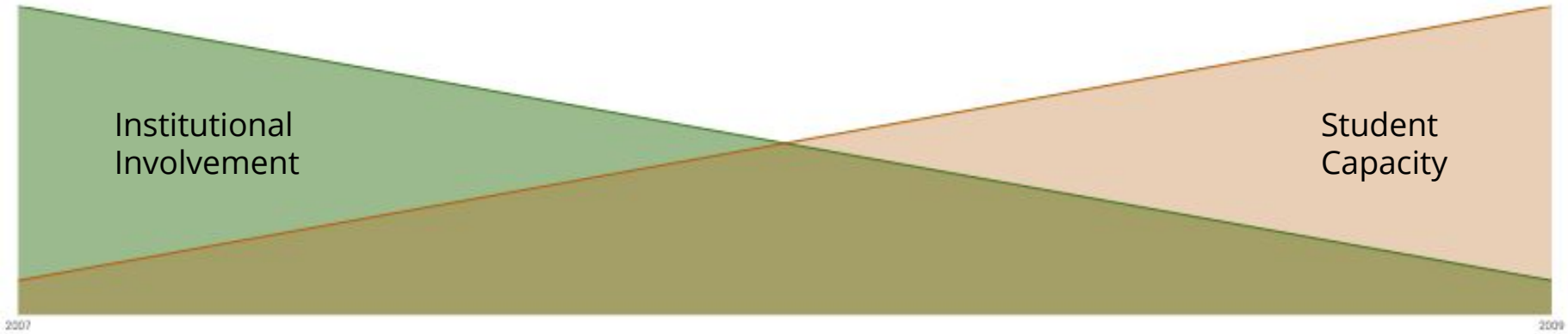


MorningStar, 2007 Solar Decathlon

Natural Fusion, 2009 Solar Decathlon



High Educational Structure & Faculty-Driven

MorningStar, 2007 Solar Decathlon

Low Educational Structure & Student-Driven

Natural Fusion, 2009 Solar Decathlon

4th RBDCC | Race to Zero - Student Capacity

2014 2015 2016 2017 2018

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Student Capacity

2014	2015	2016	2017	2018
Experienced Student Team Leader	**Experienced Student Team Leader**	New Inexperienced Student Team Leader	Semi-experienced Student Team Leader	Multiple Semi-experienced Student Team Leaders
Primarily Graduate students	Mix Undergraduate & Graduate students	Primarily Graduate students	Primarily Undergraduate students	Primarily Undergraduate students
14 Students	28 Students	**8 Students**	20 Students	27 Students

4th RBDCC | The Race to Zero at Penn State

2014 2015 2016 2017 2018

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Student Capacity

14 Students	28 Students	8 Students	20 Students	27 Students
Architecture: 5	Architecture: 18	Architecture: 5	Architecture: 7	Architecture: 7
Arch. Engr: 5	Arch Engr: 4	Arch. Engr: 1	Arch. Engr: 2	Arch. Engr: 8
Civil Engr: 2	Civil Engr: 5	Civil Engr: 2	Civil Engr: 1	Civil Engr: 2
Energy Engr: 1	Energy Engr: 1		Energy Engr: 6	Energy Engr: 3
			Mech. Engr: 3	Business: 1
			Chem. Engr: 1	Mech. Engr: 5
				Chem. Engr: 1

4th RBDCC | Race to Zero - Student Capacity

2014 2015 2016 2017 2018

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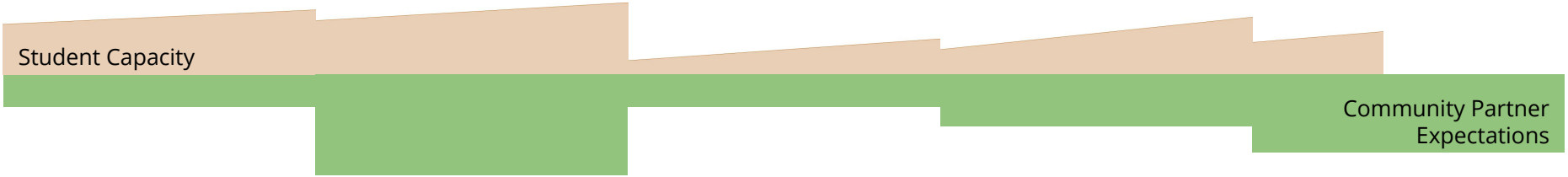
Homes Being Built

