

## Co-Design of a Sustainable Affordable Housing Demonstration Project

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### **ABSTRACT**

Housing affordability is a rising concern for many Americans, especially those of modest needs. The design and construction of energy and resource-conscious environmentally sustainable homes that are affordable in the short- and long-term are a paramount challenge. A Community Land Trust (CLT) is a private, non-profit organization whose goal is to acquire and hold land for the benefit of the community and to provide secure affordable access to land and housing for community residents. The mission of the State College Community Land Trust (SCCLT) is to “support vibrant neighborhoods by creating and maintaining sustainable housing opportunities for families and individuals who value living in the Borough of State College” (<http://www.scclandtrust.org/clt/>), a neighborhood with scarce opportunity for affordable, owner-occupied housing. Through a partnership with the Energy Efficient Housing Research group (EEHR), an outreach arm of the Penn State College of Arts and Architecture Hamer Center for Community Design, SCCLT is embarking on their first new building project – a zero energy ready residential duplex on a highly visible site in the property-constrained Borough. The duplex, once completed, will provide homes for two families of modest incomes and will be a demonstration for sustainable, affordable housing in the region. Fueled by challenges posed by the Department of Energy Zero Energy Ready Home program and *Race to Zero* student design competition, the “co-design” for the SCCLT GreenBuild demonstration project engages a diverse cross-disciplinary student and multiple-faculty team with community housing and construction leaders in an educational exchange centered on ideals for improving housing performance and community.

### **INTRODUCTION**

*Co-design is the process at which actors from different disciplines share their knowledge about both the design process and the design content. They do that in order to create shared understanding on both aspects, to be able to integrate and explore their knowledge and to achieve the larger common objective: the new product to be designed (Kleinsmann and Valkenburg, 2008).*

What role can co-design play in realizing needs for affordable housing? This question is asked in the context of an ambitious undertaking by the EEHR group at Penn State in the interest of researching new housing for the borough of State College that fills a distinct niche – providing design ideas for affordable housing that meets the needs of income eligible home owners, while educating the community and future visionaries of our built environment about the importance of long-term thinking and the impact of building design.

## **BACKGROUND**

Penn State has a successful repertoire of affordable, sustainable housing demonstration projects including and evolving from the Solar Decathlon homes, American Indian Housing Initiative, Union County Energy Efficient Housing Program projects, and the GridSTAR Smart Grid Experience Center (see Figure 1). Each project demonstrates the importance of a holistic approach and the necessity for establishing local connections and reinforcing community development in realizing a replicable model for sustainable housing (Iulo et al, 2014). These pilot projects have provided insight for achieving more affordable and sustainable homes and potential for contributing to the very real problem of housing affordability in our own community.



2007 - MorningStar PA



2007 - MorningStar MT



2009 - Natural Fusion



2012 - GridStar



2012 - UCHA EEHP Duplex

**Figure 1: Penn State Zero-Energy Home Demonstration Projects**

The Energy Efficient Housing Research group (EEHR) at Penn State was established in part as an opportunity to reflect on past projects to inform success on future initiatives that can be of benefit to local communities. EEHR is a multidisciplinary team of faculty, graduate and undergraduate students dedicated to the investigation of energy efficient, affordable and sustainable housing - from design and construction methods through performance optimization – in order to inform better housing solutions and more resource conscious living. An approach that considers planning,

design, construction, operations, monitoring, assessment and reflection is used to systematically consider affordable, sustainable, energy-efficient housing through an integrative design process. The projects undertaken by EEHR address applied strategies and solutions for realizing tangible examples for affordable, sustainable housing that are locally appropriate and address transforming markets and demographics. Over the past few years, EEHR has attracted interest from and sustained relationships with local affordable housing providers.



