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Design Schools as Drivers for Sustainable & Affordable Housing

Christopher Hazel, Lisa D. Iulo

The Pennsylvania State University, State College (USA)

Abstract

As prices and technical qualities of houses rise, the availability of both high performing and affordable housings seems to drop. Therefore, there is a need to raise the overall standard of general homebuilding to meet the needs of the contemporary resident—ecologically, socially, and financially. Additionally, there is a need to educate future designers about these arising complexities in the AEC (architecture, engineering, and construction) field that they will need to handle as they pass through school and into the profession. Over the past two years, a group of students from The Pennsylvania State University have been tackling both of these issues simultaneously by acting as the designers of an ecologically and financially conscious house within their own community. The students, with Energy Efficient Housing Research Group (EEHR) at Penn State, entered the Department of Energy's Race to Zero design competition. Instead of using a hypothetical situation, the team embraced a site in State College owned by the State College Community Land Trust (SCCLT, a non-profit organization that buys and sells houses to income-qualified buyers). After over a year of research and development, the design of the duplex is in the final stages. The result is a better and more engaged education for the students, a greater foundation of research for EEHR and Penn State, and new homes for the community of State College.

Keywords: *Education, Land Trust, Sustainability, Affordability, Community Design.*

1. Introduction

In order to appropriately and effectively combat some of the architectural and housing concerns that have arisen over the past several decades, namely affordability and energy efficiency, we must find ways of engaging students in design school so that they focus on these problems early in their careers and fully understand the complexities that go into these architectural systems. As prices and technical qualities of houses increase, the availability of both high performing and affordable housing seems to drop. Therefore, there is a need to raise the overall standard of general homebuilding to meet the needs of the contemporary resident—ecologically, socially, and financially. Additionally, there is a need to educate future designers about these arising complexities in the design field that they will need to handle as they pass through school and into the profession. Over the past two years, a group of students from the Pennsylvania State University have been tackling both of these issues simultaneously by acting as the designers of an ecologically and financially conscious house within their own community.

2. Process

In late 2013, the Energy Efficient Housing Research Group (EEHR) is a multidisciplinary Penn State organization housed within the Hamer Center for Community Design with the objective of reflecting upon past housing projects undertaken by the university—such as the 2007 Solar Decathlon entry, the

MorningStar home—while also researching new ways to design, construct, and monitor energy-efficient and affordable homes) was approached by the State College Community Land Trust (SCCLT) to learn about ways to improve energy efficient retrofits to houses that they buy and sell in the community. The SCCLT, one of over 200 land trust organizations in the United States, has been operating within the State College area for over twenty years. The nonprofit organization acquires homes and land in the Borough, an area with a dearth of affordable, non-student housing options, in the interest of providing owner-occupied housing to qualified buyers based on federal income guidelines. Only the house is sold; the land is leased to the homeowner in a long-term lease to ensure that the property remains in the affordable housing market in perpetuity. This arrangement allows for the buyer to apply for a mortgage based only on the cost of the house, thereby reducing home costs by more than 30 percent, and it allows for the home to be sold either to another income qualified buyer or back to the land trust according to a resale formula. The SCCLT also assists in educating and counseling homebuyers to promote the health and well-being of the neighborhood (SCCLT.org). This type of organization becomes especially important in a university town like State College where, over the past several decades, housing has changed drastically from owner-occupied to rental properties.

Soon after the first meeting with EEHR, the SCCLT was presented with the opportunity to buy one of the few undeveloped parcels of land in the State College Borough. This property along University Drive, a major thoroughway that connects to Penn State, allowed for the perfect opportunity to build a new house to showcase the success of the SCCLT, be a beacon of energy-efficient design, and provide new homes for people in need. The R-2 parcel measured at just over 20,000 square feet meaning that the lot was large enough for the construction of a duplex—two connected dwelling units. The SCCLT initially saw an opportunity to parallel a duplex design completed by the Union County Housing Authority in Lewisburg, PA, (under 60 miles East of State College) that was also documented and studied by EEHR. Although the Union County Housing Authority Duplex was similar to the SCCLT project desires in terms of size, energy goals, and affordability—and the house was documented by EEHR to serve as a model for similar housing builders and providers—an alternate approach was sought to design something more site specific. Due to the proximity to campus and an increased focus on Penn State's outreach and engaged scholarship programs, it was decided to use this project as an opportunity to get students involved in local design and have students begin thinking about the complex systems associated with housing and understanding all aspects of sustainable design—environmentally, socially, and economically.

