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# civil + structural ENGINEER

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## SUSTAINABLE+RESILIENT HOUSE

Design maximizes energy use, storm protection, and resiliency

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# SU+RE HOUSE: MITIGATING CLIMATE CHANGE WHILE BRACING FOR ITS EFFECTS

STEVENS INSTITUTE OF TECHNOLOGY DESIGN TEAM MAXIMIZES ENERGY USE, STORM PROTECTION, AND RESILIENCY.

By Maraliese Beveridge with Allison Outwater, EIT and A.J. Elliot

**EARLY IN OCTOBER** 2015, a house was quietly shipped across the nation, piece-by-piece via tractor trailer from Hoboken, N.J., to Irvine, Calif. It was not just any house — the Sustainable+Resilient (SU+RE) HOUSE. Two years in the making, the SU+RE HOUSE was headed west as an entry for the 2015 U.S. Department of Energy Solar Decathlon competition held at Orange County Great Park in Irvine.

This fully functioning, 1,000-square-foot structure, comprised of two bedrooms, one bathroom, kitchen, dining and living areas, consumes 90 percent less energy for heating and cooling than traditional homes, is fully solar-powered with no battery or diesel back-up, and was built to act as a resilient energy hub to assist neighboring homes during power outages. The SU+RE HOUSE Design Team maintains the structure is also hurricane resistant — a claim that exceeded the expectations of the competition design criteria.

The best part of the story? SU+RE HOUSE was designed, constructed, and tested by a team of 60 students from Stevens Institute of Technology in Hoboken. Attending a school located on the edge of the Hudson River, these students experienced firsthand the destruction Superstorm Sandy caused in 2012.

According to Wikipedia, in New Jersey alone there was an estimated \$29 billion to \$36 billion in damages with 346,000 homes damaged or destroyed and 2.5 million without power in the face of this disaster. Since 1992, Sandy took second place in the top 10 worst hurricanes, second only to Katrina in 2005 (National Hurricane Center).

## The team

The SU+RE HOUSE team is made up of a diverse group of creative, dedicated students from across disciplines at Stevens Institute of Technology and supported by a committed group of industry and non-



profit partners and sponsors. Spanning two years, this multidisciplinary project enabled students to engage the most pressing issues facing the building industry today: how to create sustainable, beautiful, and resilient buildings. Their version of fighting back coastal devastation from the likes of Sandy was designing and constructing a sustainable and resilient home for the areas at the greatest risk from rising sea levels and damaging storms.

## Setting the bar

Superstorm Sandy's destruction challenged the team to respond optimistically and prompted them to answer one question: Can we design a home for coastal regions that dramatically reduces energy use while also protecting us against the realities of an ever-changing, increasingly extreme climate? A truly sustainable home should also be resilient, an idea that has driven the design of the SU+RE HOUSE.

Team member Allison Outwater, EIT, who graduated Stevens Institute in 2015, is currently working in the Bridges and Structures Department at Maser Consulting P.A. in New Jersey and has been an integral part of the 2015 SU+RE HOUSE design and development. Growing up at the Jersey Shore, Superstorm Sandy hit Outwater personally as the storm affected her home and family. Having a history of volunteering and helping others, it was no surprise that Outwater became the volunteer coordinator in Hoboken after Sandy and worked for more than two weeks straight organizing evacuations, food and water distribution, and medical and information coordination.

Her list of awards for service, response, contribution, and coordination in Hoboken includes a Certificate of Appreciation, 2-113th Infantry of the National Guard/2012; Emerging Leader Award, Stevens Institute of Technology/2012; Outstanding Citizen Award, Stevens Institute of Technology Police Department/2012; Civic Engagement



The SU+RE HOUSE was constructed and tested in a parking lot at Stevens Institute on the edge of the Hudson River within view of the Manhattan skyline.

Photo: Juan Paolo Alicante

and Volunteer Services Award, Stevens Institute of Technology/2013; and the President's Award for Community Involvement, Stevens Institute of Technology/2013. Outwater was also assigned as the SU+RE HOUSE project's health and safety officer for the duration of the Decathlon.