**Figure 2: State College Community Land Trust mission and homes.**

In December of 2013 the State College Community Land Trust (SCCLT) approached EEHR for guidance. Since the mid-1990s this non-profit housing assistance organization has been helping income-qualified individuals and families purchase homes in State College, PA (where Penn State is located). SCCLT helps to reduce the cost of buying a home by holding the land permanently “in trust,” this means that while the house is sold to a homeowner, the land is leased long-term. The agreement allows the prospective homeowner to apply for a mortgage based only on the cost of the house, effectively reducing the cost of purchasing a first home by as much as 30 percent ([www.scclandtrust.org](http://www.scclandtrust.org)). Moreover, it ensures that the home, when resold, remains affordable. Historically, SCCLT has purchased, renovated and resold existing homes in the Borough (See Figure 2), and initially they approached EEHR to learn about energy efficiency retrofit measures. Shortly after this initial meeting, SCCLT had the opportunity to purchase a highly visible and coveted borough site to embark on their first new housing construction project. Located in an R2 district, zoning for the 20,000 square foot lot size allows for the construction of a duplex (two connected dwelling units), which is consistent with the surrounding community fabric. SCCLT saw potential in the previously completed Union County Housing Authority Duplex to serve as a “blueprint” for their project. Consistent with the Union County Housing Authority’s goals for the project, Union County’s Energy Efficient Housing Program pilot project was documented by EEHR to serve as a model for other housing providers (Iulo and Quigley, 2013; Iulo et al, 2014). Although in practice it was feasible to adapt the Union County design – the size, budget, and goals for affordability were similar to those of SCCLT – theory about sustainability informed

an alternative process. Tenets of sustainable development prioritize consideration for site-specific design strategies especially solar and a focus on local resources. Moreover, Penn State had the experience and interest to offer community design assistance. Therefore, it was determined that co-design of the project, through a university/community partnership, would be mutually beneficial.



**Figure 3: Photo of the Penn State 2015 DOE *Race to Zero* Team**

### **UNIVERSITY ENGAGEMENT**

The SCCLT project serves as an opportunity for cross-disciplinary student and multiple faculty engagement that has the potential to leverage existing connections and inform involvement in ongoing educational and research initiatives. Partnership with Penn State provides the SCCLT with added value through design expertise, increased visibility, and potential project donations and sponsorship. The close working relationship with the SCCLT was one of the hallmarks of this project because of their demonstrated interest and common goal of affecting the community. They met the Penn State team with a partially conceived vision and list of what they wanted from the project. The integration between the students and the SCCLT was vast and critical. Most importantly, the outcome of this partnership with SCCLT – two homes for local families of moderate incomes – could not afford to be experimental. Therefore a rigorous process of curricular and extracurricular engagement to test viability was undertaken, involving:

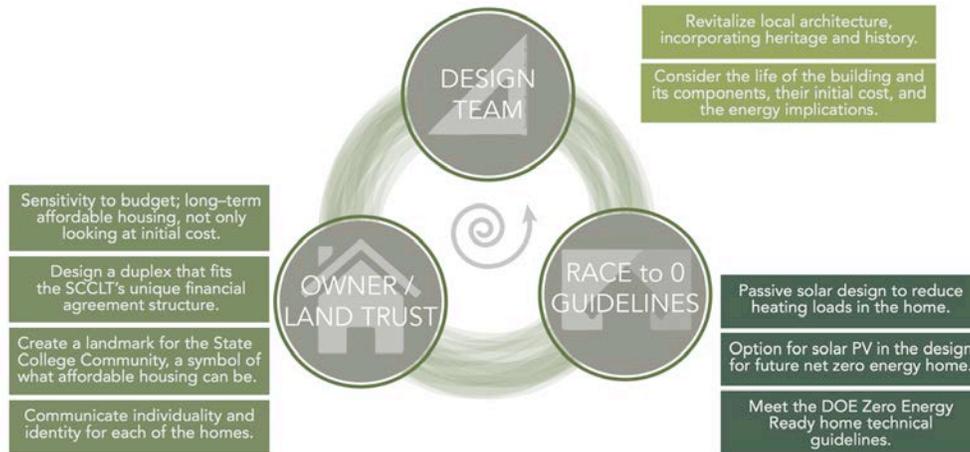
Curriculum: Multiple opportunities for integrating this project into existing undergraduate and graduate curricula and studio coursework are being undertaken or explored. In the Fall 2014 Semester the project was incorporated into a comprehensive architectural design studio course required of fourth-year undergraduate students matriculated in the professional Bachelor of Architecture degree program. Students enrolled in this class provided initial research about the need for affordable housing in State College and provided the SCCLT with ideas for project program and suggested design alternatives. This preliminary work informed students, majoring in architecture and engineering, enrolled in a special topics class in the Spring 2015 semester focused on the design of Zero-Energy Ready Homes designed to meet the needs of the SCCLT “GreenBuild” project. Additional focused courses for the development of related design, mock-ups, detail fabrication, performance monitoring and on-going research about the eventual performance of the homes post-construction are projected for the future.