Professor Lisa Iulo, the co-founder and faculty head of EEHR, facilitated the use of this project as the subject for a fourth-year comprehensive design architecture studio during the Fall 2014 semester, a special topics course focusing on the design of a Zero-Energy Ready Homes during the Spring 2015 semester, and the school's submission for the 2014/15 Department of Energy's Race to Zero student design competition. The architecture studio course during Fall 2014 laid the groundwork for the project by providing preliminary research on the need for affordable housing in the State College Borough; more in-depth analysis of the site conditions, the surrounding architectural conditions, and the climatic conditions; and several potential program and design alternatives. This initial work by the studio informed the work of the Spring 2015 special topics course taught by Professors Iulo and Scott Wing. This second course, made up of both undergraduate and graduate architecture and engineering students, focused on fully developing one duplex design that would be aligned with both the U.S. Department of Energy (DOE) Race to Zero competition and the SCCLT's "GreenBuild" initiative.

The DOE Race to Zero competition (formerly Challenge Home) is a paper-based collegiate design competition that, similar to the Solar Decathlon, invites students to design energy-efficient housing but with an aim of making that housing affordable to typical low- and moderate-income homebuyers and without the added challenge of physically constructing and transporting the home. The competition began in Fall of 2013, and Penn State has competed each year since. The second year of the competition left some programming requirements open to each team to determine, availing the Penn State team ("Heritage Homes") to use the property along University Drive as their site so that they could compete with the symbiotic benefit of the land trust organization.

The Race to Zero competition acts simultaneously as an architecture design competition, a construction/development competition, and a building science competition. In addition to designing a

construct-able and aesthetic house, students must develop a solid foundation of research to prove that their house is responsive to their selected site, climate, and demographic. This matched perfectly with a project like the SCCLT duplex where the final design was intended for construction; such a project leaves little room for experimentation and less room for error. During the first week of the Spring 2015 course, the students divided themselves into research groups so that, similar to a working firm, individual students (or groups of students) would be responsible for knowing everything pertaining to their research group and integrating it into the project. The competition judged the design on envelope durability, indoor air quality, space conditioning, energy analysis, financial analysis, domestic hot water, lighting, & appliances, and design goals. The team divided these categories into five research groups: Sustainable Site Design, Building Science/Envelope Design & Durability, Design for Comfortable and Healthy Living, Design for Energy Efficient and Net-Zero Energy Living, and Financial Analysis and Marketing (Fig. 1).



Fig. 1: Research Groups

From the outset of the project, the team distinguished the "Triad of Interests" where they documented what the student team (acting as the designers), the Race to Zero organization (acting as the owner), and the SCCLT (acting as the client) each intended for the project (Fig. 2). This organizational structure helped the team to understand the desired outcomes from each party, and to see the design as more than a hypothetical project, but as homes that people would eventually inhabit. Decisions were no longer coming from a single student nor a single group of students, but instead through communication and collaboration with the SCCLT. This improved the team's understanding of what the SCCLT was looking to get out of the duplex and the needs of the anticipated future homeowners.

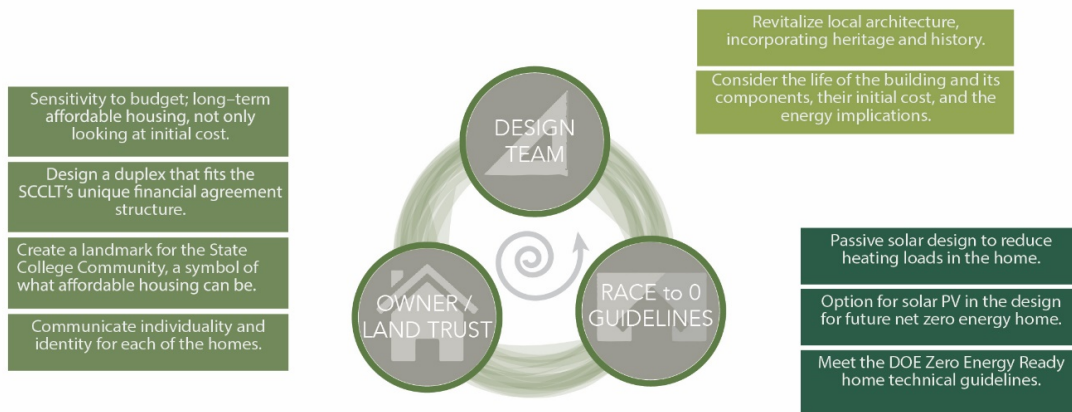


Fig. 2: Triad of Interests to organize the desired outcomes of the project by each of the associated parties.
Image Source: Penn State 2014-2015 "Heritage Homes" Race to Zero competition team.