"In a way, I think the experience of living through Superstorm Sandy gave us an unfair advantage for the competition — it injected a spirit of determination into our team that other teams in the Decathlon didn't have," Outwater said. "We weren't just competing against *them* — we were competing with Sandy."

The physical requirements of participating in the full three-week duration of the Decathlon was daunting, and not every team member was afforded the opportunity to attend. Many of the students graduated in May 2015 and went right into full-time jobs. Outwater, who began interning at Maser Consulting in 2014, was brought onboard full-time in May 2015. Barely racking up enough vacation time to afford two weeks off for the competition, firm CEO and President Richard Maser granted her an additional week off, compliments of the company, so she could complete this dream.

The evolving practical requirements of the competition resulted in everyone on the team in any capacity playing a dual role — sometimes more. As the measured contest captain, Juan Paolo Alicante was responsible for the team meeting the five measurable areas of the Decathlon (Appliances, Home Life, Commuting, Energy Balance, and Comfort Zone). As a mechanical engineer, he was responsible for monitoring the living envelope, from tracking the temperature and humidity to energy consumption and appliance performance. His third responsibility, one he took upon himself, was as unofficial photographer.

"Getting to work on the design of the mechanical room was a huge opportunity for me to understand what the underbelly of the HOUSE really looked like. I was able to work with people from all different disciplines, and it gave me so much more respect for how much goes on behind the scenes," Alicante said. "Similarly, I helped out with the communications team and learned what it took to get the word out about the project and how fulfilling it was to document and share what your team has accomplished as a whole through photography."

Newly hired at the firm of Edwards & Zuck, a New York City mechanical, electrical, and plumbing company, the firm agreed to hold-off the starting date of Alicante's position until the competition was over.

### The competition

The U.S. Department of Energy Solar Decathlon tenders this competition every other year to give competitors a sufficient window in which to cultivate their entries. Developed to challenge collegiate teams to design, build, and operate solar-powered houses that are innovative, cost-effective, energy-efficient, and attractive, the competition provides a hands-on experience and unique training that prepares them to enter the clean energy workforce. Up against some of the biggest university's in the country, students have partnered with their peers internationally, including from Italy, Germany, Honduras, and Panama. While a maximum of 20 teams were selected to compete, by competition check-in day only 14 made it all the way to the Decathlon.

The Department of Energy set forth strict juried and measured judging criteria, affirming that the winning team will be the one that best blends affordability, consumer appeal, and design excellence with optimal energy production and maximum efficiency. The point-



A team from Stevens Institute of Technology entered its Sustainable+Resilient (SU+RE) HOUSE in the 2015 U.S. Department of Energy Solar Decathlon competition.

Photo: U.S. Department of Energy

based criteria included 10 categories:

- Architecture
- Engineering
- Affordability
- Market appeal
- Communications
- Appliances
- Commuting
- Comfort zone
- Home life
- Energy balance

Not only did the team design and build the SU+RE HOUSE, they were also required to roll-out a public relations and marketing plan, including developing a website, driving their own social media, and raising funds to make the project happen. Supported through many venues — including alumni and private monetary funding; donations of materials, time, and tools — corporate donors included ExxonMobil, The PNC Foundation, and NRG Home Solar. Public Service Enterprise Group (PSEG) donated \$250,000 to help see the project to completion. Part of the scoring was dependent on team-driven votes through social media and from thousands of onsite visitors and millions of media viewers, who made 2 billion combined media impressions. The team's communications strategy drew more than 200 members of the media in attendance at the Solar Decathlon.

Once the SU+RE HOUSE was complete on its original site in Hoboken, the competition required the team to disassemble the house, ship it across the country, and were given an eight-day timeframe in which to completely re-assemble the house in the Decathlon Solar Village in Irvine.



After shipping the house across the country, it was reassembled at the Solar Decathlon site in Irvine, Calif. Photo: Juan Paolo Alicante

Additionally, the team was expected to operate the house as an exacting technical competition as well as a busy public exhibition space, conducting tours for tens of thousands of visitors for a two-week duration. At the completion of the Decathlon, the house would once again be disassembled, shipped back to New Jersey, and reconstructed on its final site.