Student Design Competition: Concurrent to SCCLT approaching the EEHR the DOE was hosting the *Race to Zero* (formerly Challenge Home) collegiate competition. This competition was a perfect fit for the work the SCCLT already was interested in, homes that could be constructed for the current housing market and are consistent with goals for extremely low-energy living. Participation in *Race to Zero* promoted engagement across disciplines and attracted visibility for the project. Through the competition, students got to delve into the details of what it means to design for efficiency and affordability. An extensive network of industry partners informed the viability of the design, engineering and financing for the project. Penn State’s team competition submission related rigorous building science research into the SCCLT GreenBuild design. Verification by 2015 DOE competition judges, experts in the housing industry and building science, allowed for some assurance that the future project can be successfully less energy-intensive without being unnecessarily experimental.

Test Bed: The SCCLT GreenBuild project is providing a test bed for research and collaboration where undergraduate and graduate students, faculty and industry partners are collaborating to explore ideas and test viable solutions for a real-world project. At its core this project is interdisciplinary. A group of over 30 students with various backgrounds in engineering, architecture and even business and finance came together to form a team of highly motivated and intelligent thinkers focused on a project specific to the SCCLT (See Figure 3).

### **[CO] DESIGN FOR A TRIAD OF INTERESTS**

A process of interaction between “town and gown” has been central to this project from conception through visualization and will be necessary for successful long-term realization. Three parties were major design drivers: The State College Community Land Trust, representatives of future homeowners; the DoE *Race to Zero* competition guidelines and related *Zero Energy Ready Housing* standards for performance; and the Penn State team (See Figure 4).

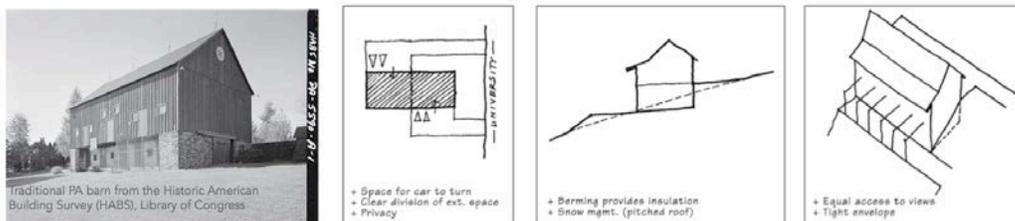


**Figure 4: Triad Diagram and related goals**

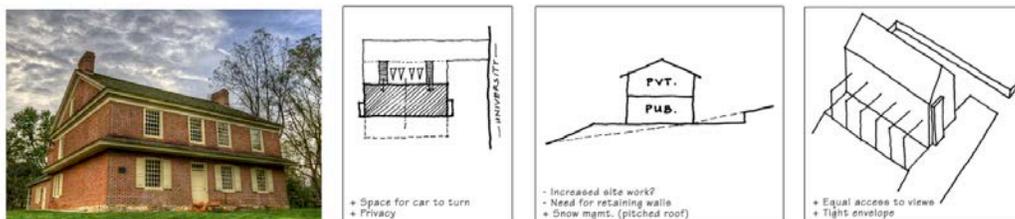
**H4 - Heritage Homes: High-Performance Living in Harmony with Community**