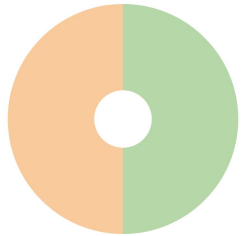
Written Summary of Expectations

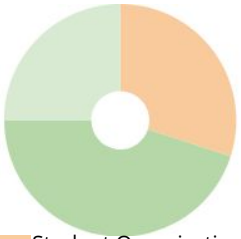
4th RBDCC | Race to Zero - Student Capacity

2014 2015 2016 2017 2018

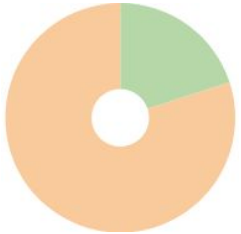
S&A HOMES This is Home




Student Organization
Independent Study


Student Organization
ARCH 497E
ARCH 431

Student Organization


Student Organization
ARCH 412

Student Organization
ARCH 412
CE411

4th RBDCC | Race to Zero - Competition Structure

2014	2015	2016	2017	2018
				S&A HOMES This is Home
28 Competing Teams	**33 Competing Teams**	**31 Competing Teams**	**39 Competing Teams**	**84 Competing Teams**
Mixed Housing Types Competition	Mixed Housing Types Competition	Specific Housing Types Competition Grand Prize Competition	Narrowed Down from 46 Applicant Teams Specific Housing Types Competition Grand Prize Competition	To be Narrowed Down to 40 Competing Teams Specific Housing Types and School Design Competition Grand Prize Competition

4th RBDCC | Race to Zero - Project Timeline

2014 2015 2016 2017 2018

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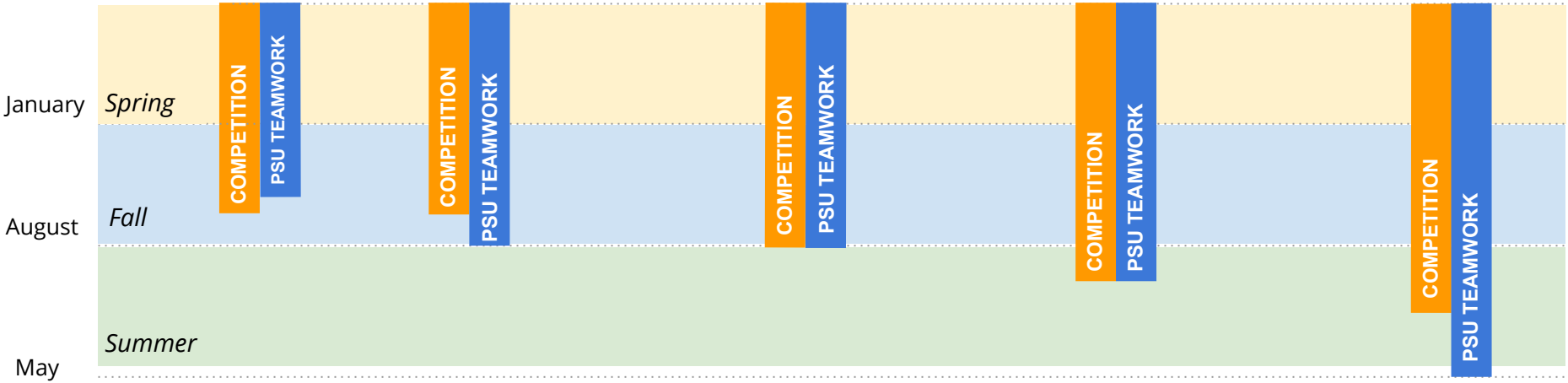
April **COMPETITION**



4th RBDCC | Race to Zero - Competition Results/Awards

2014	2015	2016	2017	2018
				S&A HOMES This is Home
28 Competing Teams	**33 Competing Teams**	**31 Competing Teams**	**39 Competing Teams**	**84 Competing Teams**
Best Technical Integration Special Recognition for IAQ Evaluation	Design Excellence Award Systems Integration Excellence Award		Finalist Team	