### Construction and engineering

Stevens Institute's first entry for the Decathlon was in 2011, for which they partnered with The New School in Manhattan to create the Empower HOUSE, which is currently functioning in Washington, D.C., as a Habitat for Humanity home. A second entry in 2013, the Ecohabitat HOUSE, was one of the top contenders in the Decathlon, placing fourth overall and second in the Architecture competition. Today, Ecohabitat HOUSE is being used as a veteran's center on the campus of California State University, San Marcos.

A true veteran of the Solar Decathlon, A. J. Elliott, a Stevens graduate student, visited every Solar Decathlon with his father since 2007 purely out of interest. Having graduated from Drexel University with a bachelor's degree in electrical and computer engineering, Elliott stumbled upon the Product Architecture and Engineering Program Stevens offers during the 2013 Solar Decathlon. With a passion for green design and contributing, he jumped at the chance and joined the Stevens team as one of the electrical engineers — with a twist. He also donned caps of team communications and public relations manager. From handling social media to writing the blog for Popular Science magazine, he continually ensured that the complex technological systems of the house were easily understood by all and that as many people as possible who could benefit from a storm-resistant home knew of the available possibilities.



The 1,000-square-foot SU+RE HOUSE comprises two bedrooms, one bathroom, an open kitchen-dining-living area (shown here) and outdoor deck. It consumes 90 percent less energy for heating and cooling than traditional homes. Photo: Juan Paolo Alicante



Storm shutters act as protection against storms when down and provide shading and support solar collectors when raised. Photo: Juan Paolo Alicante

“Each time Stevens entered the Decathlon and lost, knowledge was brought forward,” Elliott said. “Essentially, we set the bar for the competition against ourselves. This time — we went there to win!”

Constructed in a parking lot at Stevens Institute on the edge of the Hudson River with the Manhattan skyline as both a reminder of Sandy and an inspiration, the design of the SU+RE HOUSE began with research. The team developed a sustainability and resiliency boot camp that examined and integrated state-of-the-art building science and technology, climate science and its effect on coastal New Jersey, shore community planning and construction methodologies in the context of storm resiliency, and an in-depth study of previous Solar Decathlon competition entries.

The design of the SU+RE HOUSE employed a wide variety of tools, including hand sketches and complex computer analyses, to model the team’s ideas from many perspectives simultaneously. The design concurrently modeled a living envelope that combined the balance of form and structure, view and glare, energy source and sink, and a variety of other dynamic forces. The result was a feedback loop in which design fed itself.

A Stevens graduate and full-time structural engineer, Christine Hecker, EIT, is the project engineer for SU+RE HOUSE responsible for all documentation and drawings for the many innovations of the house. From calculating each iteration of the house to making sure the drawing set was in perfect order, she was the glue in binding the group together and ensuring everyone was on track with their design. Her long hours, persistence, and drive led the team to a critical first place win in the Engineering competition, which was a deciding factor in their scoring. Her training on the Stevens cross country team didn’t hurt her endurance on the project either.

“The integration of all the different disciplines of engineering and architecture was one of the most challenging but also most rewarding aspects of the project,” Hecker said. “Working with so many other talented individuals in their fields presented challenges in how to design to meet the requirements of each person, but it also taught everyone involved how to work on highly collaborative projects. I think the biggest lesson everyone learned was how to design appropriately to keep intact architectural design while also simplifying their own discipline and compromising some for the ease of everyone else. When you see the final product, all of the hoops you have to jump through to ensure everyone’s design works are completely worth it.”

### Engineering innovations

Ultra-low energy consumption is dependent on a wide range of new technologies and details that work perpetually and in tandem and were carefully chosen to maximize whole house efficiency. Every piece of equipment used to run the SU+RE HOUSE was sized to match the energy demand while using the least amount of energy possible. Some of the utilities include a highly efficient heat pump to heat, cool, and dehumidify the space; energy recovery ventilation system that utilizes its energy to precondition incoming air instead of wasting it; solar electric (photovoltaic) system to heat the water first without having to sacrifice money or electricity; highly efficient hybrid hot water system that takes up minimal space, is low maintenance, and completely environmentally friendly; and even a hybrid clothes dryer that combines conventional heating with a heat pump to recover lost heat and reduce energy demand. All of this combined to create a highly efficient living envelope that is as efficient as it is comfortable for habitation.