“Good architecture learns from the past, responds to the present, and inspires the future” (Penn State, 2015). The project concept was informed by the triad in the interest of achieving cost-effective zero-energy homes, intended for a specific client in the community of State College, Pennsylvania, that showcase the expertise of a cross-disciplinary University team. The project title, H4, Heritage Homes: high performance living in harmony with community, eludes to the main goals for the project - to foster high performance living in an accessible and affordable way, tying these ideals back to what already makes our region great, all while making the best impact on the community we serve. The design of the duplex recalls the local history and traditions of the region’s agrarian past through modern interpretations evocative of the iconic Pennsylvania Bank Barn and Farmhouse (See Figure 5).

The “Bank Barn”



The “Pennsylvania Farmhouse”



**Figure 5: “Heritage” influences. Sketches by Shivaram Punathambekar.**

Consistent with sustainable-community thinking, the site that SCCLT acquired is located in the Borough of State College, within walking distance to campus and to multiple amenities and public transportation. The south-sloping site with views to surrounding mountain ranges is also prominently located on University drive, a well-traveled road with optimum exposure to the public (Figure 6). These factors make the location an ideal showcase for the importance of and potential for sustainable, low-(or zero-) energy design in our community. The concept of “heritage” ensured that the new concepts of energy efficiency and affordability did not land alien in the community of State College. Instead, by taking into consideration the surroundings and the history of the region the team was able to engage the community at the very core of the design.

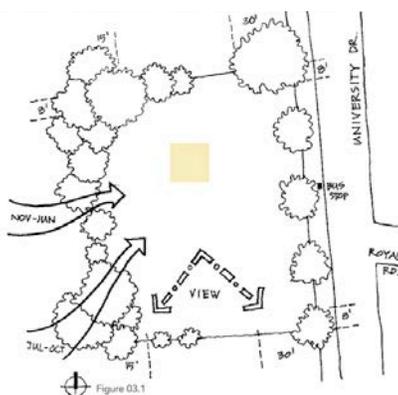


Figure 03.2 - View as seen from diagram 03.1

Design and build a moderately priced, owner-occupied duplex utilizing advanced and long-term cost-effective green technology.

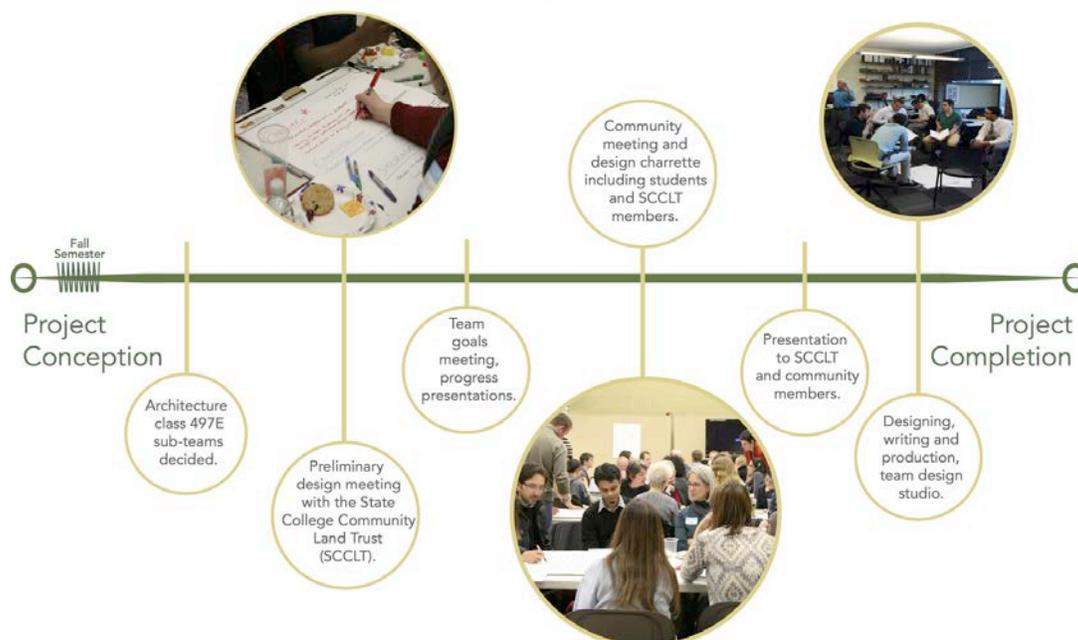
Develop a sustainable project “using best practices to create lasting environmental, economic, community and organizational vitality.”