4th RBDCC | Race to Zero - Competition Results/Awards

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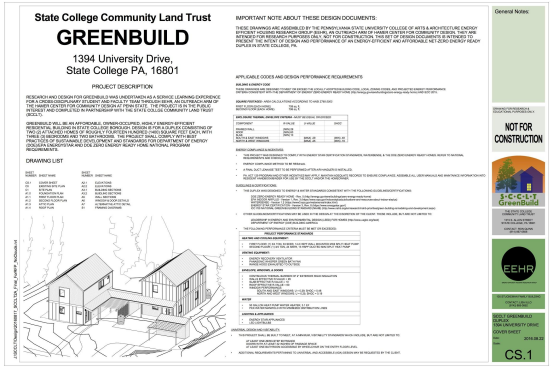
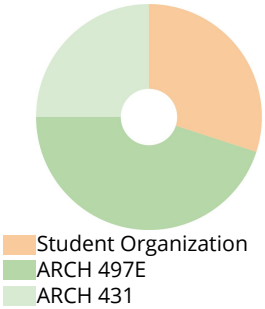
4th RBDCC | 2015 Race to Zero - GreenBuild



4th RBDCC | 2015 Race to Zero - GreenBuild

Student Capacity

Community Partner Expectations



4th RBDCC | Race to Zero - Educational Development

2014 2015 2016 2017 2018 2019

S&A HOMES This is Home

Habitat for Humanity®

Focus on Developing future student capacity

- **Articulated Community Partner Goals**
- Measure incoming and outgoing student capacity
- Develop Building Science and Housing Systems Lectures to be used by future students
- Mockups and Model Building
- Integrative Design Charrette Guide
- Comprehensive Literature Compilation/Database for Student Use

S&A HOMES

S&A Homes Profile - Race to Zero

Bob Shoemaker – Bio

My Construction experience started in the field as Bricklayer and Job Superintendent. I then later transitioned into Construction Estimating, Purchasing and Drafting/Design.

I worked for a diverse group of Local, Regional, and National Home Builders over the years. In 1999 I joined S&A Homes Inc. where I currently serve as the Construction Technical Services Manager. I'm presently responsible for overseeing the Estimating, Drafting, and Purchasing Departments, including, Production Drafting, new product design, conceptual costs development, constructability analysis, value-engineering, Sub Contractor bid analysis, and Sub Contractor scope of works. Other responsibilities include providing the Construction Production Managers with technical assistance in the field, including structural and building performance best practice training, code compliance instruction, and safety management support. I hold Liberal Arts Associates Degree from the Pennsylvania State University. I'm currently a PHRC - IAC Council member and have been involve on and off with the PHRC off and on since the 1990's.

S&A Homes Profile

4th RBDCC | Race to Zero - Educational Development

2014 2015 2016 2017 2018 2019

S&A HOMES This is Home

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4th RBDCC | Race to Zero - Educational Development

2014 2015 2016 2017 2018 2019

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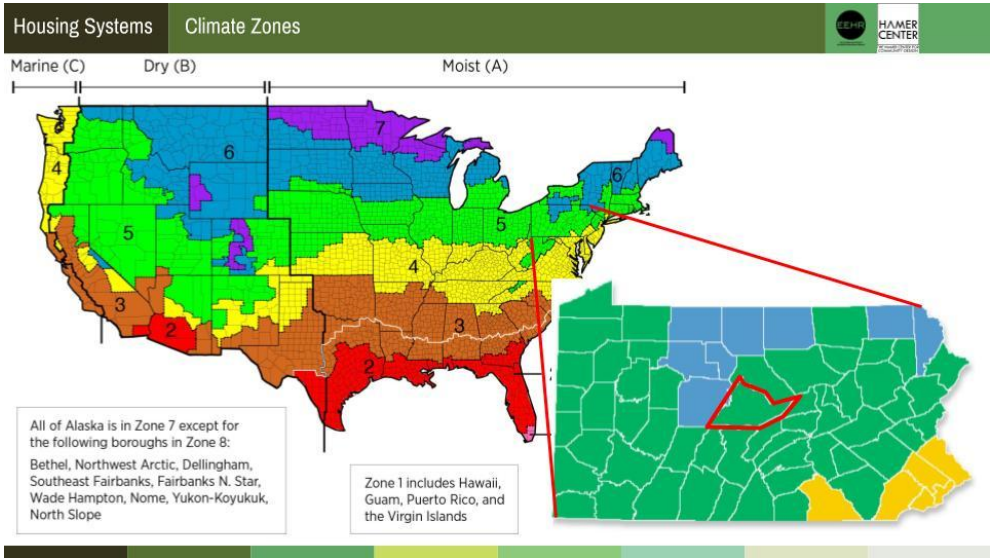

4th RBDCC | Race to Zero - Educational Development

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4th RBDCC | Race to Zero - Educational Development