### Innovations include:

- Resilient hot water system that hybridizes a photovoltaic electric



A team of 60 students from Stevens Institute of Technology researched, designed, constructed and marketed the SU+RE HOUSE. Photo: Stevens Institute of Technology

hot water system and an integrated heat pump hot water heater. Each system alone provides an efficient solution for generating hot water, however, synchronizing both systems creates an innovative solution that truly makes it both sustainable and resilient.

- **Highly efficient envelope** that utilizes a combination of radiation, conduction, and convection to control the interior ventilation, heating, and cooling.
- **Storm-resistant construction**, beyond traditional construction, lies in the details of the exterior envelope, floor/structural systems, finished interior, thermal barriers, and electrical.
- **Storm shutter doors** that are multi-purposed, acting as a protection against storms, shading system, and as solar collectors.
- **Integrated solar panels** are utilized in the flood-resistant storm shutters to collect sunlight when the shutters are in the open position. This energy is used to power the hot water heater.
- **Resilient power system** that is tied to the power grid but can switch over to a resiliency mode entirely isolated from the grid and sustain itself.
- **Durable fiber-composite siding** to help protect the SU+RE HOUSE, making it storm resilient.

## Conclusion

In case you're wondering — the answer is yes! The Stevens Institute of Technology's SU+RE HOUSE Team won the 2015 U.S. Department of Energy Solar Decathlon! Aside from the sheer glory of first place, they have received more media coverage hence, the house has been toured by more people than any other entry, which has given their ideas and innovations a vastly broader audience and an immeasurably greater impact during the Decathlon and beyond.

Climate change is here. Dealing with the new reality that Superstorm Sandy demonstrated was an opportunity for students to learn about



Stevens graduate and full-time structural engineer Christine Hecker, EIT (left) served as structural and project engineer. Allison Outwater, EIT, a Stevens graduate and currently working in the Bridges and Structures Department at Maser Consulting P.A., served as structural engineer and health and safety officer. Photo: Juan Paolo Alicante

solar energy and high-performance construction through a rigorous research and experimentation-based process. SU+RE HOUSE was an attempt to deal with this reality by maximizing sustainability and efficiency with net-zero energy use. This and other Decathlon entries have educated the next generation of problem solvers who have more tools and a wider range of technology than ever before. The Decathlon has afforded the SU+RE HOUSE Team the privilege of becoming leaders who are designing a whole new future!

Now that the Decathlon is over, and the SU+RE HOUSE has been shipped back to New Jersey, the team has begun a period of redesign to make adjustments to the house from what they've learned through this experience. By the summer of 2016, the team expects the SU+RE HOUSE to be up and running in full force for its final directive as an emergency management and coastal resiliency center in New Jersey.



For more information about SU+RE HOUSE and Stevens Institute of Technology visit these links:

- SU+RE HOUSE website — [www.sureHOUSE.org](http://www.sureHOUSE.org)
- SU+RE HOUSE Facebook — [https://www.facebook.com/sureHOUSEsd?ref=aymt\\_homepage\\_panel](https://www.facebook.com/sureHOUSEsd?ref=aymt_homepage_panel)
- Stevens Institute of Technology — [www.stevens.edu](http://www.stevens.edu)
- U.S. Department of Energy Solar Decathlon — [www.solardecathlon.gov](http://www.solardecathlon.gov)

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The following SU+RE HOUSE Team members contributed to this article: **ALLISON OUTWATER, EIT**, was structural engineer and health and safety officer; **A.J. ELLIOTT** served as electrical engineer and communications manager; **JUAN PAOLO ALICANTE** was mechanical engineer, measured contest captain, and photographer; and **CHRISTINE HECKLER, EIT**, was structural and project engineer