The student team worked on basis of a tenet of Integrative Design, "Engage Everybody Early on Everything" (7group and Reed, 2009) to engage all stakeholders of the project throughout the entire design process.

Between January and March of 2015, there was a weekly meeting between students of the competition team, faculty advisors, members of the SCCLT, and industry mentors in order to discuss and collaborate on the project's goals and process. These weekly meetings provided a consistent schedule for the students and a structure for when tasks needed to be completed. The students worked closely with over a dozen industry mentors who were able to give advice and guidance to the project ranging from research, construction or practice experience, to financial/sales experience. These mentors served as a link between the typical hypothetical studio project and the real-world project. Other than simply turning to the internet and following false or misunderstood information, the students were able to reach out to real builders and consultants for information that would inform the design.

3. Project

The PSU team name for the Race to Zero competition was H4 - Heritage Homes: High-Performance Living in Harmony with Community, and they started their competition book with the statement, "Good architecture learns from the past, responds to the present, and inspires the future" (Penn State, 2015). As mentioned before, the goal was not simply design a duplex, nor even a high-performing one, but one that would connect with the State College community and the existing built environment. During the contextual and historical study done by the Fall 2014 studio class and the competition team, the image of the bank barn and the farmhouse consistently emerged. Both of these building typologies are very important to Pennsylvania architecture, and they are certainly still relevant to an area like State College that both contains a university founded on agriculture and farming and is still surrounded by agriculture and farms that date back centuries.

Adjacent to this contextual study and analysis, the competition team also held community design charrettes to garner interest and feedback on the project. During these large design meetings, the students would interact and collaborate with members of the SCCLT, local homeowners, faculty and staff outside of the project, and industry partners. This, different than traditional architecture studios, allowed students to see their work through the eyes of people who are not architects and not studying to be architects; it allowed students to really engage with, and think like, the people whom they will be designing for in the future. For these community design charrettes, the students organized questionnaires and visual preference surveys to better evaluate and inform decisions such as program, aesthetic style, and material selection. Students also treated these charrettes as design reviews—providing a soft deadline for work and ideas to be completed and communicated. These events, where the students were often the minority, forced the students to not simply propose or suggest their designs, but to discuss the designs and invite feedback, to work collaboratively and engage the community so that the project could grow to be something of which everyone could be excited and proud.

The final design, taking full advantage of the southward-facing sloping site, exemplified a pair of connected 'bankbarn' homes with an accessible first floor (including kitchen, dining room, living room, and full bath) and dwelling rooms in the walk-out basement (three bedrooms and full bath). The design focused on open floor plans and adaptability so that the homes could change as the homeowners grew older. The site-specific design of the houses incorporated generous views to the Appalachian Mountains and ample solar exposure for Photovoltaic (PV) panels and passive solar heating. Every part of the home, from the orientation and site design, to the wall and roof construction, to the water and space conditioning systems were meticulously explored and researched by the team to assure the best possible decisions were made; there was no experimentation, per se, in the design. Rather, the house as a whole was designed to be a holistic product of research and experience. No new trials of construction are used in the house, but instead a wealth of research is brought together in ways not typically seen in current construction.



Fig. 3: Rendering of Entry for 2015 PSU Race to Zero Design Submission
Image Source: Penn State 2014-2015 "Heritage Homes" Race to Zero competition team.



Fig. 4: Variations and Adaptability in Floor Plans
Image Source: Penn State 2014-2015 "Heritage Homes" Race to Zero competition team.

The building envelope is an example of this combination of research and experience. The whole-house building envelope was rigorously studied with advisors and industry partners to determine the optimal solution between energy efficiency, cost of materials, durability, and constructability. Using both building science literature and educational resources by the DOE and Building Science Corporation and real-world experience provided by the industry partners and Green Building Advisor, the team was able to evaluate many different envelope assemblies to not only find a solution, but to find the best solution for this particular house. The envelope system is not a universal solution, nor is it intended to be; it is, however, the best solution decided by the team for the set parameters of the project (budget, material availability, typical

practices of construction, etc.). This kind of project and collaboration between students, researchers, and active architects/builders provided a multi-layered approach where conventions could be stretched and research could be practiced, not only enabling better designed homes, but a better and more rigorous way of learning for the future architects and engineers.