The Duplex:  
2 Units, 3 Bedrooms, 1.5 baths with approximately 1250 square feet of living space in each unit.

**Figure 6: SCCLT GreenBuild site and design goals.**

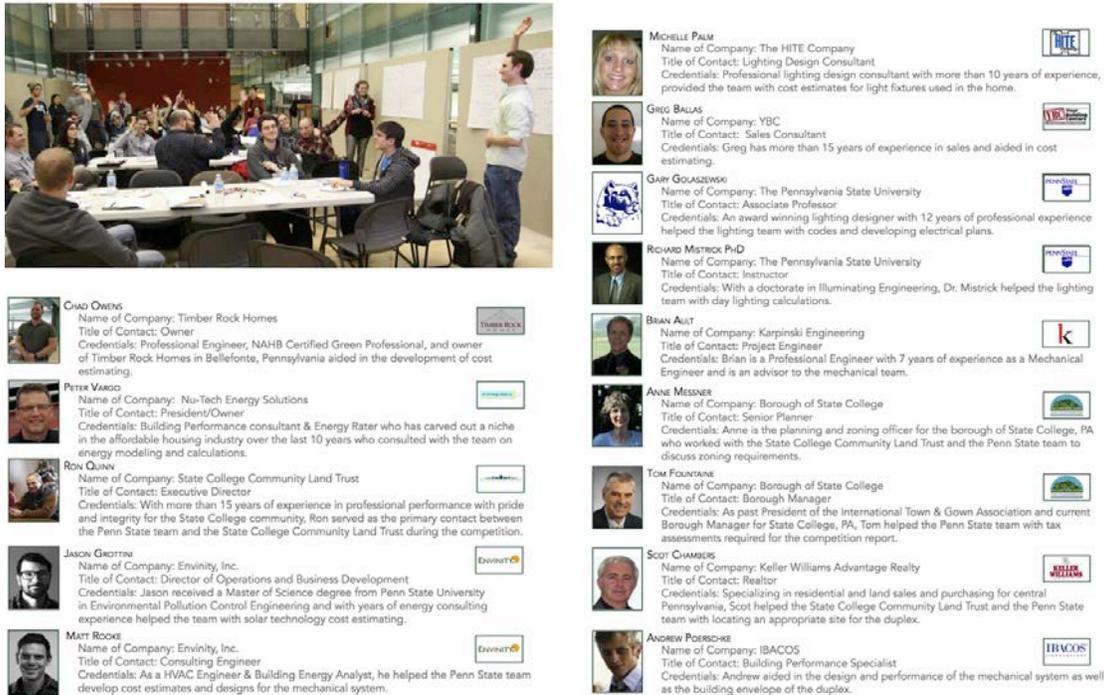
With multiple facets to the project it was best to take an organizational approach to assure that all of the stakeholders were heard and equally considered. The Penn State team took direction from 7Group, borrowing the phrase “Engage Everyone Early on Everything” (7 group and Bill Reed, 2009). The multiple interests of the triad lead to interesting interactions that encouraged everyone to consider others objectives and sometimes question preconceptions. This interaction was a key component to the realization of a project that is more “holistically” considered. Throughout the process the project team was dedicated to a whole-house systems approach as defined by the Whole-House Systems Approach (2014). In addition to the building systems, this holistic approach considered all aspects of the sustainability “triple-bottom-line”: Environmental, Economic and Social Sustainability. Tuesday evenings, from January through May 2015 the team of Penn State students and advisors, industry mentors and SCCLT members met to discuss the project goals and approaches to create cost-effective net-zero energy ready homes.