2014 2015 2016 2017 2018 2019

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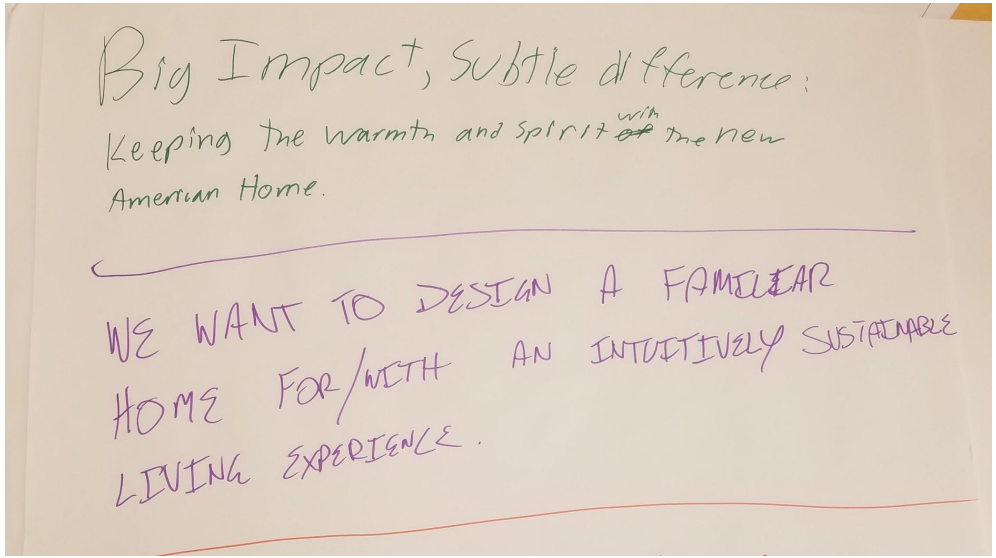

4th RBDCC | Race to Zero - Educational Development

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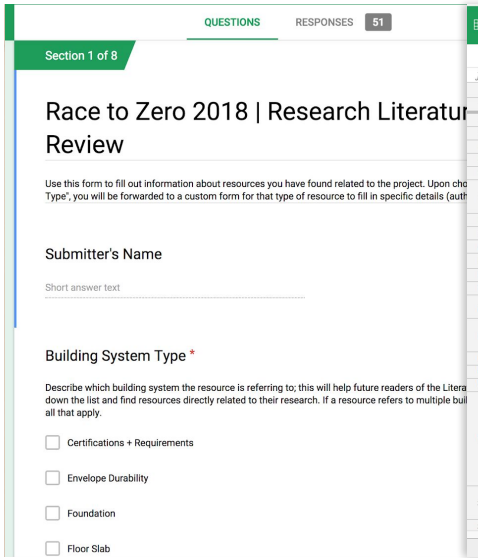
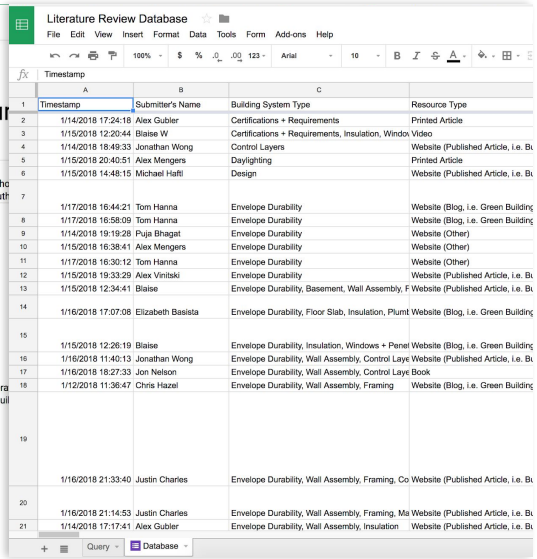
- Comprehensive **Literature Database and Research Tools** for Student Use





PHRC

(Pennsylvania Housing Research Center)
Sarah Klinetob Lowe
Housing Systems Specialist
slowe@engr.psu.edu

EEHR

(Energy Efficient Housing Research Group)
Christopher Hazel
Research Technician
cjh5327@psu.edu

We would like to thank the students, industry partners, and Penn State faculty that have been involved with the Race to Zero competition at Penn State and have helped to make it so successful.

Additionally, we would like to thank:

- Institute for Energy and the Environment at Penn State
- Penn State Sustainability Institute
- Energy Efficient Housing Research Group and Hamer Center for Community Design
- Penn State College of Arts and Architecture
- Pennsylvania Housing Research Center
- West Penn Power Sustainable Energy Fund