4. Outcome

In April of 2014, two students presented the project to a panel of judges (building scientists, academic researchers, and industry professionals) at the National Renewable Energy Laboratory (NREL) in Boulder, CO. The students interacted with their jury and other competing students from across the country, which allowed for an exchange of ideas and an assessment of the work that had been completed. The project received awards in design excellence and systems integration while also receiving a perfect score in the building envelope category. This validated the research and analysis that the team had completed over the year and ensured that, according to experts in energy-efficient home design, the duplex design was high performing, affordable, and build-able. The presentation also provided an opportunity for outside critique on the project and advice from people not immediately involved. Judges were able to inform the students not only what they had done correctly on the project, but also where improvements could be made. This was perhaps the most valuable as the project moved forward from competition to construction.

5. Next Steps

After the competition, the team met again to review the project, to go over the praises as well as the critiques by the jury. The advantage with having the competition incorporated into a formal class was for opportunities for review and go over lessons learned; rather than ending everything after presenting at NREL, the team could improve the design as well as really understand and fix any mistakes they had made during the design process. Immediately after the presentation at NREL the team prepared for their final community design charrette. Now that the competition was over, the design could loosen slightly—many of the technical and performance decisions would remain the same, but the formal design of the house could be refined to better suit the SCCLT and the community. During this final charrette, the team presented four slightly different options for the duplex combination, each of which had similar floor plan layouts and similar simulated performance but allowed for differences in site layout and building compositions.

This design work continued through the summer until a final site layout was determined by both the university design team (EEHR) and the SCCLT in early Fall 2015. Since the final layout was determined, EEHR students and faculty have been working to fully document the building so that the full design and performance intent can be understood and implemented by SCCLT with the assistance of professionals. EEHR has been working to design the drawing set to be both specific to this site and design, yet universal so that the knowledge and research that went into the drawings can be replicated on other projects. Adjacent to the drawing set, the team is compiling a research book that will provide a more thorough basis for why certain design decisions were made. The goal will be to publish both sets of documents so that builders and home-owners can make more conscious decisions about energy efficiency and home performance. After a successful fundraising campaign, SCCLT plans to select a local builder and begin construction before the end of 2016.

Involvement by EEHR doesn't end with the turning over of design documentation. Professor Iulo hopes to use the construction as a student learning opportunity, through arranging site visits and for interaction with the builders. Once design documentation is complete, the EEHR team will shift focus to evaluation and analysis of the duplex. While still in preliminary stages, initial goals will be to monitor home energy usage and learn about how the high-performance houses have influenced the owners—energy usage, lifestyle changes, etc. Even after the design is complete there will be much learning to be done by both the students and the faculty at Penn State.



Fig. 5: Rendering of Entry for updated duplex design (Fall 2015)
Image Source: Penn State EEHR.

6. Conclusions

What began as a consult for information about energy efficient design grew into an opportunity for significant research and a substantial student involvement activity, a thorough foundation of information about energy-efficient, zero-energy ready, housing, and a well-designed duplex for the community of State College. This project, although long and sometimes difficult in process, has been enlightening and beneficial for all parties involved, which speaks to the benefit of this kind of collaborative community design. Because of the 'real-world' aspect of the project, students were able to feel more engaged and that their design decisions were going to truly impact someone rather than be stored in a closet for half of a decade until the next accreditation visit. Students worked harder to make deadlines and researched more to defend their decisions; students could also interact with professionals in the design community and learn about how they design and how they make decisions. Students not only learned to be better researchers and designers in a broad sense, but they learned how to apply that knowledge to energy-efficient and affordable housing—something that has been, and will continue to be, an architectural issue.

The greatest achievement of this undertaking will be the completion of the houses. This project will be one in many that Penn State has completed over the past several years as a way to engage or give back to the State College community, distinguishing itself not only as an institution of higher education within State College but one that is part of and essential to the fabric and character of State College. This duplex will embody multiple years' worth of design and research that, otherwise, SCCLT would not have had access to. Symbiotically, the more engaged and more connected the students feel to the project and to SCCLT, the harder they work and the better the final design can be. This means that the SCCLT and the future residents receive a better house and the students receive a better education and experience. These community-based, 'real-world' design projects do more than simply teach students; they engage them in promoting healthier and better communities, teaching students not simply the how to design but the importance of design and the importance of connection to the surrounding environment.

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