Methods used to engage the design team and the community played a major role in the quantity of feedback that the design team received which ultimately contributed to the quality of the design. Several large ‘charrettes’ - community design workshops where students, faculty, the SCCLT and local homeowner and industry representatives collaborated in order to determine the direction of the project - were the most successful examples of this engagement (Figure 7). The students employed questionnaires and developed informational packets to disseminate in order to evaluate preferences on aspects of the design including program, material selection and site design. These sessions were the team’s most interactive opportunities to engage in dialogued break out sessions and solicit consensus votes to drive the process of design and decision-making. The charrettes were crucial to the project pace and informed the continuing work. In the short-term the community engagement workshops with the SCCLT and representative community members helped to ensure project success; for the long-term they may enhance the education of the future designers of our collective built environment.



**Figure 7: Project engagement timeline.**

This project allowed students to connect with a real project for affordable housing - a sector of the built environment that rarely benefits from the intensive integrative process necessary to realize more sustainable results. The learning curve associated with this project is steep because of the significance of the subject and complexity of real-time data considered. Learning was enhanced by engagement with industry mentors. These mentors worked with many of the students, providing them context to help to ground their ideas and to answer questions they had never previously encountered in a classroom (Figure 8). Conversely, the students’ presented progressive research. The benefit of this interactive learning is repaid to the community by harnessing young minds with the means to be on the cutting-edge of their selected fields.



**Figure 8: Penn State 2015 Race to Zero Industry Mentors.**

Refinement of the design continued with a smaller group of students and staff, many representing members of the initial design team, facilitated through the Hamer Center for Community Design/EEHR. Once the substantial winter snow (present on the site throughout the Spring 2015 semester) melted, several meetings were held on the site to finalize information about project siting and program. Over the summer a smaller, focused group continued work to refine the design based on information provided during focused meetings with the SCCLT GreenBuild Committee, a subset of the not-for-profit SCCLT board tasked with taking a more fine-toothed look into the project outcomes. Currently the Penn State team is finalizing a detailed report of research and related design recommendations that will inform the future project. Based on this rigorous collective process of research and design GreenBuild presents a more thoroughly considered vision addressing factors impacting the future homeowners and the broader community.

The refined duplex design (Figure 9) has been preliminarily reviewed by Borough staff to be consistent with State College zoning regulations. A local engineer - an industry sponsor to the Penn State R20 team - has been identified to assist the SCCLT in moving the project forward. Depending on the success of a fund-raising campaign currently underway, the SCCLT plans to break ground for construction of the GreenBuild duplex in mid-2016.

## CONCLUSION

In this co-design process politics and personal opinions had little to do with the progress of the project or the day-to-day decision-making. The continuity of

presenting, problem solving and communicating happened through close and continued collaboration. The project empowered students to direct the decisions. The leadership and reporting structure was established early and this allowed for clear lines of communication as well as a clear view for other team members to take responsibility based on his/her role. For example, during the competition, there were sub-teams that helped steer the direction while collectively adding to the richness of the project. Faculty guidance and support from Penn State, Hamer Center/EEHR and PHRC (Pennsylvania Housing Research Center) was invaluable for the logistics and resources needed to organize and execute the tasks of the project.

Involvement on a meaningful ‘real-world’ project inspired students to work harder and be more engaged. The team became intimately familiar with and committed to community that they were affecting, instilling an accountability that few projects can match. The relationship built with SCCLT influenced enthusiasm for the project and inspired the team to ascent to personal sustainability goals while inspiring to those of the SCCLT and the community. Participants in this project share an unparalleled experience informed by a larger conversation, tuned to the engagement of building science leadership and energy-efficient affordable design communities, transcending individual contributions. The process undertaken in the interest of this demonstration project is built on collaboration and mutual goals. Participants engaged their local community to make a grass roots difference in what high-performance efficiency and sustainability means to State College while being able to situate themselves in a larger, international conversation about future goals and ways to get there.



**Figure 9: Renderings of GreenBuild, clockwise from left: site plan, perspective looking north, and view of the duplex entry court.**

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